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FIFTY YEARS OF DIRAC MONOPOLE: COMPLETE BIBLIOGRAPHY

(1786 references with abstracts)

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MONOPOLE

P.A.M.DIRAC In : FIZIKA MIKROMIRA, Malenkaya Enciklopedia, Izd. Sovietskaya Enciklopedia /In Russian/, Moscow,1980,p.243.

MAGNETIC MONOPOLE

The laws of Nature find great similarity between electric and magnetic fields. The field equations established by Maxwell are the same for both fields. But there is still a big difference. Particles with positive and negative electric charges are constantly observed in Nature. They form in the surrounding space a Coulomb magnetic field. As for positive and negative magnetic charges - they are never observed separately. A magnet always has on its two ends two equal poles - positive and negative - and the magnetic field around it is the resultant field of both poles.

The laws of classical electrodynamics allow the existence of particles with one magnetic pole - magnetic monopoles, and give some field equations and equations of motion for them. These laws bear absolutely no prohibitions for the existence of magnetic monopoles. In quantum mechanics the situation is somewhat different. The consistent equations of motion for a charged particle moving in the magnetic monopole field and for a magnetic monopole moving in the particle field can be constructed only under the condition that electric charge "e" of the particle and magnetic charge "μ" of the magnetic monopole have the following ratio :

$$e \cdot \mu = \frac{1}{2} n \cdot \hbar c \qquad (*)$$

where $\hbar$ - is the Plank constant, c - is the velocity of light, and n - is a positive or negative integer. This condition is a consequence of the fact that in quantum mechanics particles are presented as waves and there appear interference effects in the motion of particles of one type under the influence of particles of a different type. If magnetic monopoles with "μ" charge do exist, the formula (*) demands that all charged particles in its vicini-

ty have charge "e" equal to the integer multiple of quantity $\hbar c/2\mu$. Thus electric charges should be quantized. But just this multiplicity of all observed charges to electron charge is one of the fundamental laws of Nature. In case there exists a magnetic monopole, this law will get a natural explanation. No other explanation of electric charge quantization is known.

Assuming "e" for the electron charge the value of which is defined through the relation $e^2/\hbar c = 1/137$, one can obtain from formula (*) the least magnetic charge "μ" of the monopole which is defined in its turn through equality $\mu_0/\hbar c = 137/4$. Thus, "μ_0" is much larger than "e". It follows that the track of fast moving magnetic monopole in the Wilson chamber or in the bubble chamber should be easily distinguishable among other particle tracks. Such tracks have been carefully searched for but until now magnetic monopoles have not been found.

Magnetic monopole - is a stable particle and can not disappear until it meets another monopole with an equal charge of the opposite magnetic polarity. In case magnetic monopoles are generated by high energy cosmic rays, reaching continuously the Earth, they should be often come across on the earth surface. They have been looked for, but also in vain. Thus the question whether this is due to rare production of magnetic monopoles or to non-existence of these monopoles still remains unanswered.

AUTHOR'S COMMENTS TO COMPLETE BIBLIOGRAPHY

For more than ten years the authors used the exellent opportunities of collecting information on papers concerning the problem of magnetic monopole. These data have been used as a foundation for present Bibliography. It contains more than 1700 references followed in the majority of cases by the abstracts of original articles.

Half a centure passed since Dirac predicted the possibility of existence of free magnetic charges in Nature. The history of physics it seems, does not know another precedent when such a great amount of human efforts have been given to the confirmation of serious and concrete theoretical predictions and the problem remains unsolved. The present Bibliography is an evidence of this gigantic work carried out by the physicists of the world.

Not so long ago it was possible to cover the whole problem of magnetic monopoles in the collected basic papers /356/. But with the number of papers published to the present moment it is already impossible to cover thoroughly all theoretical and experimental papers As we think, Bibliography with abstracts of original papers is the only possible and completely justified way of presenting to the physical auditorium the whole volume of works carried out on the subjec to the present moment. It enables to avoide the distortions in presenting the situation in solving this beautiful fundamental problem of modern physics.

The Bibliography allows to follow the history of magnetic monopole problem. In a short history review further below we try to attract attention to some interesting and sometimes little-known facts. As a consequence of the Dirac monopole theory the Maxwell equations obtains symmetrical form :

$$\operatorname{div}\vec{E} = 4\pi\rho_e \quad ; \quad -\frac{1}{c}\frac{\partial\vec{E}}{\partial t} + \operatorname{rot}\vec{B} = \frac{4\pi}{c}\vec{j}_e \,,$$
$$\operatorname{div}\vec{B} = 4\pi\rho_m \quad ; \quad -\frac{1}{c}\frac{\partial\vec{B}}{\partial t} - \operatorname{rot}\vec{E} = \frac{4\pi}{c}\vec{j}_m \,, \qquad /1/$$

where ρ_m and $\vec{j}_m$ are the densities of magnetic charges and magnetic currents. The known, empirically established symmetry of electric and magnetic phenomena, makes this sequence of Dirac's theory most attractive. Not many known, perhaps, that Heaviside back in 1892 reduced the system of Maxwell equations to a bit different but also completely symmetrical and dynamical complete form :

$$\operatorname{curl}(\vec{H} - \vec{l}) = 4\pi k\vec{E} + c\dot{\vec{E}} \,,$$
$$\operatorname{curl}(\vec{e} - \vec{E}) = 4\pi g\vec{H} + \mu\dot{\vec{H}} \,, \qquad /2/$$

where $\vec{H}$, $\vec{E}$ /according to Heaviside / denote the intensities of magnetic and electric fields ; $\vec{e}$ is the amount energy taken in by electromagnetic field per second per unit volume per electric current, and $\vec{h}$ is similarly related to magnetic current ; k is the coefficient of electric conductivity, g is the coefficient of magnetic conductivity; μ is the magnetic permeability , c is the dielectric permeability .

And, evidently, only fictitiousness of concepts used by him /magnetic charges and currents/ was the reason for the fact that these mathematically refined equations have not gained general recognition. It is also interesting that two completely different approaches /Dirac's and Heaviside's/ bring to the same result-symmetrization of electrodynamics system of basic equations.

We think Heaviside should be regarded an author of the first published theoretical paper directly related to the m gnetic charge problem*/. This paper opens the present Bibliography.

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*/ The papers by Carrigan /357/, /552/ cite the Epistola Petri Peregrini de Maricourt de magnete /1269/, which he thinks to be

The little known presently **/ paper by Pierre Curie should be regarded evidently as the first experimental attempt to solve the problem of free magnetism existence. The parallelism of electric and magnetic phenomena, according to Curie, gives ground for the following question - whether this analog is more complete. He writes in his paper : " Is it really absurd to suggest that there exist also the magnetism conductors, conductors of magnetic currents of free magnetism ? " And after giving a detailed analysis of the problem whether such phenomena contradict the principles of energetics / l'Energetique/ or symmetry conditions, he comes to conclusion that "...from the viewpoint of energetics and from the viewpoints of symmetry one may think seriously about magnetic currents and magnetic charges ". P. Curie concludes this paper with the words : " It would have been too daring, of course, to conclude from this that these phenomena really exists. But,if it is so, they should answer the above-mentioned requirements ".

Simultaneously, P. Curie attempts to find experimentally the magnetic conductivity basing on the "dynamic effect" suggested by him. The concept of the experiment has been as follows : " ... in case magnetic conductivity really exists, the transformer analogous to the AC-transformer but possesing a magnetic conductivity ring yoke, will transform one direct current into another direct current"

*/ probably the earliest recorded observation along these lines : "Procul dubio omnes lineae /magneticae/ hujusmondi in duo puncta concurrent sicus omnes orbes meridiani in duo concurrunt polos mundi oppositos " . /All such lines /magnetic/, undoubtedly, gather in two points as well as all meridians meet in the two opposite poles of the world. /

**/ The paper by P. Curie has been pointed to us by I.M.Frank.

He checked whether this phenomena was observed with a soft-iron yoke, but obtained no effect.

Among the papers related to the magnetic charge problem and preceeding the fundamental investigations by Dirac, one should pay special attention to Ehrenhaft publications. We have managed to fined more than 60 of his publications. The majority of them are experimental papers. By the number of publications the Ehrenhaft's investigations is comparable with the total number of experimental searches for magnetic monopole carried out in the world until present. For more than 20 years Ehrenhaft has been sure that he register magnetic charges in his experiments. It is difficult to tell now what was his mistake. The fact is - all these works are practically forgotten.

Dirac/7/ in 1931 when trying to explain why the observed electric charge is always multiple to the electron charge "e" and why the value of charge "e" is just the one we known from the experiment made a sudden discovery. He solved the problem completely, assuming that in Nature there exist isolated magnetic charges. This situation resembles a bit the Heaviside's case. Trying to reduce the Maxwell equations to symmetrical form, He viside had to make analogous supposition. In 1948 Dirac developed the general theory of charged particles and poles interacting through electromagnetic field/68/. It should be noted still that in contrast to Heaviside, who regarded magnetic charge as a fiction , Dirac introduced this charge as a really existing one and thus layed the foundation of the magnetic charge theory.

The first experimental estimation of the upper limit of Dirac monopole production in atmosphere by primary cosmic rays has been undertaken by Malkus in 1952/100/. The results of this experiment have demonstrated that the number of monopoles reaching the surface is less than 10^{-10} $cm^{-2}s^{-1}$.

The Dirac monopoles have been first searched for with accelerato by Bradner nd Isbell[11] in 1959 t the 6 GeV proton Bevatron of Massachussetts Institute of Technology. In the pp collisions at these energies there could appear monopole of masses between π - meson and proton masses. This experiment enabled to define the cross section upper limit $\sim 10^{-35}$ cm^2 of producing of monopole pairs of masses approximatelly equal to proton mass.

Since that time there have been carried out more than 50 experimental searches for magnetic charges. Figure I gives a fairly good idea about all experimental searches for Dirac monopole.

The majority of experiments have been based on the predicted by Dirac large value of the magnetic charge $g = 68.5\ e$. It is not, generally, difficult to detect particles of such charges at the contemporary level of physical experiment technique. In the performed experiments the monopoles has been detected through such effects as: characteristic ionization; abnormally large intensity of Vavilov-Cherenkov radiation; annihilation of monopole-antimonopol pairs and excitation of emf in the closed circuit at the moment a magnetic charge passes through it.

There have been measured also the values of magnetic charge, from which there have been established the upper limits of magnetic charges of an electron, proton, μ-meson, and other elementary particles.

All sorts of methods have been used in searching for Dirac monopoles. Many of them used a combination of strong pulse magnetic fields - sort of"collectors","extractors"and"accelerators" of magnetic charges with their subsequent registering over one of the above-mentioned methods. The majority of the methods suggests, as a rule, a substential time gap between the moments of monopole production and registration,which is infavourable since it is necessary

SEARCHES FOR MAGNETIC MONOPOLE

COSMIC RAYS

searches in the primary component of cosmic radiation

a) upper layers of the Earth atmosphere (baloon search)/776/

b) Alpine search (Tien Shan) /338/

c) searches at the sea level /310/,/1296/, /241/

d) deepwater searches /312/,/313/

searches for monopoles produced in the interactions of cosmic radiation with matter

a) meteorites: /156/,/955/

b) moon matter speciments /342/,/436/, /579/

c) Earth atmosphere /100/, /1133/, /205/,/439/,/633/, /700/

d) samples from the Earth surface(old rocks,snow from the poles,etc.) /1521/,/211/,/272/, /698/,/700/.

e) samples from the ocean bottom (Pacific,Atlantic) /244/,/365/,/373/, /431/,/447/.

ACCELERATORS

irradiation of the target with high and superhigh energy protons

irradiation of the target with superhigh energy electrons

a) SLAC-20 GeV 711

irradiation of the target with a beam of secondary particles

a) Bevatron MIT-6 GeV /117/

b) CERN-28 GeV /130/,/33/, /148/

c) Brookhaven-30 GeV /159/

d) Serpukhov 70 GeV /669/, /369/

e) Batavia-300, 400 GeV /551/,/613/,/711/, /992/

f) CERN-(2x30) GeV /410/,/598/,/711/, /1321/, /1569/.

a) Neutrons - 100-300 GeV /696/

b) neutrino /699/

c) γ -quant /355/,/485/

ESTIMATION OF MAGNETIC CHARGE VALUE FOR DIFFERENT PARTICLES

a) proton /286/,/69 /1518/

b) neutron /286/

c) electron /286/

d) μ-meson et al. /691/

FIGURE I

to make many different assumptions on the behaviour of monopoles during this time. Some methods, though, allow to decrease this gap to 10^{-10} s /669/,/410/.

It is also necessary to mention the attempted searches for " non-Dirac" monopoles of magnetic charges g equal to e and less than e .

The following results are obtained now in the main directions of searches for monopoles : the lowest limit of a flux of "cosmic monopoles" $10^{-19} cm^{-2} s^{-1}$ */ has been obtained in the experiments by Fleischer at al. , according to whom it is possible to put a stop to further monopole searches.

The construction of more and more powerful accelerators moved further the upper limit of the mass up to which magnetic monopoles in pp interactions were not found. The diapason of probable masses of produced monopoles with the upper limits of 1; 3; 5.5; 12; 14 m_p has been investigated consequently at cross sections reaching in certain cases the order /10^{-40} - 10^{-43}/ cm^2. The recent experiments carried out on the collidings proton beams at CERN have moved the upper limit of investigated monopole masses to 30 m_p , though at somewhat higher cross section of their production $\sim 10^{-35}$ cm^2.

There has been proved the magnetic neutrality of protons, neutrons electrons and other elementary particles. The limit of the probable nucleon magnetic charge reached the value of $\sim 10^{-26}$ the value of Dirac minimal charge.

Such a big number of unsuccessful attempts to find the magnetic monopole gave ground for certain scepticism even with the author of magnetic charge theory. In his paper published in 1973

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*/ Less than two monopoles at whole Earth surface per second.

Dirac writes *):" Another idea that I has at time, which followed from the mathematics, was that it should be possible to have single magnetic poles, monopoles. There were some very beautiful mathematics connected with these monopoles. However, monopoles have never been discovered although the experimenters have searched for them, and I'm beginning to feel doubtful whether this mathematical development is a correct one. There is room for doubt because the theory of electrons interacting with the electric and magnetic fiel is not altogether a satisfactory theory. There are some profound difficulties which shaw that some very deep alterations will have to be made. I don't want to go to a discussion of these difficulti but I merely want to say that they do cast doubts on this development, and it could very well be that when we get an improved theor in the future there may be no room in it for magnetic monopoles".

A most interesting situation occurred in this regard in 1975 when american physicists Price et al./776/ reported that they had found the track of a very heavy particle corresponding with a great probability to the track of magnetic monopole with a charge of g= 137e and mass $\gtrsim$ 200 m_p in their solid body detector irradiate for 26 days in the upper layers of Earth atmosphere with primary cosmic radiation.

The intensive discussion of the published data resulted in a number of other, more prosaic, interpretation of the detected event and the authors had to deny the discovery of magnetic monopole/964/ Though there was no discovery, the stormy responce of scientific and world public to this report allowed to judge on the importance

*) This work has been pointed out to us by S.Dubnichka.

of the problem. We do not know whether this or some other factors has given an impulse to further investigation, but after 1975 one can note a quick growth of the number of publications on the subject /see Fig. 2/. The shadoved part of this figure is based on the data in the possesion of authors in 1975. The figure demonstrates also that a tendency to rapid growth of the number of publications has been present earlier. This has been noted by academician Vonsovski[596] in 1973, but annual number of articles published in the 50 years of this problem existence has been exceeded by now 1700.

A part of this papers develops the Dirac theory by removing from it some earlier difficulties / see for example papers by Yang, Frankel et al.,a.o./. Other papers give a variety of different original approaches to magnetic charge problem. Without going into detail we shall illustrate them with just a list of current names of the magnetic monopole.

Besides Dirac monopole one can come across : Schwinger's dyon, Sommerfield-Prasad dyon, t'Hooft-Polyakov monopole , Wu-Yang monopole, Yang-Mills-Higgs monopole, BPS /Bogomolny-Prasad-Sommerfield/ monopole, Abelian monopole, non-Abelian monopole, SU/3/ magnetic monopole, coloured magnetic monopole, topological monopole, tachyon monopole, gravitational magnetic monopole, a.o. . The Dirac theory does not give concrete predictions of the magnetic monopole mass*/ and if one does not take into account

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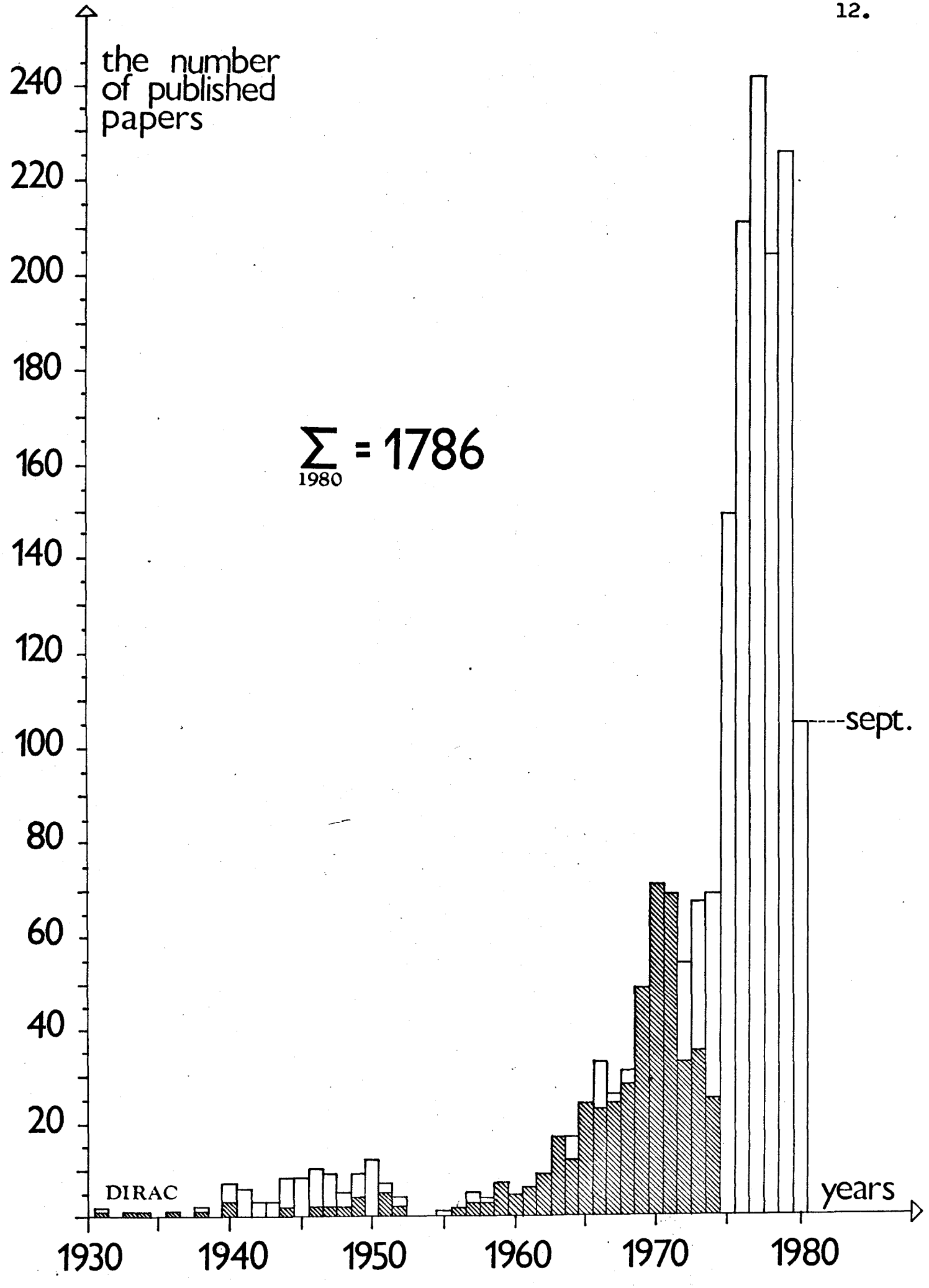
*/ According to the t'Hooft-Polyakov theory the magnetic charge mass $m_g \sim \frac{m_W}{\alpha}$. At the W-boson mass of $m_W \doteq 80$ GeV the mass m_g equals $\sim$ 11 TeV.


the number of published papers
240
220
200
180
160
140
120
100
80
60
40
20
$\sum_{1980} = 1786$
----sept.
DIRAC
years
1930
1940
1950
1960
1970
1980

/such alternative/ a chance that it does not exist, all the negative results of monopole searches with the accelerators find a natural explanation in the fact that the monopole mass is essentially higher than the limit obtained by modern accelerators. Due this the search for magnetic monopoles is carried out systematically with construction of more powerful accelerators. Presently, there are intensions to search for magnetic charges on the accelerators LEP/1709/, VBA/1723/ and colliding $p\bar{p}$ beam machine.

The authors do not regard themselves as competent enough to systematize all the theoretical papers concerning the magnetic charge problem. But upon the whole one can conclude assuredly that the magnetic charge problem becomes one of the probable directions on the way to solving the problem of elementary particle inner structure. Of considerable interest here are the papers by Schwinger Sawada, Barut, Fryberger and others. Note also that one of the authors of this Bibliography/1435/ has pointed out the simple relation connecting the electron magnetic momentum μ and the Dirac magnetic charge g, which has been unnoticed until now : $\mu = e\hbar/2m_e c = e/2\alpha \cdot r_e = g \cdot r_e$, where r_e is a classical electron radius. In case we express the electric charge e through the magnetic charge g : $e = g.2\alpha$ we find that two basic characteristic of elementary particle are directly related to the magnetic charge g. Isn't it perhaps, an indirect indications to the fact that the magnetic charge should be a value characterizing not the particle itself but the components of its structure ?

And finally we would like to attract attention to the authors index of approximately 1000 names added to the Bibliography. Among these names one can find the Nobel prize winners : Dirac, Curie, Fermi, Schwinger, Tamm, Frank, Alvarez, Yang, Weinberg, Salam, the names of many prominent physicist from the all over the world, who

have given much effort to solving this problem. Many authors return again and again to the magnetic charge problem and publish numerous results /Barut,Strazhev,Mignani,Recami,Tomil´chik,Yang,Carrigan a.o. One can hope that with this interest, noted recently, the magnetic charge problem will be solved.

Some words on the Bibliography itself. It embraces all the papers on the subject which were available to us. The earlier Bibliography on the subject compiled by Stevens[585] covering the period up to 1972 - is significantly expanded instead of 160 references there are now 584 references. Bibliography by Carrigan[1064] /1973-1976/ is supplied wherever possible with authors abstracts of original papers. Besides, the Bibliography is expanded with the papers by Soviet authors and with papers published in 1977-1980.

To avoid the technical difficulties caused by the fact that the majority of papers on magnetic monopole are published in English the latter has been adopted for the whole Bibliography.

The data are presented chronologically in alphabetic order for each year. In compiling this Bibliography we used the following sources :

1. SIGNAL INFORMATIONS ; PHYSICS ; PARTICLE AND FIELDS ; /until N° 7, 1980/.
2. INIS SYSTEM - the search with the CDC-6500 computer /until July 1980/.
3. PHYSICS ABSTRACTS /until January 1980/.
4. INTERNATIONAL ATOMIC ENERGY AGENCY. Vienna /until N° 11,1980
5. NUCLEAR SCIENCE ABSTRACTS /until July 1976/.
6. ERDA ENERGY RESEARCH ABSTRACTS /until December 1978/.
7. REVIEW JOURNAL ; PHYSICS ; /until N° 7, 1980/.
8. HIGH ENERGY PHYSICS INDEX /until N° 14, 1980/.
9. ARTICLES - on the subject of the JINR published in the journals recieved by the JINR Scientific Technical

Library /until N° 35, 1980/.

10. PREPRINTS - list of preprints received by the JINR Scientific Technical Library /until N° 35, 1980/.

The authors used also the catalogues of the JINR Scientific Technical Library. Many works have been found at reading the original papers and numerous review reports. The data compilation has been completed in September 1980.

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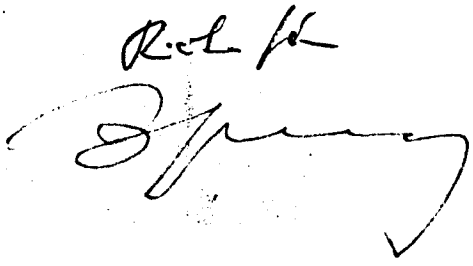
Dubna, 2nd November, 1980.



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2. Curie P. Séances Soc.Phys., Paris, 1894,pp.76-77.

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See also "Oeuvres de Pierre Curie", Societé Francais de Physique Paris, 1908, pp.142-144.

3. Poincarè H. Compt.Rend., 1896, vol.123, No 14,pp.530-533.

ELECTRICITY - REMARKS ON M.BIRKELAND'S EXPERIMENT (In French)

See also Birkeland M. Archives des Sciences physiques et naturelles de Genéva, Juin 1896, t.1, 4^{e} periode.

4. Thomson J.J. London, 1900.

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See also section 284, of the third(1904) and subsequent editions.

5. Rainich G.Y. Trans.Amer.Math.Soc., 1925, vol.27, No 2, p.106.

ELECTRODYNAMICS IN THE GENERAL THEORY OF RELATIVITY

6. Ehrenhaft F. Phys.Zeitschr., 1930, vol.31, No 10, pp.478-485.

LONGITUDINAL AND TRANSVERSAL ELECTRO AND MAGNETO-PHOTOPHORESIS(In German)

1931

7. Dirac P.A.M. Proc.Roy.Soc., London ,1931, Ser.A., vol.13 p.60.

QUANTISED SINGULARITIES IN THE ELECTROMAGNETIC FIELD

Shows that quantum mechanics does not preclude the existen of isolated magnetic poles. In fact, this formalism, when developed without y the imposition of arbitrary restrictio leads to wave equations whose only physical interpretation is the motion of an electron in the field of a single magn tic pole.

8. Tamm Ig. Z.Physik, 1931, vol.71, p.141.

THE GENERALIZED SPHERICAL HARMONICS AND THE WAVE FUNCTIONS OF AN ELECTRON IN A FIELD OF A MAGNETIC POLE (In German)

Properties of the generalized spherical harmonics are related to Dirac's wave equation of an electron in the field of a magnetic pole.

1932

1933

9. Tuve M.A. Phys.Rev., 1933, vol.43, p.770.

SEARCH BY DEFLECTION-EXPERIMENTS FOR THE DIRAC ISOLATED MAGNETIC POLE

The discovery of the positron predicted by Dirac motivates this discussion of detecting isolated Dirac magnetic poles by deflection experiments in magnetic and electric fields.

1934

1935

10. Grönblom B.O. Z.Physik, 1935, vol.98, p.283.

ON SINGULAR MAGNETIC POLES (In German)

For a system of a magnetic pole (infinitely heavy) and an electron, interacting through an arbitrary magnetic potential, the energy and the transition probability are shown to be independent of the position of a (straight) singular string.

1936

11. Saha M.N. Ind.J.Phys., 1936, vol.10, p.141.

THE ORIGIN OF MASS IN NEUTRONS AND PROTONS

1937

1938

12. Ehrenhaft F. Physikal.Z., 1938, vol.39, p.673.

DEVELOPMENT AND PROGRESS IN DETERMINING THE CHARGE AND VALUE OF SEPARATE PARTICLES

13. Jordan P. Ann.Physik., 1938, vol.5/32, p. 66.

ON THE DIRAC MAGNET POLE (In German)

For Dirac's system of singular strings each positive pole which produces such a string must either terminate at a negative pole or at infinity and conversely. It is proven that all physical statements concerning Dirac's theory must be independent of the special choice of these strings.

1939

1940

14. Ehrenhaft F. Sent to the Royal Society ,London,March, 1940.

PRODUCTION OF SINGLE MAGNETIC POLES BY LIGHT
(A hypothesis of magnetic ions and magnetic currents)

This paper also deals with the aparent changes of poles (magnetic charges) on the test particles, moving between the "magnetrodes" in either direction. They behave analogous to electric ions in electric fields, changing their charges only when under the influence of a very low magnetic field or without any field at all, and are very rare with ferromagnetic particles and very frequent with diamagnetic particles. Whether such a magnetic current is surrounded by a constant electric field has yet to be investigated.

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IS THERE "TRUE MAGNETISM" OR NOT ?

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THE MAGNETIC CURRENT

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PHOTOPHORESIS AND ITS INTERPRETATION BY ELECTRIC AND MAGNETIC IONS

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MAGNETIC CURRENT IN GASES

29. Ehrenhaft F. Science, 1942, vol.96, p.228.

MAGNETIC ION

1943

30. Ehrenhaft F. Phys.Rev., 1943, vol.63, p.216.

DECOMPOSITION OF MATTER THROUGH THE MAGNET (MAGNETOLYSIS)

31. Ehrenhaft F. Phys.Rev., 1943, vol.63, p.461.

MAGNETOLYSIS AND THE ELECTRIC FIELD AROUND THE MAGNETIC CURRENT

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FURTHER FACTS CONCERNING THE MAGNETIC CURRENT

1944

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NEW EXPERIMENTS ABOUT THE MAGNETIC CURRENT

34. Ehrenhaft F. Phys.Rev., 1944, vol.65, p.256.

CONTINUATION OF EXPERIMENTS WITH MAGNETIC CURRENT

35. Ehrenhaft F. Phys.Rev., 1944, vol.66, p.38.

PONDEROMOTIVE FORCES ON A MATTER IN ELECTRIC AND MAGNETIC FIELDS

36. Ehrenhaft F. Phys.Rev., 1944, vol.65, p.287.

DECOMPOSITION OF WATER BY THE SO-CALLED PERMANENT MAGNET AND MEASUREMENT OF THE MAGNETIC CURRENT INTENSITY

37. Ehrenhaft F. Phys.Rev., 1944, vol.65, p.349.

DECOMPOSITION OF WATER WITH A PERMANENT MAGNET

38. Ehrenhaft F. American Physical Society,Rochester Meeting June 23-24, 1944.

MAGNETIC CURRENT

39. Ehrenhaft F. Nature, 3909, 30 September 1944,p.426.

MAGNETIC CURRENT

40. Fierz M. Helv.Phys.Acta , 1944, vol. 17, p.27.

ON THE THEORY OF PARTICLES WITH MAGNETIC CHARGE (In German)

A proof is given for Dirac's postulate that a magnetic charge g must be an integer multiple of $\hbar c/2e$ in quantum theory.

1945

41. Ehrenhaft F. Phys.Rev.,1945, vol.67, p.63.

NEW EVIDENCE FOR THE MAGNETIC CURRENT

For a homogeneous electric field through which flows a constant electric current, it is predicted and confirmed by observation that a single magnetic pole will move in a spiral path.

42. Ehrenhaft F. Phys.Rev., 1945, vol.67, p.201.

THE MEASUREMENT OF SINGLE MAGNETIC CHARGES AND THE ELECTROSTATIC FIELD AROUND THE PERMANENT MAGNET

For test bodies of various substances in the microscopic dark field of a permanent magnet it has been observed that north or south magnetic charges can be measured.

43. Ehrenhaft F. Phys.Rev., 1945, vol.68, p.102.

THE ELECTRIC COUNTERPART OF OERTED'S EXPERIMENT

44. Ehrenhaft F. Phys.Rev., 1945, vol.68,p. 102.

POLARITY OF MAGNETISM

45. Ehrenhaft F. Phys.Rev., 1945, vol.68, p.105.

MAGNETISM AS A POLAR VECTOR

46. Ehrenhaft F. Phys.Rev., 1945, vol.68, p.102.

PONDEROMOTIVE FORCES OF LIGHT UPON MATTER AS SHOWN BY EXPERIMENTS

47. Ehrenhaft F. Science, 1945, vol.101, p.676.

RORATING ACTION ON MATTER IN A BEAM OF LIGHT

48. Ehrenhaft F. Phys.Rev., 1945, vol.68, p.285.

THE MOVEMENT OF SOLID BODIES IN SUNLIGHT

1946

49. Banderet P.P. Helv.Phys.Acta , 1946, vol.19,p.503.

CONCERNING THE THEORY OF SINGULAR MAGNETIC POLES (In German)

Here the work of Dirac and Fierz are extended to the scattering of charged particles in the field of a single magnetic pole and the eigenfunctions of Dirac's equation for an electrically charged particle in a magnetic coulomb field are found.

50. Ehrenhaft F. Phys.Rev., 1946, vol.69, p.52.

HELICAL MOVEMENTS OF MATTER IN THE BEAM OF LIGHT AND THE MAGNETIC CURRENT

51. Ehrenhaft F. Phys.Rev., 1946, vol.69, p.251.

FURTHER OBSERVATIONS ON THE HELICAL MOVEMENT OF MATTER IN SUNLIGHT

52. Ehrenhaft F. Phys.Rev., 1946, vol.69, p.260.

THE CONSTANT MAGNETIC CURRENT AND HEINRICH HERTZ

53. Ehrenhaft F. Phys.Rev., 1946, vol.69, p.684.

SOME THOUGHTS ABOUT GRAVITATION OF CELESTIAL BODIES AND PHOTOPHORETIC FORCES

54. Ehrenhaft F. Phys.Rev., 1946, vol.69, p.702.

ASTROPHYSICAL PHENOMENA AND THE MAGNETIC CURRENT

55. Ehrenhaft F. Phys.Rev., 1946, vol.70, p.114.

UNIPOLAR MAGNETIC CHARGES

56. Ehrenhaft F. Phys.Rev., 1946, vol.70, p.119.

ROTATIONAL MOVEMENTS OF MATTER IN THE HOMOGENEOUS FIELDS OF MAGNETS OR OF RADIATION

57. Ehrenhaft F. Compt.Rend., 1946, vol.222, p.1345.

PHOTOPHORESIS (In French)

58. Ehrenhaft F. Compt.Rend., 1946, vol.222, p.1100.

SPIRAL MOTION IN LONGITUDINAL AND TRANSVERSAL PHOTOPHORESIS (In French)

1947

59. Durand M.E. Compt.Rend., 1947, vol.225, p.567.

ELECTROMAGNETISM - NEW REPRESENTATION AND MORE GENERAL FORM OF EQUATIONS OF CLASSICAL ELECTROMAGNETISM (In French)

60. Benedikt E.T.,Leng H.R. Phys.Rev., 1947, vol.71, No 7, p.454.

ON THE EXISTENCE OF SINGLE MAGNETIC POLES

61. Ehrenhaft F. Phys.Rev., 1947, vol.71, p.138.

SINGLE MAGNETIC POLES AND COSMIC RADIATION

62. Ehrenhaft F. Phys.Rev., 1947, vol.71, p.143.

ELECTROPHOTOPHORESIS AND ELECTRIC CHARGES SMALLER THAN THE ELECTRONIC CHARGES

63. Ehrenhaft F. Phys.Rev.,1947, vol.71, p. 480.

THE GENERAL MOVEMENT OF MATTER POSSESSING SIX DEGREES OF FREEDOM IN FIELDS IS HELICAL

64. Ehrenhaft F. Le Journal de Physique et le Radium(VIII), 1947, vol.8, p.5.

GENERAL SPIRAL MOTION OF SUBSTANCE WITH 6-DEGREES OF FREEDOM IN SOME FIELD (In French)

65. Ehrenhaft F. Compt.Rend., 1947, vol.224, p.1151.

SPIRAL MOTION OF PARTICLES IN CONSTANT UNIFORM MAGNETIC FIELD (In French)

66. Ehrenhaft F. Compt.Rend., 1947, vol.225, p.926.

MOTION OF PARTICLES IN THE UNIFORM AND HETEROGENEOUS MAGNETIC FIELD (In French)

67. Ehrenhaft F. Europische Rundschau, 1947, No 13.

MAGNETIC CURRENT (In German)

1948

68. Dirac P.A.M. Phys.Rev.,1948, vol.74, p.817.

THE THEORY OF MAGNETIC POLES

A general theory of charged particles and poles interacting through the electromagnetic field is developed using a construction with each pole terminating an unobservable string, which lines up with the singular electromagnetic equipotential surfaces. Dynamical coordinates and momenta are introduced to describe the motion of these strings.

69. Ehrenhaft F. Acta Physica Austriaca,1948, vol.2, p.187.

HELICAL PATHS IN LONGITUDINAL AND TRANSVERSAL PHOTOPHORESIS, AND ABOUT BROWNIAN MOVEMENTS. THE UNIPOLAR MAGNETIC CHARGE.

70. Ehrenhaft F., Herzog R.F.K. Compt.Rend., 1948, vol.227, p.626.

ON THE INFLUENCE ON THE RADIATION OF UNIFORM AND LONGITUDINAL MAGNETIC FIELD (In French)

71. Harish-Chandra. Phys.Rev., 1948, vol.74, p.883.

MOTION OF AN ELECTRON IN THE FIELD OF A MAGNETIC POLE

The electron in the field of a magnetic pole is shown to have no bound states.

72. Schelding J.A. Compt.Rend., 1948, vol.227, p.470.

THE MOVEMENT OF SMALL Fe-PARTICLES HAVING SIX DEGREES OF FREEDOM IN THE AIR AROUND A WIRE CARRYING A CONSTANT ELECTRIC CURRENT (In French)

See

1949

73. Ehrenhaft F., Herzog R.F.K. Compt.Rend., 1949, vol.228, p.550.

ON THE INFLUENCE OF UNIFORM AND LONGITUDINAL FIELD ON THE RADIATION FROM RADIOACTIVE PREPARATION (In French)

74. Ehrenhaft F., Reeger E. Compt.Rend., 1949, vol.228,p.170

ON PHOTOPHORESIS AND SUN-LIGHT EFFECT,CAUSING ROTATION OF SUBSTANCE IN VACUUM (In French)

75. Ehrenhaft F., Reeger E. Compt.Rend., 1949, vol.229, p.51

ON PHOTOPHORESIS AND SUN-LIGHT EFFECT, CAUSING ROTATION OF SUBSTANCE IN VACUUM (In French)

76. Ehrenhaft F. Phys.Rev., 1949, vol.75, p.1334.

FURTHER EXPERIMENTAL PROOFS OF PROOF OF THE EXISTENCE OF SINGLE MAGNETIC POLE

77. Ehrenhaft F. Phys.Rev., 1949, vol.75, p.1628.

NEW PHENOMENA OF RADIATION IN MAGNETIC FIELDS

78. Eldridge J.A. Phys.Rev., 1949, vol.75, p.1614.

STRINGS,POLES, NAD THE ELECTRON

Dirac's treatment of magnetic poles with strings and single poles are compared. For an electron in the field of two magnetic poles the correct value of the electron spin is obtained if the charge spends only half its time between the poles.

79. Saha M.N. Phys.Rev., 1949, vol.75, No 12, p.1968.

NOTE ON DIRAC'S THEORY OF MAGNETIC POLES

Dirac's result $e_o g_o = \hbar c/2$, where e_o is the elementary electric point charge and g_o the elementary point magnetic pole, is obtained from classical electrodynamics and quantum mechanics.

80. Schedling J.A. Phys.Rev., 1949, vol.76, p.843.

THE MOVEMENT OF SMALL METAL PARTICLES HAVING SIX DEGREES OF FREEDOM IN AIR AROUND A WIRE CARRYING A CONSTANT ELECTRIC CURRENT

81. Wilson H.A. Phys.Rev., 1949, vol.75, p.309.

NOTE ON DIRAC'S THEORY OF MAGNETIC POLES

Dirac's result $e_o g_o = \hbar c/2$, where e_o is the elementary point charge and g_o the elementary point magnetic pole, is obtained from classical electrodynamics and quantum mechanics.

1950

82. Blaha F. Proc.Phys.Soc., London, 1950, vol.63, p.12.

ON MOVEMENTS OF SMALL FERROMAGNETIC PARTICLES IN INHOMOGENEOUS MAGNETIC FIELDS

83. Blaha F. Z. für Naturforschung, 1950, vol.5a, p.233.

ON THE METHOD OF A THREE-DIMENTIONAL IMAGE OF MOVEMENT OF MAGNETIC LINES OF FORCES (In German)

84. Blaha F. Electrotechn.Z., 1950, vol.71, p.581.

ON MAGNETOPHOTOPHORESIS (In German)

85. Ehrenhaft F., Reeger E. Compt.Rend., 1950, vol.230, p.938.

ON PHOTOPHORESIS AND SUN-LIGHT EFFECT, CAUSING ROTATION OF SUBSTANCE IN VACUUM (In French)

86. Ehrenhaft F., Desoyer K.V. Compt.Rend., 1950, vol.230, p.1654.

ON PHOTOPHORESIS AND SUN-LIGHT EFFECT,CAUSING ROTATION OF SUNSTANCE IN VACUUM; THE INFLUENCE OF UNIFORM MAGNETIC FIELD

87. Ehrenhaft F., Reeger E. Compt.Rend., 1950, vol.231, p.541.

ON PHOTOPHORESIS AND SUN-LIGHT EFFECT,CAUSING ROTATION OF SUBSTANCE IN VACUUM (In French)

88. Ehrenhaft F. Elektrotechn. Z., 1950, vol.71, p.656.

ON SEPARATE NORTH AND SOUTH MAGNETIC POLES, PHOTOPHORESIS AND SOME CONCLUSIONS (In German)

89. Ehrenhaft F. Acta Physica Austriaca, 1950, vol.4, p.118.

ON PHOTOPHORESIS AND LIGHT INFLUENCE CAUSING SUBSTANCE ROTATION IN VACUUM (In German)

90. Ehrenhaft F., Herzog R.F.K., Higatsberger M.J., Viehböck F.P., Weinzierl P.M. Acta Physica Austriaca, 1950, vol.4., p.129.

NEW CHARGES IN MAGNETIC FIELDS (In German)

91. Ferber J.A. Acta Physica Austriaca, 1950, vol.4, p.133.

ON MOTION OF A 10^{-4}- 10^{-5} cm METAL SAMPLES IN A HOMOGENEOUS FIELD OF A PERMANENT MAGNET AT INSTANT SWITCHING OFF THE LIGHT; MAGNETIC FLASH (In German)

92. Fermi E. Conferenze Di Fisica Atomica, Roma, 1950.

DIRAC MONOPOLE (In Italian)

See

93. Schedling J.A. Acta Physica Austriaca, 1950, vol.4,p.98.

ON REPETITION OF ORSTED EXPERIMENT, USING METAL SAMPLES WITH SIX DEGREES OF FREEDOM INSTEAD OF A MAGNETIC NEEDLE (In German)

94. Bauer E. Proc. Cambridge Phil.Soc., 1951, vol.47,p.777.

THE ENERGY LOSS OF FREE MAGNETIC POLES IN PASSING THROUGH MATTER

The ionization produced by Dirac's free magnetic poles wit pole strengths g being an integral multiple of hc/2e = 137e/2 is calculated by the calssical impact parameter method and by perturbation theory.

95. Blaha F., Schedling. J.Appl.Phys., 1951, vol.22,p.11.

IMPROVEMENTS IN VISUAL DEPICTION OF MAGNETIC LINES OF FORCE BY MEANS OF A GAS DISCHARGE

96. Ehrenhaft F. Acta Physica Austriaca,1951, vol.5, No 1, pp.12-25.

ON PHOTOPHORESIS,MAGNETIC CHARGE AND SPIRAL MOTION OF SUBSTANCE IN FIELDS (In German)

97. Cotton E.,Tauzin P.,Tsai B. Compt.Rend., 1951, vol.232, No 1, pp.44-46.

CONCERNING TWO NOTES OF EHRENHAFT AND HERZOG. IS A UNIFORM MAGNETIC FIELD CAPABLE OF ACCELERATING RADIATION EMITTED BY RaE?(In French)

Ehrenhaft and Herzog (Compt.Rend.227,550 (1948); ibid. 227, 626 (1948) have described experiments in which a uniform magnetic field apparently favoured the passage through an Al absorber of the radiation of RaE(Bi^{210}). These authors believed that the radiation contained unit magnetic poles. The present paper describes Al absorption experiments with photographic emulsion as detecting instrument, the results of which indicate that such observations are due to bremsstrahlung.

98. Cole H.J.D. Proc.Cambridge Phil.Soc., 1951,vol.47, p.196.

THE THEORETICAL BEHAVIOUR OF A MAGNETIC MONOPOLE IN A WILSON CLOUD CHAMBER

Dirac's suggestion that the quantization of electric charge can be explained by the existence of magnetic monopoles motivated a theoretical study of the behaviour of free monopoles in a cloud chamber.

99. Ford K. and Wheeler J.A. Phys.Rev., 1951, vol.81, p.656A.

SCATTERING OF MAGNETIC POLES BY ATOMIC NUCLEI

If the nucleus is assumed to be very heavy compared to a magnetic pole which is treated relativistically by the Klein-Gordon equation then it is shown that scattering by heavy nuclei at certain universal angles is a characteristic of the magnetic pole.

100. Malkus W.V.R. Phys.Rev., 1951, vol.83.,p.899.

THE INTERACTION OF THE DIRAC MAGNETIC MONOPOLE WITH MATTER

For charged particles, of arbitrary magnetic moment, moving simultaneously in the field of the monopole and an external electric field, it is shown that the monopole can be coupled to matter with energies comparable to, but not significantly greater than, that of the chemical bond.

1952

101. Fermi E. LECTURES ON ATOMIC PHYSICS.Dirac Monopole (In Russian), Moscow, 1952, p.114.

See

(In Russian) Izd. Inostrannaya Literatura

102. Frank I.M. MEMORY OF S.I.VAVILOV. Izd. Akad.Nauk, USSR, Moscow, 1952, pp.172-192.

CHERENKOV RADIATION FOR MULTIPOLES
Magnetic pole and Magnetic Multipole Radiation

103. Melvin M.A. Phys.Rev., 1952, vol.86, p.640.

PHENOMENOLOGICAL QUANTUM ELECTRODYNAMICS WITH MAGNETIC POLES

Electrodynamics is here developed with the following generalizations: (A) The flux fields B and D are distinguished from the force fields H and E. (B) The usual restriction to the absence of free magnetic poles is not made.

104. Shanmugadhasan S. Can.J.Phys.,1952, vol.30, p.218.

THE DYNAMICAL THEORY OF MAGNETIC MONOPOLES

A reformation of Dirac's theory of electric and magnetic charges in which the field tensor is expressed in terms of two four-potentials, one corresponding to charges and the other to monopoles, and the action principle for the equations of motion is set up in terms of the two four-potentials and of the tensors dual to them. The result is a generalization of Fermi Electrodynamics with the restriction that a particle cannot have charge and be a monopole.

1953

1954

1955

1955

105. Arnowitt R., Deser S. University of California Radiation Laboratory, UCRL-274, Berkeley, 1955.

HIGH-ENERGY MULTIPLE PHOTON PRODUCTION

The multiple production of photons by fast elementary particles and magnetic monopoles coupled strongly to the electromagnetic field is treated semiclassicaly. Several cosmic ray events show that conventional electro dynamic models (including antiparticle annihilation) produce too few photons and magnetic monopoles too many, to account for observed multiplicities.

1956

106. Durand E. Compt.Rend., 1956, vol.242, No 15, p.1862.

FUNDAMENTAL EQUATIONS OF THE CLASSIC NONCONSERVATIVE ELECTROMAGNETISM

107. Ohmura T. Progr.Theor.Phys., 1956, vol.16, No 6, pp.684-686.

A NEW FORMULATION ON THE ELECTROMAGNETIC FIELD

1957

108. Borgardt A.B. Zh.Eksp. i Teor. Fiz. 1957, vol.33, No 3/9, pp.791-792.

ON THE PRINCIPLE OF LARMOR INVARIANCE
(In Russian)

109. Gautier P. Compt.Rend., 1957, vol.245, No 1, p.45.

ELECTROMAGNETISM: "General solutions of the equations of classic non-conservative electromagnetism".

An extension of general solutions of electromagnetism for the case when, inside the volume, the fields are to be calculated, exist both the electric and magnetic charges, is given. The charges can displace, disappear or be created. The presented formulae contain as a special case general solutions of Maxwell's equations given by Louis de Broglie and E. Durand.

110. Hoffman H. Acta Physica Austriaca, 1957, vol.11, No 2, pp.241-251.

ON INTERPRETATION OF MAXWELL EQUATIONS USING ELECTRIC AND MAGNETIC CHARGES
(In German)

111. Misner Ch.W., Wheeler J.A. Ann.Phys.(N.Y.),1957, vol.2, No 6, p.525.

CLASSICAL PHYSICS AS GEOMETRY

Gravitation, Electromagnetism, Unquantized charge, and mass as properties of curved empty space.

112. Nierenberg W.A. Ann.Rev.of Nuclear Science, 1957, vol.7, p.349.

MEASUMERENT OF NUCLEAR SPINS AND STATIC MOMENTS OF RADIOACTIVE ISOTOPES

p.353

The Fermi-Segre formula and the Breit-Rabi diagram. ... the hyperfine structure measurement in atoms offer a possibility to distinguish whether the magnetic moment in the proton is due to rotating charges or due to magnetic moment of two monopoles.

113. Fitz H.C., Good W.B., Kassner J.L., Ruark A.E. Phys. Rev., 1958, vol.111, p.1406.

CLOUD CHAMBER SEARCH FOR PARTICLES IONIZING LESS THAN AN ELECTRON

Ionization of charged particles which varies with the square of its charge was observed in a very clean cloud chamber. Particles with small electronic charges, ze, or relativistic magnetic monopoles were sought but no subionizers with z in the range 1/6 to 1/2 were seen.

114. Goto E., J.Phys.Soc.Japan, 1958, vol.13, p.1413.

ON THE OBSERVATION OF MAGNETIC POLES

Ferromagnetic and paramagnetic trapping of magnetic monopoles is considered.

115. University of California Radiation Laboratory , UCRL-8281, Berkeley, 1958, p.67.
PHYSICS DIVISION SEMIANNUAL REPORT FOR NOVEMBER 1957 THROUGH APRIL 1958

Nuclear emulsions were used in four fruitless attempts to detect Dirac unit magnetic poles.

116. Ramsey N.F. Phys.Rev., 1958, vol.109, p.225.

TIME REVERSAL, CHARGE CONJUGATION, MAGNETIC POLE CONJUGATION, AND PARITY

A theory which includes magnetic poles has the TCP theorem replaced by a TMCP theorem. (T-time reversal, M-magnetic pole conjugation, C-electric charge conjugation, and P-inversion of space coordinates).

117. Bradner H., Isbell W.M. Phys.Rev., 1959, vol.114,p.603.

SEARCH FOR DIRAC MONOPOLE

The upper limit for the production cross section of Dirac monopoles by 6.3-BeV protons is measured using nuclear emulsions to be less than 10^{-35} cm^2 per nucleon for poles of protonic mass.

118. Dacos F. Bull.Sci.A.I.M., 1959, No 1, pp.73-103.

ELECTRODYNAMICS OF MATERIAL BODIES

The present paper is based on the remarkable investigation carried out by L.J.Chu. On indicating the way of studying the electrolyzed particles in vacuum used both as the source of field and as the way of studying the magnetic aspect of the particle, one comes to a conception of magnetic and polarization currents. The charge displacement in vacuum is considered with making use of the Maxwell equations. After this it is possible to proceed from discrete investigation to a macroscopic one of the material medium in motion. Generalized theorem expresses explicitly the energy exchange between the field and the matter.

119. Ford K.W., Wheeler J.A. Ann.Phys. (N.Y.), 1959, vol.1, p.287.

APPLICATION OF SEMICLASSICAL SCATTERING ANALYSIS

Several different examples of scattering processes are analyzed, and for each, semiclassical approximations are discussed. The scattering of magnetic monopoles by charged particles is an illustrative example demonstrating rainbow and glory effects.

1960

120. Frank I.M. Uspekhi Fiz. Nauk, 1959, vol.68, p.397.

OPTICS OF LIGHT SOURCES MOVING IN REFRACTIVE MEDIA (In Russian)

The Nobel Lectures, 1958.

121. Katz R.,Parnell D.R. Phys.Rev., 1959, vol.116,p.236.

TWO PROPOSED EXPERIMENTS FOR THE DETECTION OF THE DIRAC MONOPOLE

The deflection of a magnetic monopole in a helium chambe subjected to an electric field would produce helical tracks whose axes are parallel to the field. The ionization of monopoles in electron-sensitive emulsions could be determined from track width.

122. Takabayasi T. Compt.Rend., 1959, vol.248, No 1, p.70.

THEORETICAL PHYSICS)SPACE EQUALITY OF ELECTRO-MAGNETIC FIELD (In French)

123. Wheeler J.A. GEOMETRODYNAMICS (In Russian), Izd. Inostrannaya Literatura, Moscow, 1959.

1960

124. Cherenkov P.A., Frank I.M., Tamm I.E. THE NOBEL LECTURES ,Fizmatgiz, Moscow, 1960, p.53.

See

125. Julier M. L'Onde electr., 1960, vol.40, p.260.

ELECTRIC WAVE: NOTES ON THE TENSOR FORM OF THE MAXWELL EQUATIONS

126. Lapidus I.R., Pietenpol J.L. Amer.J.Phys., 1960, vol.28 pp. 17-18.

CLASSICAL INTERACTION OF AN ELECTRIC CHARGE WITH A MAGNETIC MONOPOLE

The motion of a charged particle in the field of a magnetic monopole is calculated classically. The differential scattering cross section obtained in the limit of small interaction strength resembles the Rutherford cross section. A single relativistic correction is discussed.

127. Nadeau G. Amer.J.Phys., 1960, vol.28, p.566.

CONCERNING THE CLASSICAL INTERACTION OF AN ELECTRIC CHARGE WITH A MAGNETIC MONOPOLE

The shortest way to get the trajectory of a charged particle in the field of a magnetic monopole is shown to be vector methods.

128. Porter N.A. Nuovo Cimento, 1960, vol.16, p.958.

THE DIRAC MONOPOLE AS A CONSTITUENT OF PRIMARY COSMIC RADIATION

A number of effects observed in large extensive air showers, which have not been explained, could be understood if it is assumed that a very small fraction, $\sim 10^{-14}$, of all primary cosmic ray particles were Dirac monopoles.

1961

129. Amaldi E. Nuovo Cimento Suppl., 1961, vol.19, No 2, pp.101-131.

ANTI-PARTICLE

130. Amaldi E., Baroni G., Brander H., De Carvalho J., Hoffman L. Mandredini A., Vanderhaeghe G. Proc. Aix-en-Provence Conf. 1961, Centre d'Etude Nucléaires de Saclay, Seine et Oise, France, 1961, p.155.

SEARCH FOR DIRAC MAGNETIC POLES

An experiment is described using nuclear emulsion to detect magnetic monopoles which produced negative results. An upper limit is put on the production cross-section.

131. Amaldi E. Notas de Fiseka, 1961, vol.8, No 15, p.25

SEARCH FOR DIRAC MAGNETIC POLES

132. Bayle D. Compt.Rend., 1961, vol.252, No 23, p.3535.

MATHEMATICAL PHYSICS: A STUDY OF A SYMMETRIC REPRE - SENTATION OF ELECTROMAGNETISM LAWS

A relativistic symmetric representation of electromagnetic laws uses, besides the notions of electric current and magnetodynamic potential, the notions of magnetic current and electrodynamic potential, as well, which plays the role of calculation artifice. The external differential forms being associated with various quantities of representation, the harmonic form theory imply that harmonic components connecting simultaneously static and dynamic or electric and magnetic properties exist in the electromagnetic field.

133. Fidecaro M., Finocchiaro G., Giacomelli G. Nuovo Cimento, 1961, vol.22, p.657.

SEARCH FOR MAGNETIC MONOPOLES

An attempt to produce monopole-antimonopole pairs up to a monopole mass of 2.8 GeV in two counter experiments had negative results which put an upper limit of 10^{-36} cm^2 on the production cross section.

134. Volz H. Phys. Blätter, 1961, vol.17, No 2, pp.79-84.

FORMATION OF THE CONCEPT OF CLASSICAL ELECTROMAGNETICS (In German)

1962

135. Amaldi E. Uspekhi Fiz. Nauk, 1962, vol.78, No 3,p.499.

ANTI-PARTICLE (In Russian)

See

136. Bolotovsky B.M., Boronin V.S. Izvestiya Vuzov SSSR,196 ser. radiofizika, vol.5, No 5, p.1033.

ON ENERGY LOSSES OF ELECTRIC AND MAGNETIC CHARGES IN FERRODIELECTRICS (In Russian)

137. Cabibbo N., Ferrari E. Nuovo Cimento, 1962, vol.23, p.1147.

QUANTUM ELECTRODYNAMICS WITH DIRAC MONOPOLES

The extension of quantum electrodynamics to the fields o electric charge and magnetic monopoles shows that the existence of monopoles is not contradicted by the observ parity conservation (and invariance under charge conjugation) in ordinary electromagnetic processes.

138. Eliezer C.J., Roy S.K. Proc.Cambridge Phil Soc., 1962, vol.58, No 11, p.401.

THE EFFECT OF A MAGNETIC POLE ON THE ENERGY LEVELS OF A HYDROGEN-LIKE ATOM

A hydrogen-like atom in which the nucleus has both an electric charge and a pole strength is considered.

139. Katz R. Amer.J.Phys., 1962, vol.30, No 1, pp.41-44.

THE MAGNETIC POLE IN THE FORMULATION OF ELECTRICITY AND MAGNETISM

The use of the magnetic pole in the development of the concepts of electricity and magnetism leads unambiguously to a relativistic formulation of the field vectors which is well within the grasp of the sophomore student. The development is wholly consistent with Maxwell's equations and leads to clear and understandable definitions of the field vectors both in vacuum and in the material medium, as well as to the relations defining the transformations of the field vectors.

140. Kolomensky A.A. Vestnik Mosk.Univ., ser. fizika-astr., 1962, No 6, p.56.

MAGNETIC MONOPOLE EMISSION IN A MEDIUM (In Russian)

141. Leen M.W., Sugai I., Clavier P.A. Proc. IRE (Correspondence), 1962, vol.50, No 1, p.90.

PHYSICAL BASIS FOR ELECTROMAGNETIC THEORY

142. Schnupp P., Leen M.W. Proc. IRE, 1962, vol.50, No 9, pp.1990-1991.

THE MAGNETIC MONOPOLE AND THE PRINCIPLE OF PARITY

143. Wheeler J.A. GEOMETRODYNAMICS, AP New York and London, 1962, vol.1.

1963

144. Alwarez L.W., University of California, Radiation Laboratory, UCRL-476, Berkeley, 1963.

145. Alwarez L.W. University Of California Radiation Laboratory, UCRL-407, Berkeley, 1963.

146. Alwarez L. W., Watt R.W. University of California Radiation Laboratory, UCRL-479, Berkeley, 1963.

A minimum volume of n=2 was suggested also by Alwarez who started from Saho consideration (ref.): If Dirac poles have spin 1/2, the electron-pole system should be composed of two fermions and therefore n should be even, so that its minimum value should be 2.

147. Amaldi E., Baroni G., Bradner H., De Carvalho H.G., Hoffman L., Manfredini A., Vanderhaeghe G. European Organization for Nuclear Research, Nuclear Physics Division, CERN 63-13, Geneva, 1963.

SEARCH FOR DIRAC MAGNETIC POLES

A review of the experimental and theoretical work done to that time concerning the Dirac monopole. Various properties of monopoles are described and three experiments performed at CERN are discussed in detail .

148. Amaldi E., Baroni G., Bradner H., Hoffman L., Vanderhaeghe G., Manfredini A. Nuovo Cimento, 1963, vol.28, No 4, pp.773-793.

SEARCH FOR DIRAC MAGNETIC POLES

Expected properties for Dirac poles are summarized and the details of an experimental search for Dirac monopoles made at the CERN-PS are given. Upper limits for the production cross-section in proton-nucleon collisions are derived.

149. Devons S. Science Progress (Great Britain), 1963, vol.51 No 204, p.601.

THE SEARCH FOR THE MAGNETIC MONOPOLE

Experiments in search of the magnetic monopole are reviewed and the consequences of the existence of the monopole are given.

150. Ford K.W. Scientific American, 1963, vol.209, No 6, pp.122-131.

MAGNETIC MONOPOLES

A popular review of the experimental efforts made in search of the magnetic monopole, a particle predicted by conservation and symmetry principles but not yet detected.

151. Goto E. Progr. Theor.Phys., 1963, vol.30, pp.700-718.

EXPECTED BEHAVIOUR OF THE DIRAC MONOPOLE IN THE COSMIC SPACE

Dirac monopoles in space are expected to be accelerated by magnetic fields and decelerated mainly by Hubble's recession of galaxies. The average energy of cosmic monopoles is estimated to be $10^{20.4\pm1}$ev with a rather sharp differential energy spectrum. Discussions of EAS's and more extensive monopole experiments are given.

152. Goto E., Kolm H.H., Ford K.W., Phys.Rev., 1963, vo.132, pp.387-396.

SEARCH FOR FERROMAGNETICALLY TRAPPED MAGNETIC MONOPOLES OF COSMIC-RAY ORIGIN

Since magnetic monopoles should be trapped and accumulated in ferromagnetic materials, an attempt to extract them from a magnetic outcrop on the earth's surface and from fragments of s stony-iron meteorite by pulsed magnet

techniques is described. From the negative results, upper-limit monopole production cross sections in the atmosphere are estimated as a function of assumed monopole mass.

153. Harrison H., Krall N.A., Eldridge O.C., Fehsenfeld F., Fite W.F., Teutsch W.B. Amer.J. Phys., 1963, vol.31, p.249.

POSSIBILITY OF OBSERVING THE MAGNETIC CHARGE OF AN ELECTRON

The Lorentz force law and Maxwell's equations are extended to include magnetic as well as electric charges, by requiring that the equations be symmetrical in these charges. This extension predicts that the absolute magnetic charge of a particle cannot be detected.

154. Levashov A.E., Vorontsov V.I. Doklady Akad.Nauk Belorussk SSR, 1963, vol.7, No 2, pp.83-86.

"MAGNETIC CHARGES" AND DUAL COVARIANCE EQUATIONS OF ELECTRODYNAMICS (In Russian)

155. Lubkin E. Ann.Phys. (N.Y.), 1963, vol.23, No 2, p.233.

GEOMETRIC DEFINITION OF GAUGE INVARIANCE

156. Petukhov V.A., Yakimenko M.N., Nucl.Phys., 1963, vol.49, No 49, p. 87.

SEARCH FOR THE DIRAC MONOPOLE

The cross section for the production of monopoles by cosmic rays is 3×10^{-40} cm^2. A method obviating the difficulties connected with the uncertainty of its mass is presented.

157. Mergelian O.S. Dokl.Akad.Nauk Arm.SSR, 1963, vol.36, No 1, pp.17-21.

TRANSITION RADIATION OF A PARTICLE ACCOUNTING A MAGNETIC CHARGE (In Russian)

Also obtainable in English translation by as Grumen Research Department Translation TR-57.

158. Pintacuda N. Nuovo Cimento, 1963, vol.29, p.216.

DO MAGNETIC MONOPOLES VIOLATE PARITY?

A twofold meaning of parity arises from the discussion of parity conservation for magnetic monopoles and a comparison with similar classical situations. A group-theoretical method is employed to define a "weak" and a "strong" parity.

159. Purcell E.M., Collins G.B., Fujii T., Hornbostel J., Turkot F. Phys.Rev., 1963, vol.129, No 5, p.2326.

SEARCH FOR DIRAC MONOPOLE WITH 30-BeV PROTONS

A search was made at the Brookhaven alternating gradient synchrotron for magnetic monopoles produced either in collisions of 30-BeV protons with light nuclei, or by γ rays secondary to these protons in yhe Coulomb field of protons or of carbon nuclei. In the runs using 5.7×10^{15} circulating protons, no monopole-like event was found. This impies an upper limit for production in proton-nucleon int ractions of about 2×10^{-40} cm^2. Experimental limits are also derived for the photoproduction of pole pairs.

160. Tomil'chik L.M. Zh.Eksp. i Teor. Fiz., 1963, vol.44, No1 pp.160-161.

ON THE EXISTENCE OF A MONOPOLE (In Russian)

It is suggested that the Dirac monopole may be forbidden

by parity concervation in electromagnetic interactions, which may explain the megative experimental confirmation of the monopole's existence.

1964

161. Alsina F. Acta Cient. Venezolana, 1964, vol.15, No 3, pp.105-109.

ON MAGNETIC MONOPOLES (In Spain)

162. Alvarez L.W., Schwe A.J., Smits R.G., Watt R.D. University of California Radiation Laboratory, Semi-annual Report, USRL-11466, Berkeley, 1964.

163. Ferrell R.A., Hopfield J.J. Physics, 1964, vol.1, p.1.

ON THE EXOSTENCE OF MAGNETIC MONOPOLES

By the Bohm-Aharonov effect, the flux within a long slende solenoid is unobservable unless it is a multiple of hc/e. The ends of such a solenoid behave as magnetic monopoles with strength quantized according to Dirac.

164. Fierz M. Helv.Phys.Acta., 1964, vol.37, p.663.

ON ELECTRODYNAMICS (In German)

Magnetic charges do not fit into a theory in which the light quantum has a finite however small mass. Therefore, it is imposwible to find out what the properties of such systems which would have to be described by a relativistic quantum theory.

165. Finkelstein R.J. Rev.Mod.Phys., 1964, vol.36, p.632.

ELECTROMAGNETIC INTERACTIONS OF A YANG-MILLS

FIELD

A possible generic relationship between vector bosons and the photon, and the possibility of magnetic poles which, like the -mesons, may violate parity and be produced only at very high energies are examined.

166. Kronenberg S., Berthowitz A.L. U.S. Army Electronics Command, Fort Monmouth, N.J., Technical Report, 1964.

167. Lebnert B. DYNAMICS OF CHARGED PARTICLES (North Hollan Publ. Co., Amsterdam, 1964, p.32.

A charged particle is shown to move on a conical surface in the field of a magnetic monopole.

168. Okulov Yu.I. GEOMAGNETISM AND AERONOMY (Russ.), 1964, vol.IV, No 6, pp.1002-1014.

DIRAC MONOPOLE,SOME PROBLEMS OF NEUTRINO PHYSICS AND GEOPHYSICS(In Russian)

It is shown, that the Dirac monopole must be a pseudo-scalar. Electron interaction with an electromagnetic field which is created by a scalar magnetic charge is considered. From the analysis it follows, that this interaction if invariant to space reflection and scalar magnetic charge value must be smaller the electron charg This allows one to assume that neutrino has a scalar magnetic charge which is not equal to zero. It is shown that basic principles of a quaternary neutrino theory do not contradict the given hypothesis. The magnetic charge of neutrino is evaluated according to experimenta data on the value of ionization cross-section when a particle passes through a substance. Some geophysical aspects of neutrino with a magnetic charge are discussed

169. Okulov Yu.I. GEOMAGNETISM AERONOMY, 1964, vol.4, p.760

DIRAC MONOPOLE AND SOME PROBLEMS OF NEUTRINO PHYSICS AND GEOPHYSICS

Dirac's monopole is shown to be a pseudoscalar, and the interaction of an electron with an external electromag - netic field, created by a scalar magnetic charge, is studied. The interaction is shown not to be invariant with respect to space reflection and the magnitude of the scalar magnetic charge must be less than the electro charge. A neutrino which has a scalar non-zero magnetic charge is allowed by the four-component neutrino theory.

170. Okulov Yu.I. GEOMAGNETISM AND AERONOMY (Russ.), 1964, vol.IV, No 6, pp.1111-1112.

BREMSSTRAHLUNG OF A MAGNETIC SCALAR (In Russian)

171. Penney R., J.Math.Phys., 1964, vol.5, p.1431.

DUALITY INVARIANCE AND RIEMANNIAN GEOMETRY

It is shown that the postulate of indistinguishability of the Maxwell field tensor from its dual leads to the concept of the electromagnetic field tensor as a spinor component in dual space. The necessity for a duality gaug condition excludes the existence of magnetic monopoles.

172. Seyfferth S. Naturwissenschaften, 1964, vol.51, p.547.

SEARCH FOR MAGNETIC CHARGED PARTICLES

The properties of magnetic particles are discussed and an experiment to detect the magnetic charged particles is discussed.

173. Strax N. Amer. J. Phys., 1964, vol.32, p.615.

NONSYMMETRICAL PROPERTY OF MAGNETIC MONOPOLES

It is shown that the sign of a magnetic monopole can be given an absolute significance as a result of the existence of electromagnetism, the existence of parity nonconserving weak interactions, and the nonsymmetry with respect to the dimensions of time which is manifest in the second law of thermodynamics and the expansion of the universe.

174. Strax N. Amer. J. Phys., 1964, vol.33, p.102.

MAGNETIC MONOPOLES, WEAK INTERACTIONS, AND ANGULAR MOMENTUM

It is shown that if magnetic monopoles were to engage in processes fully analogous to the parity nonconserving weak interaction processes, then the sign of angular momentum vectors would acquire an absolute significance as a result of the symmetries of electromagnetic and weak interactions, and the numerical inequality of the electric charge and magnetic pole strength.

175. Tomil'chik L.M. Doklady Akad. Nauk Belor. SSR, 1964, vol.8, No 6, pp.379-381.

CONTRIBUTION TO ELECTRODYNAMICS WITH MONOPOLES (In Russian)

176. Tompkins D.R. Louisiana State Univ,, Baton Rouge, Lousiana, 1964.

TOTAL ENERGY LOSS AND CHERENKOV EMISSION FROM MONOPOLES

The Cherenkov emission and Fermi theory energy loss of monopoles passing through a permetable medium are calculated. Based on their Cherenkov emission a method of identifying fast monopoles is proposed. This method woul

1965

complement the present methods which only permit the identification of slowed down monopoles.

177. Schiff L.I. Amer.J.Phys., 1964, vol.32, No 10, p.812.

CLASSICAL EXAMPLES OF TIME REVERSAL

1965

178. Bolotowski B.M. Uspekhi Fiz. Nauk, 1965, vol.85, No 4, p.761.

SUPPLEMENT TO THE ARTICLE BY S.DEVONS "SEARCH FOR MAGNETIC MONOPOLES" (In Russian)

Also see

179. Borgardt A.A.

180. Calcin M.G. Amer.J.Phys., 1965, vol.33, No 11, pp.958-960

AN INVARIANCE PROPERTY OF FREE ELECTROMAGNETIC FIELD

In the absence of charges and currents, Maxwell's equations are invariant under the transformation $E'=E\cos\theta+B\sin\theta$ $B'=-E\sin\theta+B\cos\theta$. Using Noether's theorem, we show that the corresponding conserved qunatity is proportional to the difference in the number of right and left circularly polarized photons in the field.

181. Carrigan R.A. Nuovo Cimento, 1965, vol.38, No 1, p.638.

CONSEQUENCES OF THE EXISTENCE OF MASSIVE MAGNETIC POLES

Because of violation of CP, systems are considered which would alter existing symmetry arguments. Theoretical and experimental evidence relating to the existence of magnetic monopoles and the role of magnetic monopoles in elementary-particle structure are discussed.

182. Cavalleri G. Nuovo Cimento, 1965, vol.35, p.1236.

ON THE MOTION OF QUANTIZED ELECTRIC FLUX LINES AND NONEXISTENCE OF MAGNETIC MONOPOLES

By considering unphysical the motion of the B-lines (and therefore excluding the possibility of monopoles existing at their termini) a unique and covariant description of the motion of the E-line of a single elementary charge e is made.

183. Chen H.S.C. Amer.J.Phys., 1965, vol.33, p.563.

NOTE ON THE MAGNETIC POLE

It is shown that a semiinfinitely long solenoid produces a magnetic field similar to that of a pole, and two such long solenoids interact to give a force acting through the two poles with bo torque acting on the solenoid.

184. Devons S. Uspekhi Fiz.Nauk, 1965, vol.85, No 4, p.755.

SEARCH FOR MAGNETIC MONOPOLE (In Russian)

See

185. Dorman L.I., Okulov Yu.I. Izv.Akad.Nauk SSSR, ser. fiz., 1965, vol.29, No 10, pp.1862-1864.

MOTION OF A MAGNETIC PARTICLE IN THE EARTH'S DIPOLE FIELD (In Russian)

See

186. Dorman L.I., Okulov Yu.I. Bull.Acad.Sci., USSR, Phys.Se (USA) 1965, vol.29, p.1694.

MOTION OF A MAGNETIC PARTICLE IN THE EARTH'S DIPOLE FIELD

The motion of magnetic charge in the earth's dipole field is considered and found to be more complicated than the usual view in which it will follow the lines of force and arrive at one of the poles.

187. Dorman L.I., Okulov Yu.I. Cosmic Rays, ed.Nauka,Moscow 1965, No 7, p.178.

THE ANALYSIS OF POSSIBLE EFFECTS CAUSED BY MAGNETIC PARTICLE IN COSMIC SPACE (In Russian)

Different effects which may be caused by neutrino in cosmic space are discussed if to assume that it has a scalar magnetic charge unequal to 0. The value of the neutrino charge is evaluated by the experimental data on ionization cross-section while the particles go through the substance. The motion of the magnetic charge in the magnetic fields of different type occurri in cosmic space is considered. A solution of the proble on the motion of particles with any energy in the field of the Earth's dipole is obtained. It is shown that for low energetic particles closed trajectories are possible while moving in the dipole Earth's field. An nalysis of some experiments is made to controle this hypothesis.

188. Goldhaber A.S. Phys.Rev., 1965, vol. B140, p.1407.

ROLE OF SPIN IN THE MONOPOLE PROBLEM

The scattering of an electric charge from a magnetic monopole, which explicitly incorporates conservation of angular momentum, yields a quantized version of non-relativistic spin theory which is shown to be equivalent to the Dirac Theory based on a singular vector potential

189. Hagen C.R. Phys.Rev., 1965, vol. B140, No 3, p.804.

NONCOVARIANCE OF THE DIRAC MONOPOLE

Starting from the equations which express the divergence of the Maxwell field tensor and its dual in terms of the electric and magnetic current densities, a field theory of the Dirac magnetic monopole is constructed which is incompatible with the requirement of Lorentz invariance if the usual number of degrees of freedom of the electr magnetic field is preserved.

190. Katz E. Amer.J.Phys., 1965, vol.33, p.306.

CONCERNING THE NUMBER OF INDEPENDENT VARIABLES OF THE CLASSICAL ELECTRO-MAGNETIC FIELD

Although classical electromagnetic fields are described by six independent functions of space and time, all observable effects of these fields can be derived from five components of the stress-energy tensor. Therefore, one parameter cannot be described experimentally and must be fixed by arbitrary convention.

191. Katz R., Butts J.J. Phys.Rev., 1965, vol.B137, p.198.

WIDTH OF ION AND MONOPOLE TRACKS IN EMULSION

The widths of the ion tracks in emulsion are calculated from the assumption that a developable image is formed when the energy dosage deposited by delta rays exceeds a threshold value. The width of a monopole track is given as a function of its range.

192. Kaempffer F.A. CONCEPTS IN QUANTUM MECHANICS, Academic Press, New-York and London, 1965.
See:

193. Petukhov V. Nucleus, 1965, vol.6, No 3, pp.173-178.

DIRAC MONOPOLE (In French)

194. Schiff L.I. Uspekhi Fiz.Nauk, 1965, vol. 86, No 4, pp.756-759.

CLASSICAL EXAMPLES OF SPACE INVERSION AND TIME REVERSAL (In Russian)

195. Strax N. Amer.J.Phys., 1965, vol.33, No2, pp.102-104.

MAGNETIC MONOPOLES, WEAK INTERACTIONS, AND ANGULAR MOMENTUM

If magnetic monopoles were to engage in processes fully analogous to the parity non-consering weak interaction processes engaged in by electrically charged particles, then the sign of angular momentum vectors would acquire an absolute significance. This is a consequence of the symmetry properties of electromagnetism, the symmetry properties of weak interactions, and the inequality between the numerical value of the quantum of electric charge and the numerical value of the quantum of magnetic polestrength.

196. Tassie L.J. Nuovo Cimento, 1965, vol. 38, p.1935.

DIRAC MAGNETIC MONOPOLES AND SUPERCONDUCTIVITY

Hollow superconducting cylinders can be used to detect magnetic monopoles, even if these particles are uncharged by observing the change in the trapped flux.

197. Tomil'chik L.M. Vestsi Akad. Nauk Belor.SSR, ser. fiz.-mat., 1965, No 3, pp.138-139.

DIRAC MONOPOLE AND ISOTOPIC INVARIANCE
(In Russian)

198. Tompkins D.R. Phys.Rev., 1965, vol.138, p.248.

TOTAL ENERGY LOSS AND CHERENKOV EMISSION FROM MONOPOLES

Cherenkov emission and Fermi-theory energy loss of monopoles passing through a permeable medium are calculated. Based on Cherenkov emission, a method of identifying fast monopoles is proposed.

199. Tompkins D. Phys.Rev., 1965, vol.B140, p.443.

SECOND METHOD OF IDENTIFYING FAST MONOPOLES

Since ionization and Cherenkov emission from fast monopoles is expected to be nearly uniform, identification of monopoles by comparison of the total energy loss rate to the Cherenkov emission is proposed. This method would

complement the present methods which only permit the identification of slowed down monopoles.

200. Weinberg S. Phys.Rev., 1965, vol. 138, p.988.

PHOTONS AND GRAVITONS IN PERTURBATION THEORY:

Although the existence of magnetic monopoles is consistent with parity and time-reversal invariance, it is nevertheless impossibl to construct a Lorentz-invariant S matrix for magnetic monopoles and charges in perturbation theory.

201. Zwanziger D. Phys.Rev., 1965, vol.137, p.647.

DIRAC MAGNETIC POLES FORBIDDEN IN S-MATRIX THEORY

The residue of the one-photon exchange pole in the scattering amplitude amplitude for massive particles is calculated, using unitarity and its correspondence of particles to representations of the proper inhomogeneous Lorentz groups. Magnetic monopole coupling results in a residue which contains square-root singularities. Such a non-analytic term is incompatible with the analyticity assumption of S-matrix theory.

202. Alwarez L.W. Proposal to NASA to Search for Magnetic Monopoles in Returned Samples of Moon Surface Materail, Jan.30, 1966.

203. BERKELEY NATIONAL LABORATORY ANNUAL REPORT, Section PHYSICS,1966, BNL-994, pp.70-102.
Experimental and theoretical studies on the structure and fundamental properties of matter are described.

204. Berkowitz H., Kronenberg S. U.S. Army Electronics Command, Fort Monmouth, N.J., Technical Report, ECON-2710 ,1966, (unpublished).

DIRAC MONOPOLE SEARCH

An experiment is proposed to detect magnetic monopoles of magneti charge g=137e if production cross section is 10^{-38} cm^2.

205. Carithers W.C., Stefanski R., Adair R.K. Phys.Rev., 1966, vol.14 p.1070.

SEARCH FOR HEAVY MAGNETIC MONOPOLES

The discovery of an approach breakdown in time-reversal invariance in K_2^o decays demands further investigation into the symmet properties of the fundamental interactions. Since a simple model of electric charge and magnetic poles leads to an electrodynamics which is not time- reversal invariant, it appeared essential to extend previous investigations concerning the possible existence of magnetic monopoles to regions of higher monopole mass, and lowe production cross section. An experiment was designed to detect monopoles produced in the earth's atmosphere by the primary cosmic radiation following a method introduced by Malkus. A solenoid with a magnetic moment of 3×10^5 Am^2 was used to collect monopol moving along the earth's lines of magnetic flux and to accelerate them through scintillation counters, a spark chamber and into emulsions. The negative results of the search show that the monopole flux at the surface of the earth is less than $10^{-6}/cm^2$ year. Using for the sake of comparison a simple model of monopole production such that the cross section is constant above threshold, this resul shows that the cross section for the production of monopoles by nucleon-nucleon interactions is less than $10^{-6}(\hbar/Mc)^2$ for a monopole mass M of 15 BeV/c^2. The limit on the production of mono poles by photonucleon interactions is about 10^3 times higher. In both cases the cross-section limit varies with monopole mass approximately as $M^{3.4}$.

206. Dorman L.I., Okulov Yu.I. Izv. Akad.Nauk SSSR, ser. fiz., 1966, vol.30, No 10, pp.1590-1593.

TO THE PROBLEM OF THE DIRAC MONOPOLE (In Russian)

207. Erber T. Rev.Mod.Phys., 1966, vol.38, No 4, pp.626-659.

HIGH-ENERGY ELECTROMAGNETIC CONVERSION PROCESSES IN INTENSE MAGNETIC FIELDS

General characteristics of magnetic bremsstrahlung (synchrotron radiation) are derived on the basis of calculations utilizing exac

relativistic matrix elements. The spectral and total energy losses may be described by compact expressions incorporating radiative and quantum corrections. Comparisons of the relativ efficacy of matter and magnetic fields as bremsstranhlung radiators indicate that even under relatively conservative conditions the natural conversion rates associated with the magnetic process (i.e., 9×10^3 BeV/mm) tends to favour this type of conversion over ordinary bremsstrahlung. Discussions of a similar scope-including detailed calculations, and comparisons with the corresponding processes in material media - are also carried out for magnetic pair production, direct and indirect trident cascades, and magnetic photon splitting. Circumstances peculiar to a class of external field radiative processes involving cooperative vacuum polarization corrections are illustrated by a discussion of magnetic Cherenkov radiation.

208. Ferrell R.A. University of Maryland, Tech.Report No 605, 1966.

MASS DEPENDENCE DISCONTINUITY IN THE MAGNETIC MONOPOLE STRENGTH

The limiting case of an infinite mass magnetic monopole gives the Dirac strength, while the Schwinger finite mass monopole gives strengths twice as large.

209. Fröhlich H. Progr.Theor.Phys., 1966, vol.36, No 3, pp.636-647.

GENERATION OF DUAL TRANSFORMATION THROUGH FIELDS IN ELECTRODYNAMICS

It is shown that a 4 dimensional integral in an infinitesimal region over a quantity closely connected with (H,E) generates dual transformations of electromagnetic fields H,E. The generator is of a non-local nature and has integer eigenvalues which constitute a new property of the electromagnetic field. Generators of translations previously presented in the Yukawa

memorial issue have been found to require modification. They now have also the form of 4 dimensional integrals in an infinitesimal region.

210. Greisen K. Proceedings of the ninth International Conf., on Cosmic Rays, London, 1965. Published by the Institute of Physics and the Physical Society, 1966, vol.2, pp.609-615.

HIGHLIGHTS IN AIR SHOWER STUDIES, 1965

The present review of research on extensive air showers focuses its attention on new approaches in those problem areas which seem of major import to the author. First considered are new means of resolving the detailed structure and variability of the showers, properties which reveal indirectly the physics of high energy particle behaviour and the composition of primary cosmic rays. Secondly, brief note is made of the current state of the search for anisotropy in the primary flux. The third topic is the investigation of high-energy primary gamma radiation. Fourthly, attension is called to the recent success in detecting shower by radio methods. Finally, new attacks are described on the extension of knowledge of the primary spectrum to further extremes of energy. The article closes by mentioning some curious phenomena that may be expected at very high energies, and suggesting fundamental limitations that may either prevent the particle spectrum from extending much beyond loo joules, or make the finding of such particles to be of impressive significance.

211. Hague M.B. J. Natural Sci. Math., 1966, vol.6, p.41.

CLOUD CHAMBER SEARCH FOR SUB-IONIZING PARTICLES

A search of relativistic sub-ionizing particles, either free magnetic poles or relativistic charged particles, produced by a radioactive source and detected by a cloud chamber produced five tracks.However, it was not determined that any of the tracks was produced by a new particle.

212. Jackson J.D. CLASSICAL ELECTRODYNAMICS, ed.Willey, New York, 1966.

ON THE QUESTION OF MAGNETIC MONOPOLES

See ref.

213. Kursunoglu B. Third Coral Gables Conference on "Symmetry Principles at High Energy", Miami, ed. by Perlmutter A.,a.o. San Francisco and London, 1966, pp.60-74.

SPACE-TIME SYMMETRIES, SPACE-TIME U(3,3) AND MAGNETIC CHARGE

214. Linson L., Pagels H. Ann.Phys., 1966, vol.38, No 2, pp.363-374.

TOPOLOGY OF NULL LINES

We show that for null lines along which both $e \cdot h=0$ and $e^2-h^2=0$ the periodicity conditon on the complexion vector is $\oint \alpha \cdot dx = \pi n$ where the closed circuit is about the null line. The same periodicity condition holds for a multiply-connected Rainich-Riemannian geometry indicating that topologically distinct paths are connected with the occurrence of null lines. In spite of the periodicity of the complexion being πn instead of $2\pi n$ it is possible to construct unique electromagnetic fields from the geometry. We have e examined several examples of static configurations of electric and magnetic poles and find no way of ruling out the existence of magnetic poles on a geometrical basis. It is conjectured that the existence of closed null lines on a space-like hypersurface implies the presence of electric or magnetic fluxes trapped in the topology and furthermore that if there is no line on a space-like hypersurface for which the field is null then not both electric and magnetic fluxes can be trapped in the topology on that hypersurface.

215. Mirman R. Amer. J. Phys., 1966, vol.34, No 1, pp.70-71.

MAGNETIC MONOPOLES AND INVARIANCE

216. Pearl J. Electronics, 1966, vol.39, No 12, pp.100-105.

VORTEXES ARE CREATING A STIR IN THE SUPERCONDUCTOR FIELD

Researches are developing new types of memories, transfermers and logic devices by controlling the magnetic-field penetration of superconductors.

217. Rohrlich F. Phys.Rev., 1966, vol.150, p.1104.

CLASSICAL THEORY OF MAGNETIC MONOPOLES

The field equations and the particle equations for a classical system of n electric and n* magnetic point charges are obtained by postulating duality invariance and coherence with the theory of only electric point charges. The particle equations together with the solutions of the field equations yield the (generalized) Lorentz-Dirac equations including radiation reaction.

218. Rosenbaum D. Phys.Rev., 1966, vol.147, pp.891-895.

PROOF OF THE IMPOSSIBILITY OF A CLASSICAL ACTION PRINCIPLE FOR MAGNETIC MONOPOLES AND CHARGES WITHOUT SUBSIDIARY CONDITIONS

A proof is given that an action principle exists for the classical electromagnetic field when its sources are both charged particles and magnetic monopoles unless the condition that charges never touch magnetic monopoles, which is not derivable from the action principle, is assumed.

219. Salam A. Phys.Letters, 1966, vol.22, p.683.

MAGNETIC MONOPOLE AND TWO PHOTON THEORIES OF C-VIOLATION

A modification of the magnetic monopole theory which implies the existence of a second "photon" could be used to incorporate a possible C-violation of electromagnetic interactions.

220. Sandars P.G.H. Contemporary Phys., 1966, vol.7, p.419.

MAGNETIC CHARGE

The evidence concerning the existence of magnetic charge is examined. Although its discovery would cause considerable difficulty in theoretical physics, no theoretical argument against its existence has been asserted.

221. Schiff L.I. Phys.Rev.Lett., 1966, vol.17, No 13, pp.714-716.

QUARKS AND MAGNETIC POLES

It is argued that if the Dirac magnetic monopole has a finite size R, the consequent quantization of charge applies only to the total charge of all particles within a distance R of each other. Then if quarks carry third - integral charge and R is of order of a classical hadron radius, quarks can move freely within hadrons but cannot escape as individuals.

222. Schiff L.I. Inst. of Theor. Physics, Dept. of Physics, Stanford Univ., ITP-239, 9/66, Stanford, California, 1966.

QUARKS AND MAGNETIC POLES

See ref.

223. Schwinger J. Phys.Rev., 1966, vol.144, No 4, pp.1087-1093.

MAGNETIC CHARGE AND QUANTUM FIELD THEORY

A quantum field theory of magnetic and electric charge is constructed. It is verified to be relativistically invariant in consequence of the charge quantization condition $eg/hc=n$, an integer. This is more restrict than the Dirac's condition, which would also allow half-integral values.

224. Schwinger J. Third Coral Gables Conference on "Symmetry Principles at High Energy", Miami, ed. by Perlmutter A., a.o., San Francisco and London, 1966, pp.233-248.

MAGNETIC CHARGE AND QUANTUM FIELD THEORY

see ref.

225. Schwinger J. Phys.Rev., 1966, vol.151, p.1048.

ELECTRIC- AND MAGNETIC-CHARGE RENORMALIZATION.I

An important question in the field theory of electric and magnetic charge is the relative renormalization. A general view of renormalization, as a scale change introduced in proceeding from the field to the particle level of description, indicates the universality of charge renormalization.

226. Schwinger J. Phys.Rev., 1966, vol.151, pp.1055-1057.

ELECTRIC- AND MAGNETIC-CHARGE RENORMALIZATION. II

Further evidence for the universality of charge renormalization is derived by examining the photon radiation and the static interaction of prescribed transverse currents.

227. Schwinger J. Phys.Rev., 1966, vol.152, p.1219.

PARTICLES AND SOURCES

It is proposed that the phenomenological theory of particles be based on the nsource concept, which is abstracted from the physical possibility of creating or annihilating any particle in a suitable collision.

228. Tevikyan R.V. Sov.Phys.- English Transl.: JETP, 1966, vol.23., p.606.

QUANTUM THEORY OF A PARTICLE WITH ELECTRIC AND MAGNETIC CHARGES

The quantum theory of a spinor particle with electric charge e , scalar magnetic charge g, intrinsic magnetic moment

e/2m, and intrinsic electric moment g/2m is investigated The scalar magnetic charge results in nonconservation of the P and T.

229. Teviakyan R.V. Zh. Eksp. i Teor.Fiz., 1966, vol.50, No 4, pp.911-914.

QUANTUM THEORY OF A PARTICLE WITH AN ELECTRIC AND MAGNETIC CHARGE

Quantum theory of a spinor particle which simultaneously possesses an electric charge e and magnetic charge g is investigated. In this case the particle has a proper magnetic moment e/2m and the electric moment g/2m, the magnitudes of the electric and magnetic charges being arbotrary. Due to the presence of a scalar magnetic charge in the particle P and T-parities are violated.

230. Tevikyan R.V. Zh. Eksp. i Teor. Fiz., 1966, vol.51, No 3(9), pp.791-794.

DUAL INVARIANCE IN QUANTUM ELECTRODYNAMICS

The interaction between a spinor particle with the electric and magnetic charges with electromagnetic field is considered. If it be assumed that the wave-function of the particle is related to the electron wave-function via dual rotation, it follows that quantum electrodynamics is dually invariant. This signifies that the particlr electric and magnetic charges are unobservable quantities. Experimentally only the sum of the squares of the electric and magnetic charges can be measured. If the charges are scalar then P and T parities also cannot be observed separately. Only C nnd PT have a physical meaning. Consequences of the assumption that an intermediate boson posseses definite equal values of the electric and magnetic charges are considered.

Kovashov A.E.

231. Vorontsov V.I. Izvestia Vuzov SSSR, ser. fiz., 1966, No 1, pp.68-74.

VARIATIONAL PRINCIPLE IN DUAL RELATIVISTIC ELECTRODYNAMICS (In Russian)

Relativistic electrodynamics is supplemented with a "field-current equivalence principle" generalizing Liava principle, which is widely used in radio-physics. With this the demand of the Lagrange function invariance concerning both Lorentz transformations and dual transformations which generalize Larmour-Pistolcorse principle of duality is achieved.

232. Wentzel G. Suppl. Prog. Theor. Phys., (Kyoto), 1966, vol. 37-38, pp.163-174.

COMMENTS ON DIRAC'S THEORY OF MAGNETIC MONOPOLES

Dirac's modified field-vector potential relation is discussed and elaborated in various directions, e.g., to include the case of a monopole wave-packet. A way to incorporate monopoles into Tomonaga's quantum-electrodynamics is pointed out. Contributions from virtual pole-antipole pairs are discussed with the use of duality aspects.

233. Yan Tung-Mow. Phys.Rev., 1966, vol.150, No 4, pp.1349-1351.

MAGNETICALLY CHARGED FIELDS WITH INTEGER SPIN

Schwinger's field theory of magnetic charge is extended to the case of charged fields with spin 0 or 1. A double limiting process is employed in redefining the energy densities of the charged fields in order to satisfy relativistic invariance.

234. Zumino B. STRONG AND WEAK INTERACTIONS-PRESENT PROBLEMS, Proceedings of Int. School of Physics, "Ettore Majorana", Italy, 1966. Ed. Zichichi, N.Y., 1966, vol.6, pp.711-773.

RECENT DEVELOPMENT IN THE THEORY OF
MAGNETICALLY CHARGED PARTICLES

A review of the theory of magnetic monopoles and relativistic theory of the interaction between electrically and magnetically charged particles is given.

1967

235. Barut A.O. and Kleinert H. Proceedings of the Fourth Coral Gables Conference on Symmetry Principles at High Energies, ed.by A. Perlmatter and B.Kursunoglu, Freeman, San Francisco and London, 1967, pp.76-105.

THE SOLUTION OF RELATIVISTIC DISCRETE MASS PROBLEM WITH INTERNAL DEGREES OF FREEDOM AND FURTHER DEVELOPMENTS

236. Carstoiu J. Compt.Rend.,Acad.Sci., 1967, vol.265, No 16, pp.833-836.

ELECTRODYNAMICS: MOVEMENT OF PARTICLES HAVING MAGNETIC CHARGE IN ELECTROMAGNETIC FIELD

237. Dorman L.I., Okulov Yu.I. Geomagnetism and Aeronomy (Russ.), 1967, vol.7, No 1, pp.173-174.

MAXIMUM ENERGY OF MONOPOLE IN THE FIELD OF THE EARTH'S MAGNETIC DIPOLE
(In Russian)

238. Dorman L.I., Okulov Yu.I. Geomagnetism and Aeronomy (Russ.), 1967, vol.7, No 2, pp.269-277.

MONOPOLE MOTION IN THE MAGNETIC DIPOLE FIELD
(In Russian)

It is shown, that the theory of the magnetic charge motion in a dipole field differs essentially from the same problem for electric charges. In particular, the notion of hardness of cutting-off and the Shtermer cone do not have sense for monopole. An allowed cone

is introduced for magnetic particles. The function of magnetic charge distribution in a dipole field is found.

239. Dowker J.S., Roche J.A. Proc.Phys.Soc., 1967, vol.92, p.1.

THE GRAVITATIONAL ANALOGUES OF MAGNETIC MONOPOLES

The analogy between gravitation and electromagnetic theory is used to obtain, for linearized gravitation theory, an analog of the magnetic monopole, which yields a quantization of mass. If an analogy between spin and charge is made Einstein's theory must be modified to obtain an analogue of the magnetic monopole.

240. Epstein K.J. Phys.Rev.Lett., 1967, vol.18, No 7, pp.255-256.

GENERALIZATION OF ELECTROMAGNETIC POTENTIALS

A restricted generalization of the vector potential $\vec{A}$ and the scalar potential φ is demonstrated for the cases where $\nabla \cdot B \neq 0$.

241. Green P.J., Tompkins D.R., Williams R.E. Bull.Am.Phys. Soc., 1967, ser. II, vol.12, No 2, p.190.

SEA-LEVEL COSMIC-RAY SEARCH FOR FAST SMALL-POLE STRENGTH MAGNETIC CHARGES

See ref.

242. Green P.J. II, Louisiana State University and Agricultural and Mechanical College, 1967, (Ph.D.Thesis).

SEA-LEVEL COSMIC-RAY SEARCH FOR FAST SMALL-POLE STRENGTH MAGNETIC CHARGES

The Cherenkov emission for a fast magnetic charge is enhanced by the medium's refractive index squared relativ to that for a similar pole strength electric charge, whereas the ionization energy loss is expected to be the same. This technique was used in an experiment which yielded an upper limit on the flux of magnetic charges 4.0×10^{-6} cm^{-2} sec^{-1} ster^{-1}.

243. Kaempffer F.A. CONCEPTS IN QUANTUM MECHANICS (In Russia English Transl., ed. MIR, Moscow, 1967, pp.203-205.

See ref.

244. Kolm H.H. Phys.Today, 1967, vol.20, No 10, p.69.

SEARCH FOR MAGNETIC MONOPOLES IN DEEP-SEA SEDIMENT

A portable 170-kG pulsed magnet was used to extract monopoles from deeo-sea sediment. No particles were found corresponding to the monopoles predicted by Dirac.

245. Lehnert B. DYNAMICS OF CHARGED PARTICLES (In Russian) English Translation. Atomizdat, Moscow, 1967, pp.42-44.

See ref.

246. Leiter D.J. Bull.Amer. Phys. Soc., 1967, vol.12, No 7, p.1056.

CLASSICAL ELECTRODYNAMICS THEORY OF ELEMENTARY MEASUREMENT

A classical relativistic theory of electrodynamics is developed where the absolute concept of an elementary particle is replaced by the operational concept of elementary measurement. Maxwell's equations are reinterpreted as identities within the context of the theory. The relantionaship of this theory to a wave mechanical version of it will be briefly discussed and a consistent generalization of it to include the presence of magnetic monopoles will be exhibited. The implications of this approach in regard to the existence or non-existence of magnetic monopoles are developed.

247. Maltsev V.M. HIGH ENERGY PHYSICS, ser. sci.-pop. bookle fiz.-astr., Izd. ZNANIE, Moscow, 1967, No 9, pp.54-61.

DIRAC MONOPOLE

248. Mcintosh H.V. Bull.Amer.Phys.Sic., 1967, vol.12, No 5, p.699.

DEGENERACY OF THE MAGNETIC MONOPOLE

The Schrödinger equations for most of the soluble problems of quantum mechanics show accidental degeneracy far beyond that required by their geometrical symmetry, which is spherical for central force problems. The H atom and harmonic oscillator are the best known examples of this phenomenon, O_4 occurring as a dynamical symmetry group in the first case, SU_3 in the second. These two groups are latent symmetry groups for all three-dimensional single-particle systems. In the presence of magnetic fields it is necessary to couple geometrical symmetry transformations with gauge transformations, leading to modified symmetry operators and conservation laws which take the field into account. The motion of a charged particle in the field due to a magnetic monopole examplifies such problems; moreover the field of a charged monopole provides bound states which are accidentally degenerate for certain force laws. Even in the absence of degeneracy the spectrum shows a multiplet structure which owes its existence to an SU_3 group.

249. Peres A. Phys.Rev. Letters, 1967, vol.18, pp.50-51.

SINGULAR STRING OF MAGNETIC MONOPOLES

The significance of the "string" attached to the Dirac magnetic monopole is reviewed and the mechanism proposed by Schiff, to explain the absence of free quarks in nature, is shown to be invalid.

250. Potupa A.S., Strazhev V.I. Tomilchik P.M. Lab.of Theor. Phys., Inst. of Phys., Acad. of Science Belorussk. SSR, Minsk, 1967.

DUAL INVARIANCE IN ELECTRODYNAMICS
(In Russian)

An attempt is made to perform successively a group inter-

pretation of the dual invariance in electrodynamics and to consider this symmetry in conformity with some concrete problems to ground quantum electrodynamics.

251. New Scientist, 1967, vol.33, No 534, p.413.

QUARKS AND ISOLATED MAGNETIC POLES

252. Schiff. Phys.Rev., 1967, vol.160, p.1257.

QUARKS AND MAGNETIC POLES

A mechanism is proposed for the apparent ability of quarks to move freely within hadrons even though individual quarks have not been observed. The mechanism is based on Dirac's use of a magnetic pole to account for charge quantization. Such a pole should have some finite size R, and then quantizes only the total charge of all particles within a distance R of each other.

See ref.

253. Schwinger J. Uspekhi Fiz. Nauk, 1967, vol.91, No 1, pp.49-59.

RELATIVISTIC QUANTUM FIELD THEORY
(In Russian)

254. Taylor J.G. Phys.Rev.Letters, 1967, vol.18, p.713.

NONCLASSICAL THEORY OF MAGNETIC MONOPOLES

A strictly nonclassical model of magnetic monopoles, which may be used to violate CP invariance, and makes monopoles far more invisible than expected is presented.

255. Taylor J.G. Preprint Oxford University, 1967.

QUARKS AND MAGNETIC MONOPOLES

256. Tevikyan R.V. Izv.Akad.Nauk Arm.SSR, Ser.Fiz., 1967, vol.2, p.3.

INVARIANT THEORY OF INTERACTION WITHOUT POTENTIALS (In Russian)

Without using potentials, a system of scalar particles interacting by the Yang-Mills fields is investigated assuming that each particle has electric and magnetic charges. A quantum electrodynamics with magnetic monopoles is constructed, and the electromagnetic interaction of the charged vector boson is investigated.

257. Tevikyan R.V. Nucl.Phys., 1967, vol. B1, p.79.

QUANTUM ELECTRODYNAMICS WITH MAGNETIC MONOPOLES

Dirac has considered the possibility of building quantum mechanics with a magnetic monopole, but is is shown that Dirac's theory does not describe a magnetic monopole, so a quantum electrodynamics with a magnetic monopole is constructed.

258. Veselago V.G. Zh. Eksp. i Teor. Fiz., 1967, vol.52, No 4, pp.1025-1026.

ELECTRODYNAMIC PROPERTIES OF A MIXTURE OF ELECTRIC AND MAGNETIC CHARGES (In Russian)

It is shown that a set of magnetic monopoles may possess at low frequencies a negative magnetic permeability. A mixture of a gas-plasma and such monopoles may also possess a negative value of the dielectric permitivity. It is shown that in such a mixture light pressure is replaced by light attraction.

259. Yan T.M. Phys.Rev., 1967, vol.155, p.1423.

MAGNETIC CHARGE AND GENERAL RELATIVITY

The compatibility of the magnetic charge concept with

general relativity is examined, using Schwinger's field theory of magnetic charges and his formulation of the quantized gravitational field.

260. Yan T.M. Phys.Rev., 1967, vol.160, p.1182.

CLASSICAL THEORY OF MAGNETIC CHARGE

A classical theory of magnetic charge is formulated on the basis of an action principle. It is an extension of Schwinger's quantum theory of magnetic charge to the classical level.

261. Amaldi E. OLD AND NEW PROBLEMS IN ELEMENTARY PARTICLES, Vol. dedicated to G.Bernardini ,Academic Press, New-York, 1968, pp.1-61.

ON THE DIRAC MAGNETIC POLES

Predicted properties of monopoles are summarized, experiments described and Dirac's theory reviewed.

262. Amaldi E. A COLLECTION TO G.BERNARDINI'S SIXTIETH ANNIVERSARY (In Russian). Izd. INOSTRANNAYA LITERATURA, Moscow, 1968.

263. Burguladze A.A., Mamidzhanyan E.A.,Ashton F., King J., Smit N.I. Report at the All-Union Conf. on Cosmic Ray Physics, Tashkent ,1968.

SEARCH FOR MAGNETIC MONOPOLES IN COSMIC RAYS (In Russian)

264. Calcin M.G. Phys.Lett., 1968, vol.28A, No 1, p.45.

GENERALIZATION OF THE DIRAC'S RELATION BETWEEN THE ELECTRIC AND MAGNETIC CHARGE CTRENGTHS

A generalization of Dirac's relation between the electric and magnetic charge strengths invariant under duality transformations is obtained.

265. Coombes Ch.A. Can.J.Phys.,1968, vol.46, No 8, pp.929-933.

ELECTRODYNAMICS WITHOUT POTENTIALS

By ascribing a mass to the photon a Lagrangian formulation of electrodynamics is obtained without the use of potentials. In the limit of the mass going to zero the standard results of electrodynamics are obtained. A unique method for calculating the commutator for an electron and a magnetic monopole also results.

266. Domogatski G.V., Zheleznykh I.M. Report at the All-Union Conference on Cosmic Ray Physics, Tashkent, 1968.

HOT MODEL OF UNIVERSE AND MAGNETIC CHARGE PROBLEM (In Russian)

267. Engels S. Priroda (Russ.), 1968, No 3, p.125.

DO MAGNETIC CHARGED PARTICLES EXIST? (In Russian)

268. Hurst C.A. Ann. Phys. (N.Y.), 1968, vol.50, pp.51.

CHARGE QUANTIZATION AND NONINTEGRABLE LIE ALGEBRAS

The Schrödinger equation for the motion of an electric charge in the field of a magnetic monopole is examined to see how the quantization of the interaction constant follows from the requirement of rotational invariance.

269. Hurst C.A. Proceedings of the Fifth Coral Gables Conference on Symmetry Principles of High Energies, University of Miami, 1968, edited by A. Perlmutter, C. Anglas Hurst, and B. Kursunoglu, Benjamin, New York, 1968, pp.105-113.

CHARGE QUANTIZATION AND NON-INTEGRABLE LIE ALGEBRAS

See ref.

270. Jehle H. HIGH ENERGY PHYSICS AND FUNDAMENTAL PARTICLES, Lectures in Theoretical Physics, vol.XB, Eds. Asim O. Baru and Wesly E. Brittin, 1968, pp.673-684.

FLUX QUANTIZATION, CHARGE QUANTIZATION AND THE ELECTROMAGNETIC INTERACTION CONSTANT

271. Katsev V.P. MAGNET FOR THREE THOUSAND YEARS (In Russian Moscow, Atomizdat, M., 1968, p.72.

272. Kolm H.H. Science J., 1968, vol.4, No 9, pp.60-66.

MAGNETIC MONOPOLES

A new search is being carried out for an elementary particle which is in effect a lone magnetic pole. First predicted by Dirac, the particle has been neither observed nor explained away in three decades of effort.

273. Kukanov A.B. Optika i Spektroskopia, USSR, 1968, vol. XXIV, No 4, pp.614-616.

ON THE THEORY OF VAVILOV-CHERENKOV RADIATION DUE TO A MAGNETIC MONOPOLE (In Russian)

274. McIntosh H.V., Cisneros A. Bull.Amer.Phys.Soc., 1968, ser.II, vol.13, No 6, p.909.

MOTION OF A CHARGED PARTICLE IN THE FIELD OF A MAGNETIC MONOPOLE

The placement of a magnetic monopole at the origin of an electrostatic central force has the primary effect of confinding the motion to the surfacr of a cone, rather than a plane. In order to retain the closed orbits typical of the harmonic oscillator and Kepler problems one may postulate a centrifugal potential proportional to the square of the magnetic pole strength to retain the "accidental" degeneracy of those potentials. The Kepler motion is particularly interesting inasmuch as the particle still moves in a plane, which does not contain the attracting center. There is a conserved "total" angular momentum D, and a Runge vector based on D; together they generate an O/4/ group. Curiously, no wave functions have O total angular momentum, and the ground state is triply degenerate if one accepts Schwinger's minimum monopole rather than Dirac's. If one considers a pair of charged monopoles, each with arbitrary electric and magnetic charge, and both the repulsive centrifugal potentials, he finds the classical and quantum mechanical problems both separate in ellipsoidal coordinates. The repulsive potential is so strong that it prevents the particle from spiralling

around the magnetic field lines, while its dependence on the square of the pole strength precludes forming a magnetic dipole as a limiting case.

275. Mitchell T.P., Burns J.A. J.Math.Phys., 1968, vol.9, No 12, pp.2016-2017.

RELATIVISTIC DYNAMICS OF A POINT CHARGE IN A MAGNETIC MONOPOLE FIELD

This paper derives and interprets the constants of the charge's motion. The physical meaning of these constants and their use in discussing the over-all motion of the charge are presented.

276. Palmer R.F., Taylor J.G. Nature, 1968, vol.219, No 5158, pp.1033-1034.

MAGNETIC CHARGE OF THE PROTON AND NEUTRON

If monopoles exist with any value of magnetic charge, then the first place to search for them is in ordinary matter. The upper limits on the magnetic charge of the known elementary particles are then calculated.

277. Peres A. Phys.Rev., 1968, vol.167, No5, p.1449.

ROTATIONAL INVARIANCE OF MAGNETIC MONOPOLES

The Schwinger quantization relation for magnetic charges g=nhc/e (n integer), is derived by group-theoretical methods, from the requirements of rotational invariance and gauge invariance without resorting to "singular strings" of magnetic monopoles.

278. Porter N.A. Nature, 1968, vol.217, pp.329-331.

DIRECTED EMISSION MODEL FOR QUASARS

If the large emission of energy from quasars is assumed to be unidirectional, it is probably necessary to invoke particles such as the magnetic monopoles, to explain the acceleration of cosmic-rays.

279. Potupa A.S., Strazhev V.I., Tomil'chik L.M. Vestsi Akad. Nauk Belorussk. SSR, ser. fiz.-mat., 1968, pp.124-128.

DUAL INVARIANCE IN ELECTRODYNAMICS AS A UNITARY SYMMETRY (In Russian)

It is shown, that Maxwell-Lorentz electrodynamics assumes the existence as a symmetry group, of a one-parameter group of generalized dual transformations of the locally isomorphous U(I). Charge, density of energy field and Lorentz force are the invariants of this group. The avalability of such a group forbids the existence of two observed charges (electric and magnetic ones), and allows one to solve the known problem of inadequacy between a number of independent field components and an amount of energy-momentum tensor components of the electromagnetic field. On the possibility of the existence of a latent symmetry group which is more wide than U(I) is pointed out.

280. Potupa A.S., Strazhev V.I., Tomil'chik L.M. Vestsi Akad. Nauk Beloreussk. SSR, ser. fiz.-mat., 1968, No 2, pp.126-128

TO THE PROBLEM OF SECOND CHARGE IN DUAL-INVARIANT ELECTRODYNAMICS (In Russian)

On the basis of an operational metric form model an attempt is made to build the systems of self-consistent quantization of fields and charges in dual-invariant electrodynamics. It is managed to introduce charge quantization and to obtain the equality on modulus of the electric charges of all charged stable particles. The relation of the Dirac-Schwinger type between the values of the electric and magnetic charges appears as uncertainty relation, what, in fact, means the prohibition to monopole discovery. Fractional charges are also forbidden due to the universality of coupling constant.

281. Potupa A.S., Strazhev V.I., Tomil'chik L.M. Doklady Akad. Nauk Beloreussk.SSR, 1968, vol.12, No 8, pp.690-692.

DUAL INVARIANCE AND MINIMAL QUANTITY OF ELECTROMAGNETIC INTERACTION (In Russian)

282. Schwinger J. Phys.Rev., 1968, vol.173, pp.1536-1544.

SOURCES AND MAGNETIC CHARGE

A beginning is made on a phenomenological reconstruction of the theory of magnetic charge using the suggestion that ordinary matter is a magnetically neutral composite of magnetically charged particles that carry fractional electric charge. There is a brief discussion of such a magnetic model of strongly interacting particles, which makes contact with empirical classification schemes.

283. Strazhev V.I., Tomil'chik L.M. Vestsi Akad.Nauk Belorussk. SSR, 1968, ser. fiz.-mat., No 2, pp.102-108.

TO THE PROBLEM OF DUAL-INVARIANT ELECTRODYNAMICS

Classical electrodynamics with field magnitudes and charges which are invariant relatively to a one-parameter group of generalized dual transformations, where two types of photons and charges are possible is built. It is shown, that dual-invariance condition leads to zero equality of photon mass. A new preservation law is connected with a possibility of existence of two types of photons. Generalization of the discrete operations P,T,C,M is given. Possible consequences of the dual-invariance disturbance are discussed.

284. Taylor J.G. Lectures in Theoretical High Energy Physics, Ed. by H.H.Aly, London-New-York -Sydney, 1968, pp.25-50.

PC AND T VIOLATION

285. Usachev Yu.D. Report at the VIII-th All-Union Interuniv. Conf. on the Theory of Elementary Particles, Uzhgorod, 1968.

286. Vant-Hull L.L. Phys.Rev., 1968, vol.173, pp.1412-1413.

EXPERIMENTAL UPPER LIMIT ON THE MAGNETIC MONOPOLE MOMENT OF ELECTRONS, PROTONS, AND NEUTRONS, UTILIZING A SUPERCONDUCTING QUANTUM INTERFEROMETER

A superconducting quantum interferometer is shown to be capable of directly detecting magnetic charge. In sample gree of Dirac monopoles, div B is determined to be less than 1.2×10^{-14} $\omega b/kg$.

287. Yakimenko M.N., Petukhov V.A. THE WORLD SEEN BY A YOUNG SCIENTIST, Fiz.-mat.mekh., Izd. NAUKA, Moscow, 1968, pp.29-36.

ON THE DIRAC MONOPOLE

288. Yan T.M. Thesis, Harvard University, 1968.

289. Zrelov V.P. VAVILOV-CHERENKOV RADIATION AND ITS APPLICATION FOR HIGH ENERGY PHYSICS (In Russian), ATOMIZDAT, Moscow, 1968, part 1, p.270.

290. Zwanziger D. Phys.Rev., 1968, vol.176, pp.1480-1488.

EXACTLY SOLUBLE NONRELATIVISTIC MODEL OF PARTICLES WITH BOTH ELECTRIC AND MAGNETIC CHARGES

The quantum-mechanical problem of the interaction of two particles, each with arbitrary electric and magnetic charges is considered. The Dirac charge quantization condition causes electromagnetic interactions to be characterized by two free parameters: the electronic charge $e \sim (137)^{-1/2}$, and the electic charge of the magnetic monópole, whose absolute magnitude is not fixed and thus defined a second elementary quantum of electric charge.

291. Zwanziger D. Phys.Rev., 1968, vol.176, No 5, pp.1489-1495.

QUANTUM FIELD THEORY OF PARTICLES WITH BOTH ELECTRIC AND MAGNETIC CHARGES

The quantum field theory of particles with both electric and magnetic charges is developed as an obvious extension of Schwinger 's quantum field theory of particles with

either electric or magnetic charge. The general solution leads to the introduction of a second elementary quantum of electric charge e_z, the electric charge on the Dirac monopole, besides the first elementary charge e, the charge on the electron.

1969

292. Alwarez L.W., Eberhard P.H., Ross R.R., Watt R.D., University of California Radiation Laboratory, UCRL-19440, Berkeley, 1969.

SEARCH FOR MAGNETIC MONOPOLES IN THE LUNAR SAMPLES OF APOLLO 11

An electromagnetic search for magnetic monopoles of the minimum size predicted by Dirac or of any larger magnitude, has been performed on 8.37 kg of lunar surface material returned by the Apollo 11 crew. No monopole was found. This experiment sets new limits on the production cross section for monopoles, and on their occurrence in cosmic radiation.

293. Ashton F., Burguladze A.A., King J., Smit N.I., Mamidzhanyan . Phys. Ser. (Transl. Engl.), 1969, vol.33, pp.1658-1660.

SEARCH FOR MAGNETIC MONOPOLES IN COSMIC RAYS

294. Ashton F., Burguladze A.A., King J., Smit N.I., Mamidzhanyan Izv. Akad. Nauk SSSR, ser. fiz., 1969, vol.33, No 11, pp.1817-1819.

SEARCH FOR MAGNETIC MONOPOLES IN COSMIC RAYS
(In Russian)

See ref.

295. Barkov L.M., Martemjanov V.P., Ogurtsov V.V., Tarasenkov V.G Khakimov C.Kh. Inst. Atom. Energ., IAE-1856, Moscow, 1969.

DIRAC MONOPOLE (In Russian)

Basic properties of the Dirac monopole and the experiments on the search for monopoles at high-energy particle accelerators are discussed.

296. Barut A.O., Baiquni A. Phys.Rev., 1969, vol.184, No 5, pp.1342-1344.

THEORY OF THE RELATIVISTIC H ATOM AND POSITRONIUM

It is shown that a relativistic infinite-component wave equation correctly describes the relativistic effects in the H atom including the motion of the nucleus. An exact mass formula for the singlet $\ell = n-1$ levels of positronium is derived.

297. Barut A.O. Preprint University of Colorado, nov.1969,

PROTON FORM FACTOR, MAGNETIC CHARGES AND DYONIUM

Extensive references about magnetic charges can be found in this paper.

298. Carstoiu J. Compt.Rend., Acad.Sci., 1969, vol.269, No 18, pp.860-863.

ELECTRODYNAMICS: ON THE EXISTENCE OF A MAGNETIC CHARGE: A CURIOUS ROLE OF THE ANGLE OF SIGNAL (In French)

299. Carstoiu J. Compt.Rend., Acad.Sci., 1969, vol.269, No 22, pp.1109-1112.

GRAVITATION: ON POTENTIAL ENERGY OF TWO ELECTRIC PARTICLES: CORRECTION TO THE CLASSICAL THEORY OF RELATIVITY

300. Cherenkov P.A., Tamm I.E., Frank I.M. THE NOBEL LECTURE Fizmatizd., Moscow, 1969.

301. Coombes Ch.A. Canad.J.Phys., 1969, vol.47, No 1, pp.71-73.

PSEUDOSCALAR CHARGE DENSITY

It is shown that a true pseudoscalar charge density - a $\psi^*\psi$ which has opposite signs in two regions - can exist. This fact is accomplished by allowing a parity transformation, for which $p^*p=-1$, and by making the operation of hermitian adjoint differ by a minus sign in the two regions. The calssical explanation is ac - complished by requiring a change in the sign convention used in the two regions connected by the inversion process.

302. Dadykin V.L., Lebedev P.N. Inst.Acad.Sci., Report, USSR, 1969, No 117 .

A METHOD FOR SEARCHING FOR DIRAC'S MATHEMATICAL MONOPOLES (In Russian)

This paper discusses an idea of an experiment to search for Dirac's monopoles. If we assume that only energetic monopoles reach the Earth, and the cross-section of the catestrofic energy losses by monopoles is so small that the monopoles can't slow down in higher layers of the Earth the result of the previously papers must be revised so that the upper limit of monopoles' flux be increased In addition, these results are not free from uncertainties connected with the behaviour of monopoles slowing down in substence. Therefore an attempt to detect relativistic monopoles in cosmic rays may be of some interest. This work suggests that, detecting Cherenkov radiation of monopoles in air. The arrangement is to be placed in a salt mine at depth of more than some tens of m under-ground. A single 6 in. diameter photomultiplier views ~ 10 m^2 of area of detection; the number of photons on

a photocathode is more than 500. To distiguish monopoles from showers produced by muons the godoscope consisted of Geiger's counters for t detecting the shower sizes is used.
In addition to a pure search this arrangement can be used for the investigation of the extensive showers produced by muons.

303. Domogatskii G.V., Zheleznykh I.M. Yadern.Fiz., 1969, vol.10, pp.1238-1242.

HOT UNIVERSE MODEL AND THE DIRAC MONOPOLE PROBLEM (In Russian)

The concentration of magnetic charges is calculated in the framework of the Hot Universe model. The restrictions on the value of the monopole-antimonopole annihilation cross section and also on the mass of the monopole can be obtained by comparing the calculated concentration of the monopoles in cosmic ray with experimental data.

304. Domogatskii G.V., Zheleznykh I.M. Phys.Ser. (Engl.Transl.), 1969, vol.33pp.1635-1638.

HOT UNIVERSE MODEL AND THE DIRAC MONOPOLE

See ref.

305. Domogatskii G.V.,Zheleznykh I.M. Izvestia Akad.Nauk SSSR, ser. fiz., 1969, vol.33, No 11, pp.1792-1795.

HOT UNIVERSE MODEL AND THE DIRAC MONOPOLE PROBLEM(In Russian)

See refs.

306. Efinger H.J. Amer.J.Phys., 1969, vol.37, No 7, pp.740-741.

AN INSTRUCTIVE MODEL FOR THE QUANTIZATION OF MAGNETIC MONOPOLES

The properties of magnetic monopoles which are placed into an electric field are studied. The model is treated non-relativistically following the pattern of Landau's diamagnetism. However, the role of electricity and magnetism are interchanged. We obtain Dirac's value for the monopole strength and find that the total charge which serves as a source for the electric field is to be quantized in accordance with Dirac's prediction.

307. Efinger H.J. Bull.Amer.Phys.Soc., 1969, ser. II, vol.14, No 4, p.579.

MAGNETIC MONOPOLES

Following the pattern of Landau's theory of diamagnetism it is shown that the quantization of the electric charge and Dirac's value for the strength of hypothetically assumed magnetic monopoles can easily be derived.

308. Efinger H.J. Physica, 1969, vol.44, No 4, pp.621-622.

A NOTE ON THE QUANTUM THEORY OF ELECTRIC AND MAGNETIC CHARGES

A quantization rule for the product of electric and magnetic charges can be easily obtained from Schrödinger's equation which is solved under the condition that an electric charge is interacting with a uniform magnetic field produced by a plane sheet of magnetic charge.

309. Feld B.T. MODELS OF ELEMENTARY PARTICLES. Blaisdell publ company, Waltham, Massachusetts-Toronto-London,1969.

v ser ref.

310. Fleischer R.L., Price P.B., Woods R.T. Phys.Rev., 1969, vol.184, pp.1398-1401.

SEARCH FOR TRACKS OF MASSIVE,MULTIPLY CHARGED MAGNETIC POLES

Massive magnetic monopoles of charge $\geq \hbar c/e$ (twice Dirac's value of the minimum pole strength and half of Schwinger's) would leave tracks in natural minerals,

provided they arrive at the earth with sufficient energy. In order to test Porter's hypothesis that cosmic-ray particles of energy $> 10^{17}$ eV are (or include) magnetic monopoles, samples of mica and of obsidium have been scanned for the distinctive, long particle tracks which would have been stored over geological times. The failure to find monopole tracks sets an upper limit (90% confidence) of 1.2×10^{-19} monopoles per cm^2 sec for penetrating monopoles incident upon the earth and rules out Porter's hypothesis for the charge and mass rauge within which poles would have been detected.

311. Fleisher R.L., Hart H.R., Jacobs I.S., Price P.B., Schwarz W.M., Woods R.T., Aumento F., Goodell H.G., Proceedings of the 11-th International Conference on Cosmic Rays, Budapest, 1969, vol.3, High Energy Interactions Extensive Air Showers, pp.27-30.

SEARCH FOR COSMIC MAGNETIC MONOPOLES

A search for magnetic monopoles in nature has been made in order: 1) to try to establish whether they exist and 2) to test whether the high energy component of cosmic rays ($> 10^{17}$ eV could be cosmic monopoles. We have searched old magnetic materials from ocean bottoms for cosmic monopoles which would have been trapped after being slowed to termal velocities by the earth's atmosphere and the ocean. We have also searched old materials for tracks of energetic monopoles. From the failure to observe monopoles in the energy range up to 10^{19} eV unless the monopoles possess a mass $>$ 150 (proton masses) and a magnetic pole strength of $< \frac{1}{2}hc/e$ (i.e. half the minimum charge inferred by SCHWINGER). With this limitation the flux of monopoles onto the earth is less than 1/2 monopole/cm^2 (age of the earth).

312. Fleischer R.L., Hart H.R., Jacobs I.S., Price P.B., Schwarz W.M., Aumento F. Phys.Rev., 1969, vol.184,p.1393

1393-1394.

SEARCH FOR MAGNETIC MONOPOLES IN DEEP OCEAN DEPOSITS

High-field magnets and solid-state track detectors have been used in an endeavour to extract and observe magnetic monopoles from ferromanganese pavement that was deposited at the bottom of the North Atlantic Ocean during the last 16 million years. The failure to observe poles sets new and restrictive limits on the abundance of monopoles and upon their production cross section. For proton-nucleon are $\leq 10^{-42}$ cm^2 if the monopole mass is one proton mass mp and $\leq 2 \times 10^{-34}$cm^2 at 1000 mp Any magnetic charge up to 60 times Dirac's value of $\hbar c/2c$ could have been detected. The flux of monopoles reaching the ocean floor is less than 4×10^{-18}/cm^2 sec./$^{-1}$ at the 90% confidence level, so that no portion of the cosmic -ray energy spectrum up to $\approx 10^{19}$ eV is composed dominantly of magnetic monopoles.

313. Fleischer R.L.,.Jacobs I.S., Schwarz W.M., Price P.B., Goodell H.G. Phys.Rev., 1969, vol.177, No 5, p.2029.

SEARCH FOR MULTIPLY CHARGED DIRAC MAGNETIC POLES

A 265000 g pulsed magnet and plastic track detectors have been used to extract and observe magnetic monopoles from manganese nodules formed on the floor of the Southern Ocean. Because of their low growth rate, these nodules compress a long period of possible monopole trapping ($\approx$ 300000years) into small volumes of material, making possible in this search(an area) x (time) factor of 3×10^{14} cm^2/sec. The detector system has the merit of containing zero background, making possible a sensitivity such that any multiple of Dirac's original charge of up to 120 could have been detected. The absence of monopoles in the material searched sets new limits on the abundance of multiply-charged monopoles and of monopoles that are low massive ($> 3m_{proton}$) to have been produced in previously reported accelerator experiments. The results imply that at no energy up to at least 2×10^{17} eV are the primary cosmic rays dominantly composed of magnetic monopoles.

314. Gamblin R.L. J.Math.Phys., 1969, vol.10,pp.46-48.

COMMENTS ON THE CLASSICAL THEORY OF MAGNETIC MONOPOLES

The classical theory of electromagnetism including magnetic monopoles is formulated in terms of harmonic functions. The fac that there is no consistent action-integral formulation of the field that yields both particle and field equations for both electric and magnetic charges is discussed in detail.It is seen that a consistent formulation can be developed through an action integral, but in such a development a monopole does not have what has been considered to be appropriate interaction with either an electric charge or another monopole.

315. Ganssauge E. Phys.Blätter, 1969, vol.25, No 4, pp.157-167

MAGNETIC MONOPOLE(In German)

316. Goebel C.J. University of Wisconsin, Dept. of Phys., Wisconsin Preprint COO-232, Madison, 1969.

THE SPATIAL EXTENT OF MAGNETIC MONOPOLES

Discusses monopole sizes. Prediction. Monopole sizes.

317. Gurevich I.I., Khakimov S.Kh.,Martemianov V.P.,Mishakova A. Ogurtzov V.V., Tarasenkov V.G., Barkov L.M.,Tarakanov N.M. Inst.Atom.Energ.,IAE-1914, Moscow, 1969.

SEARCH FOR THE DIRAC MONOPOLE AT THE 70 GeV IPHE PROTON SYNCHROTRON (In Russian)

See ref.

318. Jette A.D. Amer.Math.Monthly, 1969, vol.76, No 2, pp.164-167.

THE PATH OF A CHARGED PARTICLE IN THE FIELD OF A MAGNETIC MONOPOLE

319. Kartsev V. Nauka i Zhizn (Russ.),1969, No.8, pp.61-64.

IN SEARCH FOR MONOPOLE BEAUTY (In Russian)

320. Kolm H.H. APPLICATION OF MODERN PHYSICS TO THE EARTH AND PLANETARY INTERIORS Ed.John Wiley and Sons, London, 1969, p.661.

SEARCH FOR MAGNETIC MONOPOLES

Magnetic monopoles make Maxwell's equations symmetric by providing two missing terms, magnetic charge and magnetic currer which are not seen in nature. This concise account monopole physics is presented, primarily to geologists, cosmologists, and others whose fields would be affected by the existence of magnet monopoles.

321. Lipkin H.J., Weisberger W.I., Peskin M. Ann.Phys. (N.Y.), 1969, vol.53, pp.203-214.

MAGNETIC CHARGE QUANTIZATION AND ANGULAR MOMENTUM

The motion of an electric charge in the field of a magnetic charge is solved quantum mechanically by algebraic methods which exhibit the direct relation between charge quantization and angular momentum. The Dirac quantization formula for the charges is obtained as a necessary and sufficient condition for the realization of all the observables.

322. Malvin A., Ruderman and Zwanzinger D., Phys.Rev.Lett.,1969, vol.22, No 4, pp.146-148.

MAGNETIC POLES AND ENERGETIC PHOTON SHOWERS IN COSMIC RAYS

Various anomalous high-energy pure photon showers seen in cosmic- ray emulsions are interpreted in terms of bound pole-antipole pairs. It is argued that such bound pairs are the most likely state for created monopoles.

322a Mavrychev V.S. (see 267)

323. McIntosh H.V. Amer.J. 1969, vol.37,p.1175.

THE MOTION OF A CHARGED PARTICLE IN THE FIELD OF TWO CHARGED MAGNETIC MONOPOLES

The motion of a charged particle in the field of two charged magnetic monopoles is investigated and computer programs are written to integrate the equations of motion for the problem.

324. Mukhtarov A.I. and Niyazova E.N. OPTIKA I SPEKTROSKOPIA (Russ.), 1969, vol.XXVI, No 3, pp.379-382.

TO CHERENKOV RADIATION OF THE DIRAC MONOPOLE (In Russian)

Characteristic polarization peculiarities which Cherenkov radiation particles should possess, having simultaneously the magnetic and electric moments, are considered in order to investigate the possibilities of experimental discovery of hypothetical charges, carrying the magnetic charge (monopole).

325. Murashova V.A., Petukhov V.A., Syreischikova T.I., Telnov Yu.Ya., Usachev Yu.D., Yakimenko M.N. Fiz.Inst. Akad.Nauk SSSR, Preprint -56, Moscow, 1969.

SEARCH FOR ELEMENTARY PARTICLES WITH A MAGNETIC CHARGE

326. O'Connell R.F. Lett.Nuovo Cim., 1969, vol.2, No 6, pp.221-222.

SIMPLE DERIVATION OF SCHWINGER QUANTIZATION RELATION BETWEEN ELECTRIC AND MAGNETIC CHARGES

327. Parker E. Phys.Rev., 1969, vol.188, No 5, pp.2287-2292.

FASTER-THAN-LIGHT INERTIAL FRAMES AND TACHYONS

By means of a mathematical transformation, we introduce a set of reference frames, called superluminal inertial frames, relative to which tachyons in one spatial dimension behave as ordinary particles. One-dimensional processes involving tachyons and photons can be analyzed in the new frames, and the results transformed to the subluminal frames. The mathematical symmetry or duality between subluminal and superluminal frames and particles suggests an extension of the principle of relativity, according to which the totality of physical laws ahs the same form relative to both subluminal and superluminal frames. One possible consequence of this extended principle of relativity is that charged tachyons might have properties similar to those of the magneti monopoles. Another consequence is that the cross section for the backward scattering of photons by photons should be twice as great as is predicted without taking into account tachyons. The relevance of these results to our three-dimensional world is questionable because it does not appear to be possible to extend the one-dimensional theory to three-dimensions. Photon-photon scattering experiments in vacuum can reveal unambiguously whether or not the predictions have physical relevance.

328. Parker E., Henry Norris Russel Lecture, "THE ORIGIN OF MAGNETIC FIELDS", AAAS Meeting, August 1969, N.Y., USA.

329. Potupa A.S., Strazhev V.I., Tomil'chik L.M.
Vestsi Akad. Nauk Belorussk. SSR, ser. Fiz.-mat, 1969, No 1, pp. 89-96.

TO MAGNETIC CHARGE PROBLEM IN ELECTRODYNAMICS

It is shown, that introduction of the objects of the Dirac and Schwinger monopole type is connected with the refusal from the Neutonian mechanics models of charged particles and it leads to symmetry loss which inherents to the equations for a free electrodynamic field. Magnetic charge consideration as a really existing object within the framework of Neutonian mechanics and classical field theory is not yet possible. The known ways of obtaining the

correlations eg= 1/2 nhc; eg= nhc are based on a different approach to a model choice for a magnetic charge.

330. Rabl A. Phys.Rev.m 1969, 179, No 5, pp.1363-1370.

PERTURBATION THEORY FOR MAGNETIC MONOPOLES

The Feynman-dyson perturbation theory is applied to Schwinger's model of the monopole. The propagator for photon exchange between electric and magnetic charges is found to be $D^{AB}_{\mu\nu}(k)=(k^2 + i\,e)^{-1} \times (e_{\mu\nu K}\, n^{\nu}\, k^{K})/(n\,k)$. / In the frame of quantization, $n=(0,\hat{n})$, where $\hat{n}$ is the unit vector in the direction of the singularit line/. Since the exact theory is independent of n, one might try to obtain a manifestly covariant perturbation expansion by averaging over all direction of n. Under such a procedure the Born term reproduces the known non-relativistic limit if proper care is taken of the helicity-flip phase factor.

331. Rabl A. Berkeley, California, 1969.

TOPICS IN CURRENT ALGEBRA AND ELECTROMAGNETIC INTERACTIONS

332. Ross D.K. Phys.Rev., 1969, vol.181, No 5, pp.2055-2063.

EXTENDED MAGNETIC MONOPOLES IN FIELD THEORY

A field theory of electric and magnetic monopoles which are either point of extended particles is constructe using Mandelstam's path-dependent field quantities specia-lized to stright-line paths. Restriction on the paths and form factors which are needed for self-consistency have been given. It is found that the Jacobi identity is satisfied. Schiff's selection principle for quarks, originally derived in ordinary quantum mechanics, follows easily and is thus generalized to field theory.

333. Ruderman M.A., Zwanziger D. Phys.Rev.Lett., 1969, vol.22, No 4, pp.146-148.

MAGNETIC POLES AND ENERGETIC PHOTON SHOWERS IN COSMIC RAYS

Anomalous high-energy pure photon showers seen in cosmic-ray emulsions are interpreted in terms of properties of the production of bound pole-antipole pairs. It is argued that such bound pairs are the most likely state for created monopoles.

334. Schwinger J. Science, 1969, vol.165, pp.757-764.

A MAGNETIC MODEL OF MATTER

Hadronic matter is viewed as a magnetically neutral composite of dual-charged particles that are based electrically upon a new unit of charge. A speculation probes deep within the structure of nuclear particles and predicts a new form of matter.
See ref.

335. Taylor John G. Zenith, 1969, vol.6, No 2, pp.14-16.

MONOPOLES. HOW TO DIVIDE A MAGNET INTO TWO PARTS?

336. Tompkins D.R. Bull.Amer.Phys.Soc., 1969,ser.II, vol.14, No 4, p.617.

CHERENKOV COUNTERS METHOD OF IDENTIFYING MAGNETIC CHARGE PAIR PRODUCTION

The Cherenkov emission from fast magnetic charges depends on the refractive index in a characterisitc manner which results in a characteristic pulse "ratio" from a pair of Cherenkov counters with different refractive indices. A characteristic Cherenkov pulse ratio is also found for magnetic dipole radiation. It is reasonable to expect magnetic charge pairs to rapidly recombine. Considering the production of magnetic charge pairs in Cherenkov counter targets it is shown that it should be possible to identify fast magnetic charge pairs whose laboratory lifetime is no shorter than 10^{-14}/ sec, where

$$\gamma = 1/\sqrt{1-\beta^2}$$

and where β refers to the laboratory velocity of the pair. The possibility of both monopole and dipole radiation from the magnetic charge pair is considered.

337. Wu T.T. and Yang C.N. In: PROPERTIES OF MATTER UNDER USUAL CONDITIONS. H.Mark and S.Fernbach Eds.- Interscience, 1969, New York, pp.349-354.

338. Yerlykin A.D., Yakovlev V.I. Zh.Eksp. i Teor.Fiz.,(Russ.) 1969, vol.56, No 6, pp.1849-1850.

UPPER LIMIT FOR RELATIVISTIC DIRAC MONOPOLE FLUX AT MOUNTAIN HEIGHTS

339. Yerlykin A.D., Yakovlev V.I. Sov.Phys.- English Transl.: JETP, 1969, vol.29, pp.992-993.

UPPER LIMIT FOR RELATIVISTIC DIRAC MONOPOLE FLUX AT MOUNTAIN HEIGHTS

The flux of relativistic Dirac monopoles of various energies measured by above ground and underground calorimethers at the Lebedev Physics Institute's Tyan'-Shan' high-altitude scientific station to be $\leq 2.5 \times 10^{-12} cm^{-2} sec^{-1} sr^{-1}$ at energies $E \geq 10^{13}$ ev.

340. Zumino B. In: THEORY AND PHENOMENOLOGY IN PARTICLE PHYSICS. International School of Physics, Ettore Majorane, a MPI-NATO Advanced Study Institute Spansored by CERN and Weizman Institute of Science, Erice, 1968, Ed. by A.Zichichi, part B, pp.772-775, 1969.
General Discussion

1970

341. Alvarez L.W., Antuna M.Jr., Byrns R.A., Eberhard P.H. Gilmer R.E., Hoyer E.H., Ross R.R., Stellrecht H.H., Taylor J.D., Watt R.D. University of California Radiation Laboratory, USRL-19756, Berkeley, 1970.

A MAGNETIC MONOPOLE DETECTOR UTILIZING SUPERCONDUCTING ELEMENTS

An electromagnetic detector has been built to extend the search for magnetic monopoles to the lunar sample returned during the Apollo missions. It is sensitive to the minimum magnetic charge allowed by Dirac's theory, and permits analysis of a sample without changing any of its properties.

The apparatus consists of a superconducting niobium sensing coil with a core at room temperature, shorted by a superconducting mechanical switch and protected against the effects of variable ambient magnetic field by an adequate shield made of supercpnducting lead. Characteristic features performance, and sample containers are described.

342. Alvarez L.W., Eberhard P.H., Ross R.R., Watt R.D. Science, vol.167, No 3918, 701 (1970).

SEARCH FOR MAGNETIC MONOPOLES IN THE LUNAR SAMPLE

An electromagnetic search for magnetic monopoles of the minimum size predicted by Dirac, or of any larger magnitude, has been performed on 8.37 kilograms of the lunar surface material. No monopole was found. This experiment sets new limits on the production cross section for monopoles and on their occurence in cosmic radiation.

343. Alvarez L.W., Eberhard P.H., Ross R.R. and Watt R.D. Geochimico et Cosmochimico Acta, Apr.1970, vol.34 (Special Moon Edition).

SEARCH FOR MAGNETIC MONOPOLES IN THE LUNAR SAMPLE

See ref.

344. Alvarez L.W. University of California Radiation Lab., UCRL-470, Berkeley,1970.

345. Alvarez L.W., Eberhard P.H., Ross R.R., Watt R.D. NAL Proposal No 3, Batavia, Illinois, 1970.

PROPOSAL FOR A SEARCH FOR MAGNETIC MONOPOLES AT NAL

It is proposed that an experiment would be performed to search for magnetic monopoles based on their electromagnetic properties at macroscopic distances only.

A ferromagnetic trap would be exposed in a beam dump at NAL and monopoles would be searched for using an existing detector.

346. Amaldi E., Baroni G., Manfredini A., Bradner H., de Carvatho M.G., Hoffmann L., Vanderhaeghe G. DIRAC MONOPOLES, ed. MIR, Moscow, 1970, pp.112-164.

SEARCH FOR DIRAC MAGNETIC POLES

See refs.:

347. Amaldi E., Baroni G., Romano G. European Organization for Nuclear Research, CERN-ISRC/70-8, Geneve, 1970.

PROPOSAL OF AN EXPERIMENT FOR SEARCHING THE DIRAC MAGNETIC MONOPOLES AT THE I.S.R. WITH PLASTIC TECHNIQUE

348. Barut A.O. In: PROCEEDINGS OF CORAL GABLES CONFERENCE ON FUNDAMENTAL INTERACTIONS AT HIGH ENERGY. vol.II, edited by A.Perlmutter et al. (Gordon & Breach - New York-London-Paris)1970,pp.199-220.

DYONIUM - ATOM AND MOLECULES. ELECTROMAGNETIC ORIGIN OF STRONG INTERACTIONS

349. Barut A.O. XV-th INTERNATIONAL CONFERENCE ON HIGH ENERGY PHYSICS. Kiev, 1970,p.615.

FURTHER PROPERTIES OF HADRONS IN THE DYONIUM MODEL

The simplest model of hadron structure consistent with the known form factor is a system called "dyonium", the bound state of two spinless particles having both electric and magnetic charges g=(e,g) (dyons) suth that the total system is magnetically neutral. In this model the strong interaction Hamiltonian is known and is reduced to (strong) electromagnetic origin; the dynamics is most conveniently written in the form of a relativistic infinit component wave equation with a conserved vector current which couples to the electromagnetic field. The mass spectrum derived is essentially linear in spin for small values of spin. The chiral invariant parameter $\mu = q_1 \times q_2$ $(e_1 g_2 - g_1 e_2)$ determines the lowest spin of the system. The interaction of two hadrons in this model is then analogous to the van der Waals interactions between electrically neutral systems. Further points discussed in this paper are: 1) diffraction slopes; 2) anomalous magnetic moments magnetic polarizabilities; 3) meson production viewed as multiple production of dyon-pairs, relation to partons conformal invariance.

350. Barut A.O., Bornzin G.L. University of Colorado,Dept. of Phys.,Boulder, Colorado, 1970.

SO(4,2)-FORMULATION OF THE SYMMETRY BREAKING IN RELATIVISTIC KEPLER PROBLEMS WITH OR WITHOUT MAGNETIC CHARGES

See ref.

351. Barut A.O. University of Colorado, Dept. of Physics and Astrophysics, Boulder, Colorado, 1970.

THE SUPERSELECTION RULE FOR MAGNETIC CHARGES AND THE SEARCH FOR MAGNETIC MONOPOLES

Parity eigenstates are superpositions of states with positive and negative magnetic charges. Although magnetic charge is separately conserved,it need not satisfy a superselection rule, if at the production there are only eigenstates of parity. Theoretical and experimental consequences are pointed out.

352. Berrondo M., McIntosh H.V., J.Math.Phys., vol.11, pp.125-141, 1970.

DEGENERACY OF THE DIRAC EQUATION WITH ELECTRIC AND MAGNETIC COULOMB POTENTIALS

Investigation is made of the symmetry and degeneracy of the Dirac equation for a Coulomb potential with a fixed center bearing both electric and magnetic charge. It is found that magnetic charge must be quantized - a requirement seen from the angular part of the wavefunction exactly as in the nonrelativistic problem. Seen from the newpoint of calssical mechanics, relativistic procession removes the accidental degeneracy of the nonrelativistic potential.

353. Bialynicki-Birula I., Bialynicka-Birula Z. NYO-3829-57, 1970.

MAGNETIC MONOPOLES IN THE HYDRODYNAMIC FORMULATION OF QUANTUM MECHANICS

Nonrelativistic quantum theory of a particle having both electric and magnetic charges moving in an arbitrary external electromagnetic field is presented. The theory is based on the hydrodynamic formulation of quantum mechanics. Dirac's quantization condition for the electric and magnetic charges is rederived as a consistency condition for the motion of the probability fluid. Neither the wave function nor the electromagnetic potential, which were the source of ambiguities in all other formulations, appear in our approach. Nevertheless, this theory has all the essentia

features of the standard quantum mechanics, including the superposition principle.

354. Blagov M.I., Isakov A.I., Murashova V.A., Petukhov V.A., Samojlov A,V., Syreischikova T.I., Tel'nov Yu.A.,Frolov A.M. Usachev Yu.D., Yakimenko M.N. Lebedev Phys.Inst.Acad. of Sci. USSR, Preprint FIAN, No 46, Moscow, 1970.

SEARCH FOR ELEMENTARY PARTICLES? POSSESSING A MAGNETIC CHARGE (In Russian)

Translated in English at CERN by B.Hodge, CERN Translation 71-10 (March 1971).

355. Blagov M.I., Murashova V.A., Syreitshikova T.I., Tel'nov Yu.Ya., Usachev Yu.D., Yakimenko M.N. XV-th International Conference on High Energy Physics. 1970, Kiev, vol.1, p.314.

SEARCH FOR MAGNETIC CHARGE PARTICLES PRODUCED BY PHOTON BEAM

Because of the absence of successive theory of magnetic charge it was supposed (1) the existence of monopoles with charges, which are different from Dirac's one (g= 68.5e) (2).An attempt was made to discover particles with magnetic charge $g=(1 \div 7)e$ produced by 600 MeV synchrotron γ -ray using scintillation technique. There were detected the 0.1 ± 0.1 events per 10^{10} effective quanta intensity flux using experimental set with acceptance $2,3 \times 10^{-3}$ MeV sterad.

Assuming the matrix element for monopole production is equal constant we have obtained monopole production cross section upper limit. In particular, it was obtained $\sigma_{95\%} \leq 3 \times 10^{-29}$ cm^2 per nucleon for $g=(1 \div 7)$ e and masses up to 200 MeV/c^2.

356. Bolotovski B.M., Usachev Yu.D. DIRAC MONOPOLE, MIR,Moscow, 1970.

Introductory paper. (In Russian).

357. Carrigan R.A.,Jr., Nezrick F.A. National Accelerator Laboratory, Batavia, Illinois, 1970.

SEARCH FOR MAGNETIC MONOPOLES PRODUCED AT NAL

Following the ideas outlined in our Oct.29, 1969 letter of intent to E.L.Goldwasser we propose to undertake a three phase program to search for possible magnetic monopole production at NAL. In the first phase we will look for free magnetic monopole production in strong and electromagnetic interactions by using collectors placed in the proton beam dump and an electronic detection technique similar to one previously employed in cosmic ray searches. The second phase will extend the search we have recently carried out for neutrino production of free magnetic monopoles by placing large collectors in the NAL neutrino beam. In the third phase we will search for bound magnetic monopoles by looking for breaks as a function of energy in the production of low energy gamma ray showers by protons.

358. Carrigan R.A.?Jr., Nezrick F.A. National Accelerator Laboratory, NAL-44, Batavia, Illinois, 1970.

UPPER LIMIT FOR MAGNETIC MONOPOLE PRODUCTION BY NEUTRINOS

Existing magnetic monopole searches are re-evaluated in terms of monopole production by cosmic-ray neutrinos. The upper limit for the cross section for monopole production inside the best ocean-bed sample is $\sigma_D \leq 1.0 \times 10^{-39} E_T^2$ cm^2. An even lower limit of $\sigma_C \leq 3.0 \times 10^{-45} E_T^2$ cm^2 is established if the monopoles are collected on the sample from surrounding ocean water.

359. Carrigan R., Yamanouchi T., Derenzo S., Frankel S., Lee W.Y., Mischke R.E., Trefil J.S. In 1970 summer study, 1970, TID-25874, pp.397-405.

QUARK AND MONOPOLE SEARCHES AT NAL

The general field of quarks and monopole searches at NAL is discussed; facilities which should be provided are recommended, and priorities to be given to various types of experiments are suggested.

360. Collins G.B., Ficenec J.R., Trower W.P., Fischer J., Shibata S. National Accelerator Laboratory, NAL Proposal No 22, Batavia, Illinois, 1970.

EXPERIMENTAL PROPOSAL TO THE NATIONAL ACCELERATOR LABORATORY FOR A SEARCH FOR MULTIGAMMA EVENTS FROM MAGNETIC MONOPOLE PAIRS

The failure of numerous attempts to find isolated Dirac magnetic monopoles is well known. Ruderman and Zwanziger have speculated that monopole pairs may be created by high energy photons. Because these pairs would have an extremely strong, as well as long range attraction for each other, they would quickly annihilate. This whole process would give rise to a great number of photons both from annihilation radiation and bremsstrahlung. Observation of a few anomalous pure photon cosmic ray showers, which display characteristics explainable only by this model, were in part responsible for this theoretical speculation. Thus motivated we propose to survay multigamma events emerging from a thin target bombarded with protons at the highest accelerator energy attainable. We propose also to search, by consentional methods, for the possible production of free monopoles.

361. Collins G.B., Ficenec J.R., Trower W.P., Fischer J., Shibata S. Physics Dept. Virginia Polytechnic Inst., VPI-ERP-70-7, Blacksburg, Virginia, 1970.

EXPERIMENTAL PROPOSAL TO THE NATIONAL ACCELERATOR LABORATORY FOR A SEARCH FOR MULTIGAMMA EVENTS FROM MAGNETIC MONOPOLE PAIRS

See ref.

362. Dadykin V.L. Acta Phys.Acad.Sci.Hung., vol.29, Suppl.4, pp.461-463, 1970. Proc. 11-th Conf. on Cosmic Rays, Budapest, 1969.

ON A METHOD OF FINDING DIRAC'S MAGNETIC MONOPOLES

An experiment is suggested to find fast cosmic monopoles by detecting their Cherenkov radiation in air. The required equipment consists of about 100 multipliers and about 1000 Geiger counters. The apparatus must have a collecting power

of about 10^3 m^2 sr and has to be placed in a salt mine.

363. Efinger H.J. Lett.Nuovo Cim., 1970, vol.4, No 7, pp.277-280.

ON SCHWINGER EVEN INTEGER CHARGE QUANTIZATION CONDITION

364. Fleischer R.L., Hart H.R., Jr., Comstock G.M., Hubbard E.L., National Accelerator Laboratory, NAL Proposal No 74, Batavia Illinois, 1970.

PROPOSAL TO NATIONAL ACCELERATOR LABORATORY FOR A SEARCH FOR MAGNETIC MONOPOLES

The fundamental particle whose discovery would require the most thorough reassessment of modern physics is the magnetic monopole. A beam of 500 GeV protons in principle makes possible the creation of pairs of monopoles each of mass up to 15 m_p (p=proton) under controlled laboratory conditions. We propose to use solid state track detectors to observe directly the flight of monopoles which hopefully would be created by interactions in a target foil placed directly in the accelerator beam. The method has the merits of simplicity and directness, the use of detectors with zero background, applicability within the entire mass range opene by increased accelerator energies, and applicability within the entire charge range regarded as plausible in the light of past and current theoretical work. The experiment could be run as a satellite to another experiment or to the early yune up of the accelerator.

365. Fleischer R.L., Hart H.R., Jr., Jacobs I.S., Price P.B., Schwarz W.M., Goodell H.G., Aumento F. Radiat.Eff.,1970, vol.3, No 1-2, pp.137-138.

DEEP SEA SEARCH FOR MULTIPLY-CHARGED MAGNETIC POLES

366. Fleischer R.L., Hart H.R.,Jr., Jacobs I.S., Price P.B., Schwarz W.M., Woods R.T., Aumento F., Goodell H.G. Acta Phys.Acad.Sci.Hung., 1970, vol.29, Suppl.3, pp.27-30.

SEARCH FOR COSMIC MAGNETIC MONOPOLES

367. Goebel C.J., QUANTA ESSAYS IN THEORETICAL PHYSICS DEDICATED TO GREGOR WENTZEL. The Univ. of Chicago Press, Chicago-London, 1970, pp.338-344.

SPATIAL EXTENT OF MAGNETIC MONOPOLES

See ref.

368. Goldhaber A.S. DIRAC MONOPOLE, ed. MIR, Moscow, 1970, p.269.

ROLE OF SPIN IN THE MONOPOLE PROBLEM
(In Russian)

See ref.

369. Gurevich I.I., Khakimov S.Kh., Marthemianov V.P., Mishakova A.P., Ogurtzov V.V., Tarasenkov V.G., Barkov L.M., Tarakanov N.M. Phys.Lett., 1970, vol.31B, No 6, pp.394-396.

SEARCH FOR THE DIRAC MONOPOLE AT THE 70 GeV PROTON SYNCHROTRON

The article describes a search for the Dirac monopole at the 70 GeV IPHE proton synchrotron. It was found that the upper limit of the monopole production cross-section was σ (90%)$\lesssim 1.5 \times 10^{-41}$ cm^2 for m q $\leq$ 5 m p.

See ref.

370. Gurevich I.I., Khakimov S.Ch., Martemianov V.P., Mishakova A.P., Ogurtzov V.V., Tarasenkov V.P., Barkov L.M., Tarakanov N.M. XV-th International Conference on high energy physic 1970, Kiev, vol.1, p.312.

SEARCH FOR THE DIRAC MONOPOLE AT THE 70 GeV IPHE PROTON SYNCHROTORN

The 70 GeV IPHE proton accelerator is able to produce monopoles with the mass up to 5-7 proton-masses. The sample made of a tungstem plate and a permendur foil 100 μ thick were displaced near the target. Target material is an aluminium. The detailed analysis of the monopole compartment in various medium has been developed; it shows that in the present experiment monopoles loss their energy efficiently down to thermal velocity and are accumulated in the permen-

dur foil. After the end of irradiation the magnetic field with the intensity of 220 Kgs has been applied to the samples. The BR-2 type nuclear photoemulsion has been used as a detector. The upper limit on the production cross section for monopoles, calculated on the base of the number of p-target interactions, is σ (90%) $\leq 1.5 \times 10^{-41}$ cm^2.

371. Han M.Y., Biedenharn L.C., Phys.Rev.Lett., 1970, vol.24, p.118.

DYON THREE-TRIPLET MODEL OF HADRONS

Schwinger's composite model of hadrons, based on dyons, is formulated as a dyon three-triplet model with the postulated symmetry group SU(3) (electric) $\otimes$ SU(3) (magnetic). The hadron spectrum is dominated by the superstrong magnetic-charge exchange forces; we find the first "exotic" states to be in the meson channel of the (2D2 $\bar{D}$) system. This model possesses the good features of the quark model and explains its paradoxes.

372. Heymann F.F. European Organization for Nuclear Research, CERN/ISRC/70-4, Geneva, 1970.

BRIEF REPORT ON MONOPOLE MEETING OF 10 MARCH 1970

373. Janis A.I., Amer.J.Phys., 1970, vol.38, No 2, pp.202-206.

ENERGY AND OBSERVABLES IN ELECTROMAGNETIC THEORY

A comparison is made of two ways of introducing auxiliary variables into Maxwell's equations. The first is the usual introduction of potentials. The second introduces twice the usual number of potentials. Although both formalisms lead to the usual vacuum-field equations when expressed in terms of the original variables (the component of the electromagnetic field tensor), they are found to describe physically distinct theories. It is seen that the second formalism leads to a different stress-energy tensor and to the prediction of new observable quantities, which apparently have no counterpart in nature.

374. Kerner E.H. J.Math.Phys., 1970, vol.11, pp.39-46.

CHARGE AND POLE: CANONICAL COORDINATES WITHOUT POTENTIALS

For particles having both magnetic and electric charge it is shown that (a) in the nonrelativistic many-particle problem where only Coulomb and Biot-Savat fields need be considered and (b) in the one particle relativistic problem (orbital pole-charge moving around a fixed pole-charge), the well-set classical dynamics can be reduced directly from the equations of motion to Hamiltonian, without the introduction of potentials and Dirac strings. The Lie-Koenigs theorem, which can give Hamiltonian format to any dynamics, is inlooked for this. The essential feature is that canonical coordinates cannot be physical particle coordinates. For (a) and (b) suitable canonical variables are explicitly constructed. Using only Bohr-Sommerfeld quantization the Schwinger charge-pole quantum condition is obtained for pure-charge-pole interactions; but when Coulomb forces are additionally considered, no quantum restriction on charge and pole strength is required.

375. Kolm N.N., Fleischer R.L., Hart H.R.,Jr., Jacobs I.S., Price P.B., Schwarz W.M., Woods R.T. J. of Appl.Phys., 1970, vol.41, ,p.958.

ROCKS, LIQUIDS AND MONOPOLES

Magnetic Monopoles: Where Are They and Where Aren't They?

The existence of isolated magnetic charges (Monopoles) in nature would require profound rethinking not only in elementary particle physics but also in high energy cosmic-ray physics and astrophysics. Monopoles whose possible existence was first suggested by Dirac in 1931 and whose properties were later recalculated by Schwinger would be intensely ionizing particles similar to their effects in passing through matter to relativistic rare-earth ions (or still heavier nuclei). As Parker has noted only a very minute abundance of monopoles in the galaxy would ne necessary to have removed or at least grossly altered the galactic magnetic field on an astrophysically interesting time scale. Solid-state nuclear track detectors have led to a

new series of intensive monopole searches: one of these takes ferromanganese deposits from the deep oceans (as a material whicle would have magnetically trapped monopoles) and exposes them to high magnetic fields sufficient to loosen monopoles and accelerate them into a detection system; the other experiment is designed to utilize natural detectors to record over geological time the paths of massive penetrating monopoles. The negative results obtained set new and highly restrictive limits on the abundance of monopoles. These limits are such tha the mysterious high-energy cosmic rays (10^{17}-10^{19} eV) cannot be monopoles as has been suggested, non can the galactic magnetic fields be seiously altered by the maximum permitted abundance - even over the galactic age-finally, the flux of monopoles onto the earth over the earth's entire age is 1/2 monopole/cm^2. Qualifications on these claims are indicated in the article.

376. Kukanov A.B., Davydov V.N. Izvestia Vuzov SSSR, ser. fiz., 1970, No 6, pp.114-116.

ON THE THEORY OF COMPTON EFFECT ON MAGNETIC MONOPOLE(In Russian)

377. Leiter D. Can.J.Phys., 1970, vol.48, No 3, pp.279-282.

THE SYMMETRIZATION OF MAXWELL'S EQUATIONS AND FRACTIONALITY CHARGED PARTICLES

It is shown that Maxwell's equations can be consistently symmetrized by the introduction of an additional vector 4-current as the source of the dual of the generalized electromagnetic tensor. The additional 4-current is related to a second type of electric charge which we shall call "m-electric charge", as distinguished from the conventional electric charge (denoted as "e-electric charge). A Lagrangian formulation of this theory for classical point charges is constructed, yielding the symmetrized Maxwell equations, in which each particle is assumed to carry both an "e-electric" charge and an "m-electric" charge. We show that if the "m-electric" to "e-electric" charge ratio is the same for all particles

in the model universe, then the predictions of the symmetrized Maxwell equations are the same as that of the unsymmetrized, conventional Maxwell equations. However, if all particles in a detector carry the same m-electric to e-electric charge ratio, not equal to zero, then a detected particle with different m-electric to e-electric charge ratio (than that of the detector) could appear to have only a fractional e-electric charge. This implies that fractionally charged particles could be generated even if only integral multiples of e-charge and m-charge were allowed in the symmetrized theory. This means that it might be experimentally difficult to distinguish between a differently "m-charged" particle, and an SU^3-type "quark", in purely electromagnetic interactions alone.

378. Levman G.M. Canad.J.Phys., 1970, vol.48, No 20, p.2423.
ON A DUALITY INVARIANT ACTION PRINCIPLE IN VACUUM ELECTRODYNAMICS

379. Libby L.M. University of Colorado, Boulder, Colorado, 1970.
QUESTION OF QUARK, MAGNETIC MONOPOLE AND DYON DETECTION

380. Lubkin E. Phys.Rev., 1970, vol.2, No 10, pp.2510-2511.
PHENOMENOLOGICAL PRESENTATION OF THE DIRAC QUANTIZATION OF MAGNETIC CHARGE

The field-dependent difference is phse associated with two paths in an interference experiment employing electrically charged particles of electric charge e is proportional to the magnetic flux through a surface bounded by the difference of the paths. If considered as a visible electron-optical fringe displacement, it may be used as phenomenological support for Dirac's condition $eg=\frac{1}{2}n$, restricting the strength of a magnetic monopole.

381. McIntosh H.V., Cisneros A., J.Math.Phys., 1970, vol.11, pp.896-916.
DEGENERACY IN THE PRESENCE OF A MAGNETIC MONOPOLE

The symmetry of the force field of a magnetic monopole is comparable in its simplicity to that of the hydrogen atom or a harmonic oscillator. Neither the mechanical nor the canonical angular momentum is conserved in the presence of a monopole field, but rather a total angular momentum which incorporates angular momentum resident in the magnetic field.

382. Majumdar S.D., Pal R. Proc.Roy.Soc.,London A, 1970, vol.316, No 1527, pp.525-537.

CHERENKOV RADIATION IN ANISOTROPIC MEDIA

The problem of Cherenkov radiation in anisotropic media is studied in a Lorentz frame in which the charged particle is at rest and the medium is moving with a uniform velocity. Both electric and magnetic anisotropy are assumed to be present, but the axes of the permittivity are permeability ellipsoids are taken to be parallel to one another. The electromagnetic field generated by the charge is described by two scalar potentials. Each of these satisfies a partial differential equation of the fourth order when the velocity vector lies in a principal plane of the ellipsoids. The two equations closely resemble one another, and passage from one to the other is possible by means of certain simple symmetry operations. The equation for the scalar potential of the electric field is solved by the standard technique of Fourier transformation. In evaluating the Fourier integrals, however, it is found necessary to assume that two of the ratios e_i/μ_i of the principle permittivities and permeabilities are equal. With this additional restriction the integrals are evaluated easily by the residue theorem and expressions for the field and the radiated energy are obtained in closed forms.

383. Mavrychev Yu.S. Izvestia Vuzov SSSR, ser.fiz.,1970,No9, p.129.

ON THE CHARGE PHASE IN ELECTRODYNAMICS

(In Russian)

384. Newmeyer I.L., Trefil J.S. Univ.of Virginia, Charlottesville, Va., 1970.

SPECULATIONS ON INDIRECT SEARCHES FOR MAGNETIC MONOPOLES

385. Osborne W.Z. Phys.Rev.Lett., 1970, vol.24, No 25, pp.1441-1445; vol.25, No 5, p.324 (erratum).

LIMITS ON MAGNETIC MONOPOLE FLUXES IN THE PRIMARY COSMIC RADIATION FROM INVERSE COMPTON SCATTERING AND MUON-POOR EXTENSIVE AIR-SHOWERS

Flux limits for monopoles in the primary cosmic radiation have been derived on the basis of muon-poor air-shower data and the analog of universe Compton scattering of monopoles from universal microwave background photons. Calculation on both galactic and universal scales were performed. The resulting limits are generally smaller than existing experimental limits are applicable to strongly interacting monopoles.

386. Parker E.N. Astrophys. J., 1970, vol.160, No 2, part I, pp.383-404.

THE ORIGIN OF MAGNETIC FIELDS

387. Potupa A.S., Strazhev V.I., Tomilchik L.M. Vestsi Akad.Nauk Belorussk.SSR, ser.fiz-mat., 1970, No 2, pp.96-100.

AXIOMATIC MODEL OF CLASSICAL ELECTRODYNAMICS (In Russain)

Axiomatic model of dual-invariant classical electrodynamics is built on the basis of measurement analysis in the system of trial bodies and the continuity equations for current. In contradistinction of the Bopp scheme the principle of least constraint is not used at any stage due to evident calculation of dual invariance.

388. Potupa V.I., Strazhev V.I. The Materials of the First Republician Conference of Young Scientists. Izd.Inst. of Akad.Nauk Belorussk.SSR, Minsk, 1970.

389. Purcell E.M., Collins G.B., Fujii T., Hornbostel J., Turkot F. DIRAC MONOPOLE, ed. MIR, Moscow, 1970,p.238.

SEARCH FOR THE DIRAC MONOPOLE WITH 30-BEV PROTONS
(In Russian)

See ref.

390. Rajput B.S. Ind.J.Pure and Appl.Phys., 1970, vol.8, pp.297-301.

REDUCTION OF GENERALIZED ELECTROMAGNETIC FIELD TO IRREDUCIBLE REPRESENTATION OF LORENTZ GROUP

The reduction of the generalized electromagnetic field to the irreducible representation of inhomogeneous,proper, orthochronous Lorentz group has been attempted for zero mass systems in the presence of magnetic charge source in addition to the electric charge source. Assuming the justification in Dirac's theoretical interpretation for the existence of a magnetic monopole as the natural generalization of the usual electrodynamical treatment and quantization of electricity, the modified field equations have been discussed. The electromagnetic fields which satisfy these equations have been reduced group-theoretically and the effects of field equations on these reduced expansions have been considered. This leads to the interesting condition which imposes the very severe restriction, that the ratio of electric charge quanta and magnetic charge quanta is the same for all the particles in the system. This condition when combined with Dirac's quantization gives a larger value for the coupling constant of magnetic monopoles and consequently explains why magnetic monopole theory could not be fully supported by experimental evidence so far.

391. Rajput B.S., Singh R.N. Ind.J.Pure and Appl.Phys., 1970, vol.8, pp.439-443.

REDUCTION OF GENERALIZED ELECTROMAGNETIC FIELDS TO THE IRREDUCIBLE REPRESENTATION OF LORENTZ GROUP FOR NON-ZERO MASS SYSTEM

The study of the reduction of wave-function which transforms as generalized electromagnetic fields to the irreducible representation of proper, orthochronous, inhomogeneous Lorentz group, for non-zero mass system, has been undertaken. The effects of generalized electromagnetic field equations on the reduced expansions of electric and magnetic fields have also been studied and it has been proved that ratio of electric charge quanta to the monopole charge quanta is the same for all the particles in the system.

392. Schatten K.H. Phys.Rev., 1970, vol.D 1, No 8,pp.2245-2251.

SEARCH FOR MAGNETIC MONOPOLES IN THE MOON

The effects of a possible magnetic charge of the moon upon the magnetic field in the lunar vicinity have been analyzed. Magnetic field observations obtained by the GSFC magnetometer aboard Explorer 35 have been studied to search for these effects. Using these observations it is possible to botain a measure of the net difference between the number of northern and southern monopoles within the moon which are of opposite sign. The search has resulted in negative finding and places an approximate upper limit on the average difference in the number of monopoles within the moon at 1.6×10^{-7} cm^{-3} or 7×10^{-32} per nucleon.

393. Schwinger J. DIRAC MONOPOLE, ed. MIR, Moscow, 1970, pp.295-312.

MAGNETIC CHARGE AND QUANTUM FIELD THEORY
(In Russian)

See ref.

394. Schwinger J. PARTICLES,SOURCES AND FIELDS, Addi on-Wesley Publ.Co.,Reading, Mass., 1970, p.227.

395. Sivers D. University of California, Lawrence Radiation Laboratory, UCRL-19794, Berkeley, California, 1970.

POSSIBLE BINDING OF MAGNETIC MONOPOLE TO A PARTICLE WITH ELECTRIC CHARGE AND A MAGNETIC DIPOLE MOMENT

See ref.

396. Sivers D. Phys.Rev., 1970, vol.D 2, pp.2048-2054.

POSSIBLE BINDING OF MAGNETIC MONOPOLE TO A PARTICLE WITH ELECTRIC CHARGE AND A MAGNETIC DIPOLE MOMENT

We argue that Dirac monopoles, if they exist, could be strongly bound to those naturally occurring free nuclei with magnetic dipole moments, and we discuss the effect this binding would have on the interpretation of experimental monopole searches.

397. Strazhev V.I. Vestzi Akad.Nauk Belorussk.SSR, ser. fiz.-mat., 1970, No 6, pp.122-124.

DUALLY CHARGED PARTICLES IN ELECTRODYNAMICS

Equivalence consequences of electrodynamics of the electric and magnetic charged particles under condition of universality of the equation g/e to the particles' electrodynamics which possess one effective charge $g=(e^2 + g^2)1/2$ are considered.

398. Strazhev V.I. Thesis, Minsk, 1970.

TO THE PROBLEM OF DUAL SYMMETRY IN ELECTRODYNAMICS

398. Strazhev V.I. Akad.Nauk Belorussk.SSR, Inst. of Physics, Minsk, 1970.

MAGNETIC CHARGE IN ELECTRODYNAMICS

399. Strazhev V.I. The Materials of the First Republician Conference of Young Scientists. Izd. Inst. of Akad.Nauk Belorussk.SSR, Minsk, 1970, pp.15-17.

QUANTUM ELECTRODYNAMICS OF ELECTRIC AND MAGNETIC CHARGED PARTICLES

400. Strnad J. Obz.Mat.in Fiz.,1970, vol.17, No 1, pp.12-20.

MONOPOLES,QUARKS,DYONS (In Slovenian)

401. Thomsen D.E. Sci.News, 1970, vol.98, No 8-9,pp.183-184.

SEARCHING FOR MONOPOLES

Theoretical neatness requires particles with one magnetic pole, but they have not been found.

402. Tompkins D.R. Bull.Amer.Phys.Soc., 1970, ser.II, vol.15, No 1, pp.39

WOULD RELATIVISTIC MONOPOLES PRODUCE STRAIGHT LIGHTING STROKES?

Thundercloud ion density estimates and cosmic ray shower properties are used to show that showers above 10^{16} eV may be capable of occasionally initiating lightning by producing a small potential impulse. Using properties of lightning itself a conducting channel mechanism of lightning initiation is also described. It is argued that the cores of showers with energy $\gtrsim 10^{21}$ eV are capable of producing very straight lightning strokes proceeded by a dart rather than a stepped leader. It is argued that a relativistic monopole could also produce such strokes. It is noted that, at best, observations of such strokes have been very rare.

403. Tompkins D.R.,Jr., University of Wyoming, Dept. of Phys., 1970.

COSMIC RAY SEARCH FOR FAST MAGNETIC CHARGES

404. Tompkins D.R.,Jr., Rebka G.A.,Jr., Kunselman A.R. ; National Accelerator Laboratory, NAL Proposal No 19-A, Batavia, Illinois, 1970.

A SEARCH FOR MONOPOLE PRODUCTION BY 200-500 GeV PROTONS

It is proposed that two Cherenkov counters, one water and one air at atmospheric pressure be placed in the 200-500 GeV proton beam. The air counter will have a high threshold and will be used to record the beam microstructure with a resolution of about 3×10^{-8} sec, The water counter

records a similar microstructure for the beam plus any relativistic heavy particles produced in the water counter (the water counter is also the target in this experiment). For the production of monopoles with n=1/2 to 4 magnetic charge units in the water counter (n=1/2 is Dirac's value) the water counter Cherenkov pulse amplitudes can be as much as 80 n^2 times larger than the average beam level. With 600 hours of beam at 10^{10} protons/burst/ 1 burst/ 15 sec/ this experiment can set a monopole production limit of 3×10^{-38} cm^2 for the above magnetic charge values.

405. Trefil J.S. University of Virginia, Charlottesville, Virginia, 1970.

ESTIMATE OF THE PRODUCTION OF BOUND MAGNETIC MONOPOLES STATES

406. Trefil J.S. Ill. University, Urbana, In 1970 Summer Study, 1970, pp. 391-396.

ESTIMATE OF THE PRODUCTION OF BOUND MAGNETIC MONOPOLES STATES

407. Von Westenholz C.V. Ann. (N.Y.) Physik, 1970, vol.7, No 25, p.337.

MAGNETIC MONOPOLE AND QUARKS (In German)

The author discusses the concept of Schwinger, which starts with the hypothesis of the existence of magnetical monopoles and results in a baryon model with magnetically charged constituents.

408. Wentzel G. DIRAC MONOPOLE, ed. MIR, Moscow, 1970, pp. 313-328.

COMMENTS ON DIRAC'S THEORY OF MAGNETIC MONOPOLES (In Russian)

See ref.

409. Yang C.N. Phys.Rev., 1970, vol.D 1, p.2360.

CHARGE QUANTIZATION, COMPACTNESS OF THE GAUGE GROUP, AND FLUX QUANTIZATION

The relationship between charge quantization and the compactness of the gauge group is discussed. Also remarks are made about charge observation of flux quantization in superconductors.

410. Yuan L.C.L., Dell G.F., Uto H., Wang C.L., Dooher J.P., Amaldi E., Borgia B., Pistilli P., and Benexentano M. European Organization for Nuclear Research Report, CERN-ISRC/70-19, Geneva, 1970.

SEARCH FOR HIGH ENERGY MULTIGAMMA EVENTS; POSSIBLE CONSEQUENCE OF MAGNETIC MONOPOLE PAIRS OR OF HIGH Z LEPTON

411. Zwanzinger D. XVth International Conference on High Energy Physics, Kiev, 1970, vol.2, p.842.

LAGRANGIAN FORMULATION OF THE QUANTUM FIELD THEORY OF MAGNETIC MONOPOLES

A lagrangian and canonical field theoretical formulation of Dirac's theory of magnetic monopoles is presented. The Lagrangian density depends on a fixed space-like 4-vector which corresponds to the Dirac string. A canonical quantization may be implemented in Lorentz frame with time axis orthogonal to the 4-vector. The green's functions of the theory and the transformation properties of the scattering amplitudes are discussed.

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412. Alvarez L.M., Antuna M.,Jr., Byrns R.A., Eberhard P.H., Gilmer R.E., Hoyer E.H., Ross R.R., Stellrecht H.H.,Taylor J.D., Watt R.D. Rev.Sci.Instrum.,1971, vol.42, pp.326-330.

A MAGNETIC MONOPOLE DETECTOR UTILIZING SUPER-CONDUCTING ELEMENTS

An electromagnetic detector has been built to extend the search for magnetic monopoles to the lunar sample returned during the Apoll missions. It is sensitive to the minimum magnetic charge allowed by Dirac's theory and permits analysis of a sample without changing any of its properties. The apparatus consists of a superconducting niobium sensing coil with a core at room temperature shorted by a superconducting mechanical switch and protected against the effects of variable ambient magnetic field by an adequate shield made of superconducting lead. Characteristic features performance and sample containers are described.

413. Andreev V.A., Malkin I.A., Man'ko V.I., P.N.Lebedev Phys.Institute Acad. of Sci. USSR, Preprint FIAN-No 1, Moscow, 1971.

DYNAMICAL SYMMETRIES OF SOME MODELS WITH MAGNETIC CHARGE

414. Bacry H., Kubar-Andre J. Centre de Physique Theoretique, CPT-71/379, Marsiele, France, 1971.

GALILEAN INVARIANCE AND MAGNETIC MONOPOLES

The existence of Dirac monopoles is known to be incompetible with Galilean invariance. A discussion follows on the interpretation of monopoles physics in a Galilean approximation.

415. Bakesigaki A., Inomate A. Lett.Nuovo Cim., 1971, vol.2, p.697.

BREAKING OF SCALE INVARIANCE, REGGE TRAJECTORIES AND DYONS

416. Barkov L.M., Gurevich I.I., Zolotarev M.S., Makarina L.A., Martemianov V.P., Mishakova A.P., Ogurtzov V.V., Ocharkin V.S Tarakanov N.M., Khakimov S.Kh., Czernyshova L.A.
Zh. Exp. i Teor.Fiz., 1971, vol.61, No 5, pp.1721-1736.

SEARCH FOR THE DIRAC MONOPOLE AT THE 70 GeV PROTON SYNCHROTRON

An experiment on the search for the Dirac monopole at a 70 GeV IHEP synchrotron using ferromagnetic traps is shown The upper limit of monopole production cross-section in proton-nucleonic collisions (95%) $\leq 2.1 \times 10^{-43}$ cm^2 for $m_g \leq 5.15\ m_p$ and $g=68.5e$ is found.

417. Barut A.O. In: TOPICS IN MODERN PHYSICS - A Tribute to F.U.Condon, ed. by W.E. Brittin and Halis Odabasi, Univ. of Colorado, Boulder, Colorado, 1971, pp.15-45.

ATOMS WITH MAGNETIC CHARGES AS MODELS OF HADRONS

General review of Barut's magnetic pole model of hadrons.

418. Barut A.O. In: BOULDER LECTURES IN THEORETICAL PHYSICS ed. by A.O. Barut and W.E.Brittin, Colorado Associated University Press, Boulder, 1971, vol.XIII.

DE SITTER AND CONFORMAL GROUPS AND THEIR APPLICATIONS

419. Barut A.O. ERSKIN LECTURES GIVEN AT THE Univ. of Canterbury, Christ Church, New Zealand, 1971.

LECTURES ON MAGNETIC CHARGES AND THE ELECTROMAGNETIC THEORY OF HADRONS AND STRONG INTERACTIONS

420. Barut A.O., Univ. of Colorado, Boulder, 1971.

A POSSIBLE PHYSICAL BASIS FOR SOME MATHEMATICAL MODEL OF STRONG INTERACTIONS: ATOMS WITH MAGNETIC CHARGES

421. Barut A.O. In: Proceedings of the Fifteenth International Conference on High Energy Physics, Kiev, 1970, USSR, Atomizdat, Moscow, 1971.

FURTHER PROPERTIES OF HADRONS IN THE DYONIUM MODEL

The simplest model of hadron structure consistent with the known form-factor is a system called "dyonium" the bound state of two spinless particles having both electric and magnetic charges $q=(e,g)$ (dyons) such that the total system is magnetically neutral. In this model the strong interaction Hamiltonian is known and is reduced to (strong) electromagnetic origin; the dynamic is most conveniently written in the form of a relativistic infinite component wave equation with a conserved vector current which couples to the electromagnetic field in spin for small values of spin. The chiral invariant parameter $u=q_1 \times q_2=(e_1g_2-g_1e_2)$ determines the lowest spin of the systems. The interaction of two hadrons in this model is then analogous to the Van der Waals interactions between electrically neutral systems. Further points discussed in this paper are: (1) diffraction slopes (2) anomalous magnetic moments, magnetic polarizabilities (3) meson production viewed as multiple production of dyon-pairs, relation to partons, conformal invariance.

422. Barut A.O. In: Proceedings of the Muon Physics Conference, 1971, Ft.Collins, Colorado, edited by P.Chand. Marcel Dekker, New York.

423. Barut A.O., Bornzin G.L. J.Math.Phys., 1971, vol.12,p.841.

SO(4,2)-FORMULATION OF THE SYMMETRY BREAKING IN RELATIVISTIC KEPLER PROBLEMS WITH OR WITHOUT MAGNETIC CHARGES

The relativistic Kepler problems in Dirac and Klein-Gordon forms are solved by dynamical group methods for particles having both electric and magnetic charges (dyons).

The explicit forms of the O(4,2) algebra and two special O(2,1) algenbras (which coincide in the symmetry limit) are given and a new group -theoretical form of the symmetry breaking is pointed out. The Klein-Gordon O(2,1)- algebra also solves the dynamics in the case of very strong coupling constants (attractive singular potential), if the principle series of representations are used instead of the discrete series.

424. Barut A.O. Univ. of Colorado, Boulder, Colorado,1971.

THE NATURE OF NUCLEAR BOND AND THE STRUCTURE OF HADRONS

425. Barut A.O. Phys.Rev., 1971, vol. D 3, No 8, p.1747.

PROTON FORM FACTOR, MAGNETIC CHARGES, AND DYONIUM

The relativistic quantum dynamics of two particles having both electric and magnetic charges (e,g) is discussed. It is shown that this model is a physical realization underlying the dipole magnetic form factor $G_m(t)$ of the proton calculated in the relativistic O(4,2) model.

The mass spectrum gives a linear trajectory for low values of the principle quamtum number N, contains N^2 degeneracy and parity doubling. The slope of the trajectory and the slope of the form factor can be related in principle to the masses of the constituents and the effective electric coupling $\alpha \equiv -(e_1 e_2 + g_1 g_2)$.

426. Bialynicki-Birula I., Bialynicka-Birula Z. Phys.Rev.,1971, vol. D 3, pp.2410-2412.

MAGNETIC MONOPOLES IN THE HYDRODYNAMIC FORMULATION OF QUANTUM MECHANICS

The nonrelativistic quantum theory of a particle having both electric and magnetic charges moving in an arbitrary external electromagnetic field is presented.
See ref.

427. Bialynicki-Birula I., Bialynicka-Birula Z. Phys.Rev.,1971, vol.D 3, p.2413.

RELATIVISTIC QUANTUM MECHANICS OF DYONS. EXACT SOLUTION

A relativistic quantum mechanics of dyons (hypothetical particles endowed with both electric and magnetic charges) is formulated. The hydrodynamics formulation of quantum mechanics is used to overcome all problems created by the simultaneous presence of both electric and magnetic charges. In the case of one dyon moving in the electromagnetic field of another dyon the exact solutions are found and the energy levels are determined.

428. Blagov M.I., Murashova V.A., Syreischikova T.I.,Tel'nov Yu. Ya., Usachev Yu.D., Yakimenko M.N. Survey on Physics,1971 No 6, pp.23-27.

SEARCH FOR MAGNETICALLY CHARGED PARTICLES IN A PHOTON BEAM

See ref.

429. Brand R.A. European Organization for Nuclear Research, CERN-Preprint 1397, Geneva, 1971.

STRUCTURE OF THE WEAK INTERACTION

430. Carrigan R.A., Nezrick F.A. Bull.Amer.Phys.Soc.,1971, vol.16, No 1, p.17.

BUBBLE CHAMBER SEARCH FOR NEUTRINO PRODUCED MAGNETIC MONOPOLES

As suggested by J.Schwinger, magnetically charged particles could be produced via a magnetically charged intermediate boson process similar to the mechanism ordinarilly envisioned for double muon production by neutrinos. A search for magnetic monopole production by neutrinos has been made by re-examining the CERN heavy liquid bubble chamber pictures obtained during the neutrino exposures of 1963 and 1967. Searches were made for events, which contained free monopole pairs with and without target excitation and for bound monopoles which de-excited by photon emission. No events were found. Neutrino monopole production cross section limits and a mass limits will be present.

431. Carrigan R.A.,Jr, Nezrick F.A. Phys.Rev.,1971, vol.D 3, p.56.

UPPER LIMIT FOR MAGNETIC-MONOPOLE PRODUCTION BY NEUTRINOS

Existing magnetic-monopole searches are reevaluated in terms of monopole production by cosmic-ray neutrinos.
The upper limit for the cross section for monopole production inside the best ocean-bed sample is $\sigma \leq 1.0 \times 10^{-39} E_T^2$ cm^2, where E_T is the threshold energy to produce a pair of

monopoles expressed in BeV. An even lower limit of $\sigma_c \leq 3.0 \times 10^{-45} E_T^2$ cm^2 is established if the monopoles are collected on the sample from surrounding ocean water.

432. Clarke C.J.S. Gen. Relativity Gravitation, 1971, vol.2, No 1, pp.43-51.

MAGNETIC CHARGE, HOLONOMY AND CHARACTERISTIC CLASSES: ILLUSTRATIONS OF THE METHODS OF TOPOLOGY IN RELATIVITY

433. Davydov V.N., Kukanov A.B., Usachev Yu.D. Vestn. Mosk. Univ., 1971, vol.3, pp.310-313.

TO THE PROBLEM OF IONIZATION LOSSES OF MAGNETIC CHARGE ENERGY IN A MEDIUM

The problem of magnetic charge dispersion on a free electrically charged particle is being studied on the basis of classical electrodynamics. The results obtained are applied for calculation of ionization losses of magnetic charge energy in a medium.

434. Dooher J. Grumen Research Department, Report RE-410J, June, 1971.

TRANSITION RADIATION FROM MAGNETIC MONOPOLES

See ref.:

435. Dooher J. Phys.Rev., 1971, vol.D 3, pp.2652-2660.

TRANSITION RADIATION FROM MAGNETIC MONOPOLES

Transition radiation from magnetic monopoles is calculated. The image picture is applied and compared with the rigorous solution of Maxwell's equations utilizing the symmetry between magnetic and electronic charges. Possible experimental applications are discussed in searching for monopoles in accelerators and cosmic radiation.

436. Eberhard P.H., Ross R.R., Alvarez L.M., Watt R.D. Phys. Rev., 1971, vol. D4, No 11, pp.3260-3272.

SEARCH FOR MAGNETIC MONOPOLES IN LUNAR MATERIAL

A search for magnetic monopoles in lunar material has been performed by the electromagnetic measurement of the magnetic charge of samples. All measurements were found consistent with zero charge for all samples and inconsistent with any other value allowed by the Dirac theory. Upper limits are determined for the monopole flux in cosmic radiation and for the pair-production cross section in proton-nucleon collisions.

437. Feld B. THE MODEL OF ELEMENTARY PARTICLES(In Russian), Izd. MIR, Moscow, 1971, p.434.

438. Fleischer R.L., Hart H.R.,Jr.,Nichols G.E., Price P.B. General Electric Company Corporate Research and Development , No 71-C-102, New York, 1971.

SEA LEVEL SEARCH FOR COSMIC MAGNETIC MONOPOLES

See ref.:

439. Fleischer R.L., Hart H.R.,Jr.,Nichols G.E.,Price P.B. Phys.Rev., 1971, vol.D4, No 1, pp.24-27.

SEA-LEVEL SEARCH FOR COSMIC MAGNETIC MONOPOLES

On the hypothesis that the highest-energy cosmic rays consist at least in part of magnetic monopoles, heavily ionizing particles have been sought at ground level using an 18-m^2 detector array exposed for 630 days. The observable flux of Dirac monopoles at ground level is less than 1.5 x $10^{-9}/m^2$-sec-str with 95% confidence. Monopoles are not the dominant cause of air showers lowing energies up to 30 x 10^{16} eV.

440. Flovers J.W. Bull.Amer.Phys.Soc., 1971, vol.16, No 7, p.787.

HIDDEN VARIABLES

The absence of magnetic charge in Maxwell equations denies symmetry. Quantitative symmetry also appears to be denied for electric charge. For charges of each kind having quantitative symmetry through extremely precise quantization

Maxwell equations reduce to: $\Delta \cdot E = P_e \cdot \nabla \cdot B = P_m \cdot C\,(\nabla \times B) = \partial E/\partial t + \partial P_e/\partial t$, and $-c(\nabla \times E) = \partial B/\partial t + \partial P_m/\partial t$ where P_e and P_m are polarizations. Each kind of charge requires a set of even integers equally divided according to signs with a unit quantum number , a significant number in the associated collective total. With suitable approximations and substitutions the usual Maxwell microscopic equations are derivable from these scale invariant equations. Evidently scale equations and theories using them, in effect, neglect symmetry provided by P_e and P_m and by no less than two differential quantum numbers arising with each charge observed and for each kind. The charge-position variables P_e and P_m are hidden or revealed only partially with collective and coherent effects associated with large differential quantum numbers or with uncertainty with small numbers.

441. Goldhaber A.S. and Nieto M.M. Rev.Mod.Phys., 1971, vol.43, No 3, pp.277-296.

TERRESTRIAL AND EXTRATERRESTRIAL LIMITS ON THE PHOTON MASS

We give a review of methods used to set a limit on the mass of the photon. Direct tests for frequency dependence oft the speed of light are discussed along with more sensitive techniques which test Coulomb's law and its analog in magnetostatics. The link between dynamic and static implications of finite u is deduced from a set of postulates that make Proca's equations the unique generalization of Maxwell's. We note one hallowed postulate, that of energy conservation, which may be tested severely using pulsar signals. We present the merits of the old methods and of possible new experiments, and discuss other physical implications of finite u. A simple theorem is proved; for an experiment confined in dimensions D, effects of finite u are of order $(u\,D)^2$ -there is no "resonance" as the oscillation frequency approaches u(h=c=1). The best results from past experiments are (a) terrestrial measurements of c at different frequencies.

441. Gomberoff L., Tolmachev V. Nuovo Cimento, 1971, vol.3A, p.657.

IS PARITY VIOLATED IN E WEAK INTERACTIONS?

The possibility of understanding weak interactions without violation of parity, by introducing pseudoscalar charges, is discussed. These pseudoscalar charges would tranform under parity as the hypothetical magnetic monopoles.

442. Gurevich I.I. Zh.Eksper. i Teor. Fiz. , 1971, vol. 61, No 5, p.1721.

SEARCH FOR THE DIRAC MONOPOLES AT THE 70 GeV PROTON SYNCHROTRON(IHEP, SERPUKHOV)

See ref.

443. Gurevich I.I., Khakimov S.Kh., Martmianov V.P., Mishakova A.P. Ogurtsov V.V., Tarasenov V.G., Barkov L.M. and Tarakanov N.M. Proceedings of the International Conference on Elementary Particles, Amsterdam, July 1-7, 1971.

444. Han M.Y., Biedenharn L.C. Nuovo Cimento, 1971, vol.2A, No 2, pp.544-556.

MANIFEST DUALITY INVARIANCE IN ELECTRODYNAMICS AND THE CABIBBO-FERRARI THEORY OF MAGNETIC MONOPOLES

One of the intrinsic symmetry properties of the Maxwell-Lorentz theory of electrodynamics is the invariance of the theory under " duality" transformation that is a dual transformation on fields and sources simultaneously. In this paper we give a manifestly duality-invariant formulation of electrodynamics. This is done by expressing the electromagnetic field tensors in terms of an antisymmetric tensor of rank two, called a Hertz tensor, consisting of electric and magnetic Hertz vector potentials. An equation is derived which relates the electromagnetic fields when sources consist of electric charges only, magnetic charges only, and both. The present formalism provides a natural physical basis for the Cabibbo-Ferrari theory in which two four-vector potentials and a mixed gauge transformation between them are introduced.

445. Khakimov S.Kh., Martemianov V.P. Priroda, 1971, No 5, pp.75-76.

SEARCH FOR DIRAC MONOPOLES AT SERPUKHOV ACCELERATOR

446. Jehle H. Phys.Rev., 1971, vol. D3, No 2, pp.306-345.

RELATIONSHIP OF FLUX QUANTIZATION TO CHARGE QUANTIZATIO AND THE ELECTROMAGNETIC COUPLING CONSTANT

447. Kolm H.H., Villa F., Odian A. Phys.Rev., 1971, vol.D4, No 5., pp.1285-1296.

SEARCH FOR MAGNETIC MONOPOLES

If magnetic monopoles exist, they are evidently too massive to have been produced in man-made radiation, too rare to have been observed directly in cosmic radiation, and too energetic to have accumulated in ferromagnetic surface minerals. Ocean water of more than the penetration depth would thermalize monopoles and allow them to accumulate in deep-sea sediment.The authors describe apparatus designed to extract magnetic monopoles from massive quantities of sediment.

448. Kox A.J. MAGNETIC MONOPOLES, 1971, vol.37, No 15, pp.377-378. Nederlands Tijdschrift Voor Naturkunde

449. Kukanov A.B., Davydov V.N. Optika i Spektroskopia, USSR, 1971, vol.30, No 5, pp.971-972.

POLARIZATION OF THE RADIATION OF MAGNETIC MONOPOLES MOVING IN A CONSTANT AND HOMOGENEOUS ELECTRIC FIELD
(In Russian)

See ref.

450. Kukanov A.B., Davydov V.N. Opt.Spektr., USSR, Engl.transl. 1971, vol.30, No 5, pp.516-517.

POLARIZATION OF THE RADIATION OF MAGNETIC MONOPOLES MOVING IN A CONSTANT AND HOMOGENEOUS ELECTRIC FIELD

See ref.

451. Kutyur K. Priroda (Russ.), 1971, No 5, pp.73-75.

CHASE FOR MAGNETIC MONOPOLES

452. Lepton and Photon Physics in Europe. In: Proceedings of the Daresbury Study Weekend, 1-3 oct.1971, ed. by A.Donnachie, p.169.

SEARCH FOR DIRAC MONOPOLES

453. Lubkin E. Amer.J.Phys., 1971, vol.39, p.94.

A SIMPLE PICTURE FOR DIRAC'S CHARGE-POLE QUANTIZATION LAW

If something appears to bear a magnetic monopole of strength g not equal to the quantized charge of Dirac, as a result of measurement of the magnetic field about it over most of the 4 solid angle, then at least one visible bar magnet will be found by the electron-optical interferometric experiment of Aharonov and Bohm, in the remaining solid angle.

454. Malkin I.A., Man'ko V.I. Preprint FIAN SSSR, No 1,1971.

455. Mavrychev Yu.S. Izvestia Vuzov, ser.fiz., No 6, pp.135-136, 1971.

ON CALIBRATED TRANSFORMATIONS IN A MAGNETIC MONOPOLE THEORY

456. Martemianov V.P. IHEP,Candidate's Thesis,1971,Serpukhov.

SEARCH FOR DIRAC MONOPOLE AT THE 70 GeV PROTON SYNCHROTRON, IHEP

457. McIntosh H.V. GROUP THEORY AND ITS APPLICATIONS. Ed. E.M.Loebl, vol.II,1971, pp.101-105.

458. Mitskevich N.V. PHYSICAL FIELDS IN THE GENERAL THEORY OF RELATIVITY, Izd. NAUKA,Moscow, 1971.

459. Miller D.T. Proc.Cambridge Phil.Soc.,1971, vol.69, p.449.

COMMENTS ON THE CLASSICAL THEORY OF MAGNETIC MONOPOLES

The classical theory of electromagnetism with both electric and magnetic charges is discussed. Following Gamblin(1) we proceed from an action principle and investigate the resulting particle equations. A constant theory in which electrically and magnetically charged particles interact amongst themselves and with each other, without any constraints, is shown to be possible in contrast to the conclusions of Gamblin. The introduction of constraints is considered.

460. Newmeyer J.L., Trefil J.S. Phys.Rev.Lett., 1971, vol.26, p.1509.

MODEL FOR THE PRODUCTION OF PARTICLES WITH SUPER-STRONG INTERACTION: ESTIMATES OF LOWER BOUNDS ON THE QUARK AND MONOPOLE MASSES

When particles like quarks and magnetic monopoles are produced in pairs, there is a suppression of the production due to the superstrong attractive forces which exist betwee the constituents of the pair. We present an approximate way of incorporating this effect into a production model and estimate lower bounds on the masses of the particles from present experimental data using our method in conjunction with the standard statistical model.

461. Newmeyer J.L. University of Virginia, Dept.of Physics, Charlottesville,Virginia,1971.

SPECULATIONS ON INDIRECT SEARCH FOR MAGNETIC MONOPOLES

462. Newmeyer J.L. Univ.of Virginia, Dept. of Physics, Charlottesville, Virginia, July 27, 1971.

A LETTER TO DR.TREFIL J.S.

463. NO MONOPOLES. Sci.News, 1971, vol.99, No 7, p.115.

464. Ozaki S. 9-43 Ochiai, Nishimachi, Chiryushi, Aichiken, 472, Japan, 1971.

O (4) SYMMETRY OF THE HYDROGEN ATOM WITH MAGNETIC MONOPOLE AND WITH INVERSE SQUARE DISTANCE POTENTIAL

465. Peshkin M. Ann.Phys. (N.Y.),1971, vol.66, No2, pp.542-547

ELEMENTARY ALGEBRA OF THE EUCLIDEAN GROUP WITH APPLICATION FOR MAGNETIC CHARGE QUANTIZATION

A simple treatment of the algebra of the Euclidean group E 3 is based on the introduction of a second group of rotations. Dirac's quantization of magnetic charge appears as the quantization of the generator of rotations about the axis connecting the electric and magnetic charges

466. Pestov A.B. JINR, Dubna,P2-5798, 1971.

CONNECTION BETWEEN THE DIRAC NAD THE MAXWELL EQUATIONS

It is shown that in the Dirac equations over the Klifford Algebra the Maxwell equations and some other field equations are contained. The connection between the duality rotation for the neutrino and electromagnetic fields, is established.

467. Picasso E. European Organization for Nuclear Research, CERN,Geneva, 1971.

QUANTUM ELECTRODYNAMICS:PRESENT STATUS OF THE THEORY

468. Rzazewski K., Acta Phys.Polon.,1971, vol.B2,pp.707-711.

ON THE MOTION OF DYONS

The paper deals with the problem of motion of two dyons (particles with electric and magnetic charges) in relativistic classical mechanics. It is shown that the Bohr-Sommerfeld quantization rules lead to an exact formula for energy levels.

470. Schwinger J. Uspekhi Fiz.Nauk, 1971, vol.103, p.355.

A MAGNETIC MONOPOLE OF MATTER (In Russian)
See ref.

471. Strazhev V.I. Vestsi Akad.Nauk Belorussk.SSR, ser. fiz.-mat., 1971, No 1, pp.106-112.

TO THE PROBLEM OF THE CLASSICAL THEORY OF MAGNETIC CHARGE

A possibility of a limiting transition to electrodynamics of electrically and magnetically charged particles at a universality of g/e ratio, which is equivalent to a particle electrodynamics with one effective charge $q = (e^2 + g^2)^{1/2}$ is considered as a correctness criterion for a magnetic charge theory.

The approach with two independent potentials does not satisfy this criterion contradictory to an approach based on a singularity line introduction at preservation of one independent potential.

From the analysis to build a classical theory of a magnetically charged particle it follows that introduction of the magnetic charge is not connected with the increase of a number of degrees of freedom for an electromagnetic field.

472. Strazhev V.I. Izvestia Akad.Nauk Belorussk.SSR, ser. fiz.-mat., 1971, No 5, p72.

DUAL SYMMETRY OF AN ELECTROMAGNETIC FIELD

473. Strazhev V.I. Doklady Akad.Nauk Belorussk.SSR,1971, vol.15, No 10, pp.885-888.

TO THE CONDITION OF CHARGED QUANTIZATION IN A MAGNETIC CHARGED THEORY

474. Tarkhanian R.G. Dokl.Akad.Nauk Arm.SSR,1971, vol.53, No 3, pp.156-161.

ELECTRODYNAMICS OF DUAL CHARGED PARTICLES

Develops a dual-charged electrodynamics in contrast to Dirac.

475. Tomil'chik L.M. Lecture at International School of Young Scientists, Gomel, 1971, (JINR, Dubna, 2-6371, 194, 1972).

MAGNETIC CHARGE PROBLEM

476. Tompkins D.R., Jr. Phys.Rev., 1971, vol.D 4, p.1268.

WOULD SHOWER CORES OR RELATIVISTIC MONOPOLES PRODUCE STRIGHT LIGHTNING?

Can the atmosphere below thunderclouds act as a giant spark chamber for the detection of ultra high-energy shower cores or relativistic monopoles?

The return stroke of ordinary lightning is crooked because the stepped leader is crooked and changes direction at most steps. In multiple strokes the subsequent strokes are preceded by a leader following the ionization channel of the previous return stroke. The cause of leaders occasionally leaving old stroke channels is found to be atomic and molecular negative ions inside and outside old stroke channels respectively. From this it is shown that the ionization in shower cores and possibly that in monopole paths would be capable of carrying a lightning leader which would then be straight and result in a straight return stroke. An important question is: would the ionization from a shower core or relativistic monopole initiate a lightning leader? It is shown that radio emission plus shower counter data may be able to answer this. Artificial initiation of lightning shows that even thunderclouds without spontaneous lightning maintain large potential gradients over large areas for significant periods of time. Straight lightning may lack the normal preleader radio emission of spontaneous lightning. Thundercloud conditions for straight lightning may be more favourable over ocean than land areas.

477. Trefil J.S., Newmeyer J.L. Bull.Amer.Soc., 1971, vol.16, No 4, p.528.

A MODEL FOR THE PRODUCTION OF PARTICLES WITH SUPERSTRONG INTERACTIONS AND AN ESTIMATE OF THE LOWER BOUND OF QUARK AND MAGNETIC MONOPOLE MASSES

We present a semi-classical treatment of the final-

state interactions that would inhibit the free production of such superstrongly interacting particles as quarks and magnetic monopoles, which must be produced in pairs. This treatment can be incorporated into any standard production model. Using the Hagedorn statistical model of strong interactions as our production model, and assuming that monopoles and quarks have a component that interact strongly with the hadrons we are able to set new lower limits on the particles' masses of 3.2 GeV for the Dirac monopole (eg)hc= 1/2 and 1.75 GeV for the quark. We also find that unless the monopole mass is below the currently popular value of 5 GeV it is unlikely that we shall observe that particle directl

478. Yoshio Yamaguchi J.Phys. Soc.Japan, 1971, vol.31, No 6, pp.1605-1607.

A POSSIBILITY OF P,T VIOLATING BUT C=PT CONSERVING STRONG INTERACTIONS

A possibility of P- and T- violating but C=PT conserving strong interactions is discussed. It is pointed out that there exist strong interaction models in which P and T reasonably well satisfied at low momentum trasfer regions while they are violated in large momentum trasfer phenomena. (Another possibility is given by C- and T- violating but P=CT invariant strong interactions). The two pion decay of the long-lived neutral kaon can naturally be interpreted as the clash between C(or P) conserving strong interactions and T invariant weak couplings.

This type of strong interaction model can naturally be formulated on the basis of Schwinger's dyon theory. It is suggested that the mass of syons (dually charged particles is roughly fifteen times nucleon mass.

479. Zrelov V.P., Kollarova L., Kollar D., Pavlovic P., Ruzicka J., Sabasov M.F., Sulek P., Janik R. 1971, Dubna, USSR, Proceedings of the International Conference on Instrumentation for High-Energy Physics, 1971, pp.479-481.

METHODS FOR SEARCHING FOR MAGNETIC CHARGES USING HIGH-ENERGY ACCELERATORS

Equipment was designed for making a search for Dirac's

monopole in the internal beam of the 70 GeV proton synchrotron. A proton beam is aimed at a target of optical quartz. Vavilov-Cherenkov radiation originates in the target and is emitted through windows of the accelerator. Discrimination of charged particles according to the polarized Vavilov-Cherenkov radiation may be enhanced through use of a supplementary analyzer, based on a difference in the reflecting ability of light of different polarizations from glass surface close to Brewster's angle.

480. Zwanziger D. Phys.Rev., 1971, vol.D 3, p.880.

LOCAL-LAGRANGIAN QUANTUM FIELD THEORY OF ELECTRIC AND MAGNETIC CHARGES

We present a local Lagrangian density, depending on a pair of four-potentials A and B , and charged fields ψ_n with electric and magnetic charges e_n and g_n. The resulting local Lagrangian field equations are equivalent to Maxwell's and Dirac's equations.

The Lagrangian depends on a fixed four-vector, so manifect isothropy is lost and is regianed only for quantized values of ($e_n g_m - g_n e_m$). This condition results from the requirement that the representation of the Poincaré group. The finite Lorentz transformation laws of A,B and ψ_n are presented here for the first time. The familiar apparatus of Lagrangian field theory is applied to yield directly the canonical commutation relations the energy-momentum tensor, and Feynman's rules.

1972

481. Adair R.K. Proceedings of the XVI International Conf. on High Energy Physics, 1972, Chicago, vol. 4,pp.307-319.

PRESENT POSITION AND FUTURE PROSPECTS FOR DISCOVERY OF NEW PARTICLES

Review of particle searches including monopoles.

482. Amaldi E. and Cabibbo In: ASPECTS OF QUANTUM THEORY, ed. by Salen A. and Wigner E.P., Cambridge, University Press, 1972, pp.183-212.

ON THE DIRAC MAGNETIC POLES

483. Bakesigaki A., Inomata A., Friedel J. Bull.Amer. Phys. Soc., 1972, vol.17, No 4, p.515.

GEOMETRIC MODEL FOR DYONIUM

Barut's dyonium is a two-dyon atom treated in an SO(4,2) scheme to give the baryon or meson towers.

484. Barkov L.M., Gurevich I.I., Zolotarev M.S.,Makar'ina L.A. Martem'yanov V.P., Mishakova A.P., Ogurtsov V.V.,Okhapkin V.S., Tarakanov M.N., Tarasenkov V.G., Khakimov S.Kh.,and Chernysheva L.A. Proceedings of the XVI Int. Conf. on High Energy Physics, Chicago, 1972, vol.2, pp.336-339.

SEARCH FOR MAGNETIC MONOPOLES AT THE 70 GeV IPHE PROTON SYNCHROTRON

$\sigma(95\%) < 1.4 \times 10^{-43}$ at Serpukhov using a ferromagnetic tape.

485. Bartlett D.F., Lahana M.D. Phys.Rev., 1972, vol.D 6, pp.1817-1823.

SEARCH FOR TACHYON MONOPOLES

We have searched for a magnetically charged particle that travels faster than light. These particles would be detected by the Cherenkov radiation they emit moving in a

magnetic field. We find that the cross sections for photoproduction of these particles by 1 MeV gamma-rays in lead and water are less than 0.6×10^{-36} cm^2 and 2×10^{-3} cm^2 respectively. These results are subject to some assumptions about the hypothetical particles.

486. Bartlett D.F., Lahana M.D. University of Colorado, Dept.of Physics and Astrophysics, Colorado,1972,

SEARCH FOR TACHYON MONOPOLES

See ref.

487. Barut A.O. Univ. of Colorado, Boulder, Colorado, 1972.

LECTURES ON MAGNETIC CHARGES AND THE ELECTROMAGNETIC THEORY OF HADRONS AND STRONG INTERACTIONS

488. Barut A.O. International Center for Theoretical Physics, IC/72/114, Trieste, Italy,1972.

FERMION STATES OF A BOSON FIELD

The spin 1/2 bound state of two spinless doubly-charged particles (dyons) provides another example of a fermion state of the underlying electromagnetic boson field and, contrary to recent claims, does not require abnormal statistics for the spin 0 dyons. The wave functions of dyonium are shown to be elements of the space $L^2(R^2 \otimes S^2)$. A generalization of the Ehrenfest-Oppenheimer Theorem is given.

489. Barut A.O. Phys.Lett., 1972, vol.38B, p.97.

SUPERSELECTION RULE FOR MAGNETIC CHARGES AND THE SEARCH FOR MAGNETIC MONOPOLES

We show that (a) one can construct a quantum mechanics of particles with electric and pseudoscalar magnetic charges in which parity and time reversal are conserved, (b) in a chiral invariant and parity invariant theory there is no superselection rule for magnetic charges, $|g\rangle \pm |{-g}\rangle$, in which the expectation value of the magnetic charge vanishes cannot be split in electromagnetic interactions by energy measurement. The hypothesis that

magnetic charges occur in the superpositions can possibly be tested.

490. Borzin G.L. Univ. of Colorado, Ph.D.Thesis.

491. Brand R.A.,Vinciarelli P. Lett. Nuovo Cim., 1972,vol.3, p.254.

STRUCTURE ON THE WEAK INTERACTION

492. Chang Chen-Kun Phys.Rev., 1972, vol.D 5, No 4., pp.950-963.

MAGNETIC QUARKS AND ELECTRIC QUARKS IN HADRONS

Dirac's magnetic monopoles are generalized to have aspects which are similar to the conventional quarks (electric quarks). Such magnetic monopoles are called magnetic quark. This work assumes that a baryon consists of three solid bodies called electromagnetic quarks, and that an electromagnetic quark and an electromagnetic antiquark form a meson. Each of these electromagnetic quarks is considered to be composed of one electric quark and one magnetic antiquark. Such a speculation solves the difficulty in statisitcs faced by the paraquark model and allows the existence of anomalous charge conjugation parity C of mesonic states. New baryon mass relations and magnetic moments have been derived.Finally, a strong electric dipole moment is predicted to exist in a baryon state with non-zero electromagnetic-quark orbital angular momentum, $L \neq 0$.

493. Efinger H.J. From Symposium on the Structure of Matter 1972, Portland, Oregon International Scholarly Book Services, Inc., p.158.

MAGNETIC POLES AND CHARGE QUANTIZATION

Model for interaction between electric and magnetic charges. Interaction takes place in a uniform magnetic field. Motion of electrically charged particles is then subject to a simple quantization condition.

494. Feneulle S., Crubellier A. J.Phys.A (London), Gen.Phys., 1972, vol. 5, No 7, pp.944-949.

QUATERNIONIC SOLUTIONS FOR THE RELATIVISTIC KEPLER PROBLEM WITH MAGNETIC CHARGES

The relativistic Kepler problem in Dirac form is solved by means of a quaternionic method for particles having both electric and magnetic charges. The variables in spherical coordinates can be separated in a simple way and the results obtained are similar to those which are valid for the usual hydrogen atom.

495. Gryzinski M. Phys.Lett., 1972, vol.47, No 2, pp.678-692.

FREE-FALL SOLUTION OF THE KEPLER PROBLEM IN THE PRESENCE OF THE MAGNETIC MOMENT

496. Gurevich I.I., Khakimov S.Kh., Martemianov V.P.,Mishakova A.P., Makar'ina L.A., Ogurtzov V.V., Tarasenkov V.G., Chernyshova L.A., Barkov L.M., Zolotarev M.S., Ohapkin V.S., Tarakanov N.M. Sov.Phys.Engl.Transl.: JETP, 1972, vol.34, p.917.

SEARCH FOR MAGNETIC MONOPOLES AT THE 70 GeV IPHE PROTON SYNCHROTRON

See ref.

497. Henriksen R.N. and Chia T.T. Nature - Phys.Sci., 1972, vol.240, p.133.

ACCRETION VORTICES AND X-RAY SOURCES

Discusses magnetized stars. Does not suggest how proposed monopole strength is introduced.

498. Gurevich I.I., Khakimov S.Kh., Martemianov V.P., Mishakova A.P Makar'ina L.A., Ogurtzov V.V., Tarasenkov V.G., Chernyshova L.A., Barkov L.M., Zolotarev M.S., Ohapkin V.S., Tarakanov N.M. Phys.Letters, 1972, vol.38B, pp.549-550.

SEARCH FOR MAGNETIC MONOPOLES AT THE 70 GEV IPHE PROTON SYNCHROTRON

The result of a search for magnetic charged particles at the 70 GeV IPHE proton synchrotron is presented. Using the ferromagnetic trap method the upper limit of the magnetic monopole production cross-section in proton-nucleon collisions was found to be σ (95%) $\leq$ 1.4×10^{-43} cm^2.

499. Jehle H. Phys.Rev.,1972, vol. D 6, No 2, p.441.

FLUX QUANTIZATION AND PARTICLE PHYSICS

500. Jehle H. George Washington University Preprint,1972.

- NOT A MONOPOLE PAPER

Suggests that a quark be considered as a closed quantized flux loop if interlinked with other flux loops.

See ref.:

501. Joseph A. Phys.Rev., 1972, vol.5, No 2, pp.313-320.

MAGNETIC SPIN MONOPOLE FROM THE YANG-MILLS FIELD

A generalization of the magnetic monopole has been derived in the context of the Yang-Mills field. This is achieved through the observation that the quantization of the ordinary magnetic monopole derives from closure of the angular momentum and magnetic field components on the Lie algebra of the Euclidean group E(3) and the fact that the Yang-Mills field is the generalization of the Maxwell field obtained by replacing the ordinary derivative by a co-variant derivative. This leads to defining equations for the generalized monopole which are explicitly solved for the case when SV(2) is the gauge group of the field. The resulting system referred to as the spin monopole, is investigated in some detail.

502. Klotz A.H. Acta Phys.Pol., 1972, vol. B3, No 3, pp.341-354.

REVISED NONSYMMETRICAL UNIFIED FIELD THEORY

A further development of the Einstein-Kauffman nonsymmetric unified field theory is discussed.Static spherically symmetric solutions of the field equations are considered. It is shown that there does not exist a solution corresponding to a magnetic monopole.In the purely electric case, one of Papapetrou's solutions is recovered and a new "cosmological" solution is found in which the space-time metric is that of a flat Minkowski world but a diverging electric field is present.It is pointed out that the theory may be significant as an account of charged matter.

503. Konopleva N.P., Popov V.N. CALIBRATED FIELDS, Moscow, 1972, p.84.

504. Mahanthappa K.T. Department of Physics University of Colorado, Boulder, Colorado, 1972.

Comments on "FERMION STATES OF A BOSON FIELD" by A.O.Barut

505. Mahanthappa K.T. Phys.Rev., vol.D6, 1972, p.1028.

PARASTATISTICS,DYONS AND DYONIUM

It is pointed out that if the bound state (BS) of two normal or para-particles (say,dyons) having electric and magnetic charges (e_1, e_2) is a normal or para-particle, (i) the BS is a normal or para-boson if both dyons are norma or para-bosons or normal or para-fermions, and (ii) it is a normal or para-fermion if one dyon is a normal or para-boson and the othe a normal or para- fermion. This observation combined with the egular connection between spin and statistics and the Dirac quantization condition, $e_1g_2-e_2g_1=$ yields only integer values of ν for the BS. Thus the

dyonium model of proton expounded by Barut is invalidated. But it can be rescued if the regular connection between spin and statistics is violated for dyons so that one of the spinless dyons, of which the dyonium is made, is a normal boson and the othe spin-0-fermion. Comments are made concerning this violation along the lines of Greenberg and Messiah. Also, comments are made concerning the significance of the O(4,2)-wave equation used by Barut in the relativistic domain (in Ref.9).

506. Martemianov V.P., Khakimov S.Kh. Inst. of Atomic Energy, Moscow, 1972.

SLOWING-DOWN OF THE DIRAC MONOPOLES IN METALS AND AND FERROMAGNETIC SUBSTANCES

507. Martemianov V.P., Khakimov S.Kh. Zh.Eksp.Teor.Fiz., 1972, vol.62, No 1, pp.35-41.

SLOWING-DOWN OF THE DIRAC MONOPOLES IN METAILS AND FERROMAGNETIC SUBSTANCES

Estimates are made of slowing-down of the Dirac monopole in metals and ferromagnet. It is shown that ferromagnetic substances in strong magnetic fields ($\sim 10^4$ G) are effective traps for magnetic monopoles.

508. TOPICS IN HIGH ENERGY PHYSICS - APPROXIMATIONS IN MULTIPLE SCATTERING THEORY AND MAGNETIC MONOPOLE PRODUCTION

509. Martemianov V.P., Khakimov S.Kh. Sov.Phys.-Engl.Transl.: JETP, 1972, vol.35, p.20.

SLOWING-DOWN OF THE DIRAC MONOPOLE IN METALS AND FERROMAGNETIC SUBSTANCES

510. Murai N. Prog.Theor.Phys.,1972, vol.47,No 2,pp.678-692.

ON AN ANALOGUE OF MAGNETIC MONOPOLE IN A GENERAL GAUGW FIELD

The concept of an analogue of magnetic charge is introduced into the Yang-Mills field by reference to local singularities of the calssical field. On the basis of the gauge-invariant and path-dependent formalism the one - valuedness of the path-dependent quantities for a scalar field interacting with the Yang-Mills field imposes a quantum condition on the coupling constant. When the Yang-Mills field is analytic in spacetime, this property leads to consistency condition analogous to the homogeneous Maxwell equations and to Bianchi identities in the theory of the general relativity. A simple example with a non-trivial (non-zero quantum number) quantum condition is presented in a way compatible with the framework of non-relativistic quantum mechanics where the Yang-Mills field works on the scalar field as can external field. Additional remarks on more general gauge fields are appended.

511. Newmeyer J.L. Univ. of Virginia, Thesis,1972.

TOPICS IN HIGH ENERGY PHYSICS- APPROXIMATIONS IN MULTIPLE SCATTERING THEORY AND MAGNETIC MONOPOLE PRODUCTION

Second part of thesis covers magnetic monopole production.

Prediction

Monopole production cross sections for nucleons and photons.

512. Newmeyer J.L., Trefil J.S. Phys.Lett., 1972, vol.38B, No 7, pp.524-526.

MAGNETIC MONOPOLE PRODUCTION BY VIRTUAL PHOTONS

We estimate the magnetic monopole pair production cross section from internal virtual photons in pp-collisions. Comparing predictions to the only accelerator experiment to date gives a lower mass limit $M \geq 5$ GeV for monopoles produced by this mechanism. Comparison to

the Lunar data is made, and provided one accepts several assumptions, a limit of $M \gtrsim 100$ GeV is obtained. The inclusion of final state interaction between monopole and antimonopole is found not to modify the features of the other results.

513. Newmeyer J.L. and Trefil J.S., Nuovo Cimento, 1972, vol. 8 A, No 4, pp.703-721.

SPECULATIONS ON INDERECT SEARCHES FOR MAGNETIC MONOPOLES

The superstrong interaction between amgnetic suppresses the production rate of free monopoles and antimonopoles below what one would expect on the basis of standard production models, since, even when a monopole and an antimonopole are created , it is very likely they will be drawn together annihilate rather than escape each other. This makes it very difficult to search for them directly. In this paper we speculate on the feasibility of various techniques which could be used to infer the existence of monopoles indirectly. In particular, it may sometimes be possible to recognize a monopole antimonopole annihilation by its products, which for our pruposes we take to be showers of photons. Our conclusions as to the appropriateness of various methods as a function of monopole mass and (magnetic) charge are summarized in Fig.2; the indirect methods are expected to be suited to look for monopoles of high magnetic charge.

514. Pant D.N. J.Phys. A(London): Gen.Phys., 1972, vol.5, No 2, pp.225-227.

EXTERNAL FIELD OF A NONSTATIC ISOLATED SYSTEM IN BONNOR'S UNIFIED FIELD THEORY

The field equations of Bonnor's unified theory have been considered to obtain the external field of a general nonstatic spherically symmetric isolated system containing electric and magnetic charges associated with matter. It has been found that there exists only one nontrivial solution and it represents a static isolated magnetic monopole.

515. Ramana Murthy P.V. Proceedings of the I. Symp. High Energy Phys., Bombay, 1972, pp. 187-205.

STATUS REPORT ON ELUSIVE PARTICLES

Review of particle searches including upper limits as of 1972.

516. Rzazewski K. Warsaw University, Inst. of Theor. Phys., Warsaw, Poland, 1972.

ON THE MOTION OF DYONS

517. Strazhev V.I. Theor. Mat. Fiz., 1972, vol. 13, No 2, pp. 200-208.

DUAL SYMMETRY OF QUANTUM ELECTRODYNAMICS

It is shown that dual symmetry formulation of quantum electrodynamics can be given not introducing a new type of particles - The Dirac monopoles. Basing on this conception an analysis of a magnetic charge quantum theory is made. There has been given a new argument in favour of the obligatery character of charge quantization condition in the theory.

518. Strazhev V.I., Nguen Vin Kvang Yadern. Fiz., 1972, vol. 16, No 3, pp. 614-619.

ABOUT DISCRETE SYMMETRIES IN ELECTRODYNAMICS

It is shown that the traditional character of transformation of electromagnetic field under space inversion and time reversal is a particular case of the most common transformations. It is based on the possibility to formulate electrodynamics with one type of charge in dual symmetrical form.

519. Strazhev V.I. Materials of the Second All-Union Conference of Young Scientists, Minsk, 1972.

520. Schiff H. Canad.J.Phys., 1972, vol.50, No 11,pp.1062-1067.

DUALLY CHARGED PARTICLES AND DUAL INVARIANCE

Dual charges are introduced which differ essentially from the conventional(Dirac) magnetic monopoles. A natural vehicle is shown to be a dual invariant Lagrangian to represent observable charges; the dual invariance can be broken in a simple way by a class of dually charged objects which exhibit no electromagnetic interaction with observable dually charged particles. A triplet formulation can also be obtained and may be of interest in providing a basic description of bosons and fermions.

521. Suh P.K. and Erickson W., Plasma Phys., 1972, vol.14,p.981.

DISPERSION RELATION FOR CHERENKOV RADIATION OF MOVING TEST PARTICLES IN A MAGNETOPLASMA

The general radiative criterial for the Cherenkov spectrum emitted from moving test particles in a magnetoplasma are investigated by analyzing the radiative dispersion relation. The radiative criteria are given in explicit forms that are readily adaptable to the calculation of radiations emitted from various test particles.The results of the analysis have a bearing on a number of astrophysical and terrestrial proble as well as on the laboratory determination of the test particle properties.

522. Tiwari R., Pant D.N. J.Phys.A(London),1972, vol.5, No 3, pp.394-400.

NONEXISTENCE OF ISOLATED CHARGED MONOPOLES IN UNIFIED FIELD THEORIES

The possibility of the existence of isolated electric charg giving rise to a spherically symmetric electrostatic field has been considered in each of the unified field theories of Einstein, Schrödinger and Bonnor. It has been proved that none of these theories admits such a possibility.

523. Tiwari R., Pant D.N., Bandaras Hindu Univ., India, 1972.

NONEXISTENCE OF ISOLATED CHARGED MONOPOLES IN UNIFIED FIELD THEORIES

524. Tomil'chik L.M. In: International School of Young Physicists on High Energy Physics, Gomel, 1971. Dubna, 1972, JINR 2-6371, p.144.

MAGNETIC CHARGE PROBLEM

525. Usachev Yu.D. P.N.Lebedev Phys.Inst.Acad. of Sci. USSR, Preprint FIAN, No 111, Moscow, 1972.

ACTUAL STATES OF THE PROBLEM OF THE MAGNETIC CHARGE
(In Russian)

526. Usachev Yu.D. Translated at CERN from Russian, CERN-Transl.-72-1.

ACTUAL STATES OF THE PROBLEM OF THE MAGNETIC CHARGE

527. Vinciarelli P. Phys.Rev., 1972, vol. D6, No 12, pp.3419-3421.

MONOPOLE THEORY WITH POTENTIALS

The Cabibbo-Ferrari two-potentials formalism is used to construct a representation of the gauge-independent electrically and magnetically charged Mandelstam field. This representation is applied to convert the Cabibbo-Ferrari-Coleman formulation of monopole theory into a more conventional one in terms of gauge-dependent fields and potentials.

528. Vinti J.P. J.Geophysical Res., 1972, vol.77, p.2404.

TESTING GEOMAGNETIC DATA BY INCLUDING A MONOPOLE TERM IN THE SPHERICAL HARMONIC REDUCTION

If cosmic rays incident on the earth contained unequal numbers of positive and negative monopoles or if the latter were present in unequal numbers at the time of the formation of the earth, one would expect the earth to have a small magnetic monopole moment.

529. Wilcox J.M. Comments Astrophys. Space Phys., 1972, vol. 4,p.141.

WHY DOES THE SUN SOMETIMES LOOK LIKE A MAGNETIC MONOPOLE

Reviews puzzling observation of an apparent solar magnetic monopole in 1965.

530. Yamaguchi Y. J.Phys.Soc. Japan ,1972, vol.32,p.316.

A POSSIBILITY OF PARITY NON-CONSERVING STRONG INTERACTIONS

A possibility of parity-violating strong interactions is discussed. A particular emphasis is amde in order to understand the unique situation: the parity conservation could be satisfied with very good accuracies for low energy phenomena in nuclear and particle physics even when strong interactions are P-violating.

531. Zavada J. M.F., Jr. Phys.Rev., 1972, vol.D 6, No 2, pp.677-696.

MAGNETIC DIPOLE MOMENT OF THE ELECTRON IN THE LADDER APPROXIMATION

In order to calculate the magnetic dipole moment of the electron in a nonperturbative manner, the vertex function of quantum electrodynamics is studied in the Ladder approximation. The vertex function is written as the sum of form factors and coupled linear integral equations are derived for these form factors. After converting the system of integral equations into differential equations, the form factors are expressed by means of an infinite series. By using the leading term in the series solution the approximation is considered in the limit of a large coupling constant g, and the electric dipole moment μ_E, of a magnetic monopole with mass M is found to be $\mu_E \sim [\sqrt{2}(4\pi)^2 g^{-5/2}]$ g/2M. Assuming the neutron to be a bound state of magnetic monopoles, the electric dipole moment of the neutron is estimated as being 10^{-18} e cm.

532. Zrelov V.P., Kollar D., Pavlovich P., Ruzicka J., Shabashov M.F., Shulek P., Janik R., Sidorova V.I.
Inventors' sertificate No 330792.
Bulletin OIPOTZ No 16, Moscow, 1972, p.247.

533. Zrelov V.P., Kollarova L., Kollar D., Lupil'tsev V.P., Pavlovich P., Ruzicka J., Sidorova V.I., Shabashov M.F., Sulek P., and Janik R.
Proceedings of the XVI International Conference on High Energy Physics, J.D. Jackson, A. Roberts, and R.Donaldson - Ed., 1972, vol.2, pp.340-343.

PRELIMINARY EXPERIMENTAL RESULTS ON A SEARCH FOR THE DIRAC MONOPOLE AT THE 70 GEV IHEP SYNCHROTRON USING VAVILOV-CHERENKOV RADIATION

534. Zwanziger D. Phys.Rev., 1972, vol. D 6, pp.458-470.

ANGULAR DISTRIBUTIONS AND A SELECTION RULE IN CHARGE-POLE REACTIONS

In the scattering of electrically and magnetically charged particles, it is found that, besides the orbital and spin angular momentum of each particle, there is a residual angular momentum in the electromagnetic field of the in or out scattering states.

535. Acharya R. and Horvath Z. Nuovo Cimento Lett.,1973,vol.8, No 8, pp.513-519.

TAYLOR'S NONCLASSICAL THEORY OF MAGNETIC MONOPOLES AS A SPONTANEOUSLY BROKEN $U_{L1} \times U_{R1}$ MODEL

Monopole is static limit has no charge and is not an inverse square field. Get C_γ P_γ (T_γ) violation.

Predictions:

Electron mass
Electron electric dipole moment
Zero magnetic charge in static limit

536. AGAIN ON THE MONOPOLE (In Russian), Nauka i Zhizn(Russ.), 1973, No 9, p.17.

537. Bacry H. and Kubar-Andre J. Int. J.Theor.Phys., 1973, No 1-2, vol.7, pp.39-47.

GALILEAN INVARIANCE AND MAGNETIC MONOPOLES

The existence of Dirac monopoles is shown to be incompatible with Galilean invariance. A discussion follows on the interpretation of monopoles physics in a Galilean approximation.

538. Barut A.O. Proceedings of the Schladming Winter School, 1973, Int. Cent. for Theor.Phys., IC/73/34, Trieste,1973.

539. Barut A.O., Bornzin G.L. Phys.Rev., 1973, vol. D 7, p.3018

NEW RELATIVISTIC COULOMB HAMILTONIAN WITH O/4/ SYMMETRY AND A SPINOR REALIZATION OF THE DYNAMICAL GROUP O/4,2/

The Dirac-Coulomb Hamiltonian with simple modification of the scalar potential corresponding to switching off the interaction of the small components is solved by a new "squaring" procedure and is shown to describe a system

possessing O/4/ symmetry. The new realization of the generators of the corresponding O/4,2/ dynamical group shows a non-trivial but natural mixing of the space and spin coordinates in which the total angular momentum replaces the usual orbital angular momentum.

540. Barut A.O. Int.Cent. for Theor.Phys, IC/73/33, Trieste, 1973.

THE IMPOSSIBILITY OF SPITTING THE SUPERPOSITION OF STATES OF OPPOSITE MAGNETIC CHARGES IN EXTERNAL ELECTROMAGNETIC FIELDS

See ref.

The postulated coherent states of magnetic charges $|A_{\pm}\rangle = |g\rangle \pm |-g\rangle$ are shown to obey a superselection rul as in the case of the eigenstates of electric charge; an important result for the problem of experimental detectio of magnetic monopoles.

541. Barut A.O. Int.Cent.for Theor.Phys.,Trieste,1973.

MAGNETIC CHARGES AND STRINGS AS BUILDING BLOCKS OF HADRONS-CONNECTION BETWEEN ELECTROMAGNETIC AND DUAL STRINGS

Starting from a very simple physical model involving magnetic charges, it is shown how one can obtain the internal dynamical properties of hadrons.

542. Barut A.O. Proceedings of the Schladming Winter School 1973. Int.Cent.for Theor.Phys., IC/73/34, Trieste, 1973.

543. Barut A.O. Int.Cent.for Theor.Phys., IC/73/74, Trieste, 1973.

MANGETIC CHARGES AND STRINGS AS BUILDING BLOCKS OF HADRONS-CONNECTION BETWEEN ELECTROMAGNETIC AND DUAL STRINGS

Suggests that magnetic charge occurs in parity eigenstates rather than in eigenstates of magnetic charge. Discusses string excitations.

544. Barut A.O. and Föster D. Int.Cent.for Theor.Phys., IC/73/105, Trieste, 1973.

RELATION BETWEEN THE DUAL STRING AND THE DIRAC STRING

We compare the singular part of the action in Dirac's theory of magnetic charges with the action of the string in dual models and find that they are identical up to an inifinite factor. A method of regularization is proposed in the direction perpendicular to the world sheet of the string. The regularization width is related to the slope of Regge trajectories via the Dirac quantization condition for magnetic charges. The connection between the two theories is important in the study of interactions of the string with external electromagnetic fields.

545. Barut A.O. Phys.Lett.,1973, vol. 46B, No 1, pp.81-82.

THE IMPOSSIBILITY OF SPLITTING THE SUPERPOSITION OF STATES OF OPPOSITE MAGNETIC CHARGES IN EXTERNAL ELECTROMAGNETIC FIELDS. AN ANTI-SUPERSELECTION RULE

The postulated coherent states of magnetic charges $|A_{\pm}\rangle = |g\rangle \pm |-g\rangle$ are shown to obey a superselection rule as in the case of eigenstates of electric charge; an important result for the problem of experimental detection of magnetic monopoles.

546. Barut A.O. Acta Physica Austriaca, Suppl., vol.11,1973 p.565.

MAGNETIC CHARGES AND STRINGS AS A BUILDING BLOCK OF HADRON CONNECTION BETWEEN ELECTROMAGNETIC AND DUAL STRINGS

547. Barut A.O., Carmeli M., Malin S. Ann.Phys.(N.Y.),1973, vol.77, pp.454-470.

SCATTERING OF ELECTROMAGNETIC RADIATION IN TERMS OF FUNCTIONS OVER THE GROUP SU_2

Carmeli's group theoretical analysis of Maxwell's equations, in which the field variables are considered as functions over the group SU_2, is extended to the general formulation of the problem of scattering of electromagnetic waves. The relevant complex functions, defined

over the group SU_2, are explicitly given in terms of electric and magnetic phase shifts. They are shown to have a simple physical meaning in the far zone. The general expressions for the differential and total cross sections are defined. The differential cross section is shown to be the sum of two non-interfering spherical waves, which can be considered as the spherical wave analogue of the positive and negative helicities of plane waves.

548. Bellac M.Le., Lévy-Leblond J.M. Nuovo Cim., 1973,vol.14B p.217.

GALILEAN ELECTROMAGNETISM

Consistent nonrelativistic electromagnetic theories are investigated by stressing the requirements of Galilean relativity. It is shown that Maxwell's equations admit two possible nonrelativistic limits, accounting, respectively, for electric and magnetic effects. A Galilean theory is then built which combines these two theories and can embody a large class of experimental facts. As a result several so-called "relativistic" effects are shown to necessitate a re-appriasal or, at least, a more careful discussion. It is finally shown precisely how the old-fashioned formulation of the electromagnetic theor in terms of field strengths and field excitations clashes with Galilean relativity in its contitutive equations only leading to the idea of a privileged frame of reference (the ether) or to Einsteinian relativity,

549. Bilaniuk O.M. and Boccio J.R. Recherche ,1973,vol.4, p.1037.

UNFOUND PARTICLES

Short review of unfound particles including monopoles.

550. Budnev V.M. Fiz.elem.chastits i atomnogo jadra, 1973, vol.4, No 1, pp.239-284.

TWO-PHOTONS PRODUCTION OF PARTICLES AND APPROXIMATION OF EQUIVALENT PHOTONS

551. Carrigan R.A.,Jr., Nezrick F.A. and Strauss B.P. Phys.Rev.,1973, vol.D8, No 11,pp.3717-3720.

SEARCH FOR MAGNETIC MONOPOLE PRODUCTION BY 300-GEV PROTONS

Fermilab search.
$\sigma_n(95\%) < 6 \times 10^{-42}$ cm^2 for 1/6 nucleon ÷ 24 Dirac charges

552. Carrigan R.A.,Jr., Nezrick F.A., Strauss B.P. National Accelerator Laboratory, NAL-Pub-73/51,Batavia, Illinois, Aug.1973.

SEARCH FOR MAGNETIC MONOPOLE PRODUCTION BY 300 GEV PROTONS

In a search for magnetic monopoles a steel beam dump has been exposed to 3.4×10^{16} protons of 300 Gev energy at the National Accelerator Laboratory.The search apparatus employed an 80 kG solenoid 50 cm long capable of extracting a monopole and accelerating it through a series of thin scintillation counters.A monopole would have been identified by its energy loss and range in the scintillators. No monopoles with magnetic charges in the interval from 1/6 to 24 times the Dirac magnetic charge were found. The upper limit at a 95% confidence level for the cross section per nucleon on iron is 6×10^{-42} cm^2.

553. Carter E.F. and Cohen H.A. Amer.J.Phys., 1973, vol.41, No 8, pp.994-1006.

THE CLASSICAL PROBLEM OF CHARGE AND POLE

In this paper the classical dynamics of interacting electrically charged particles where one or both possess

magnetic charge is reviewed. The The equations of motion are obtained and the vector constants of motion are derived. A consistent canonical formalism is developed while related aspects such as scale invariance and the geometry of the motion are also discussed.

554. Cohen H.A. Progr.Theor.Phys.,1973, vol.50, No 2, pp.691-696.

ON THE DIRAC MONOPOLE POTENTIAL

The Grönblom-Jordan picture of the Dirac magnetic monopole is reviewed. The role of the string in a single-valued vector potential describing a magnetic monopole is demonstrated.

555. Collins G.B., Ficenec J.R., Stevens D.M.,Trower W.P., Fischer J. Phys.Rev., 1973, vol. D8, No 3,pp.982-983.

UNEXPLAINED MULTIPHOTON PHENOMENON

In 1954 Schein ,Haskin and Glasser reported a cosmic-ray event consisting solely of at least sixteen highly collimated photons. Here we compare this event and four other similar ones reported in the literature. These five events show remarkably similar characteristics and the possibility of them all being fortuitous occurrences is essentially precluded. Their characteristics also make it unlikely that the photons originate from electromagnetics showers or multiply produced π^0 mesons.Some unexplained phenomenon seems indicated.

556. Combe P. and Richard J.L. Centre National de la Recherche Scientifique-Centre Physique Theorique, CNRS-CPT-73-P-539, Marseile, France, 1973.

MINIMAL COUPLING AND MAGNETIC CHARGE

For certain conditions it is shown that principal of minimal coupling breaks down if invariance under space reflection is required.

557. Deo B.B., Singh L.P. Indian J.Phys., 1973, vol.47, No 11, pp.650-659.

LOCAL LAGRANGIAN QUANTUM FIELD THEORY OF ELECTRIC AND MAGNETIC CHARGES OF SPIN ZERO MESONS

We present a local Lagrangian field theory of spin zero mesons carrying both electric and magnetic charges. The quantization of ($e_m g_n - e_n g_m$) as integral multiples of 4π is obtained as a condition of integrability of infinitesimal Poincaré -Lie algebra to finite Poincaré group. Canonical commutation relations energy momentum tensor and Feynman rules are obtained by usual techniques of Lagrangian field theory.

558. Dirac P.A.M. Fundamental Interactions in Physics, CTS Bulletin VI-6, Center for Theoretical Studies University of Miami, Coral Gables, Florida,1973,pp.1-17.

LONG RANGE FORCES AND BROKEN SYMMETRIES

"Another idea that I has at time, which followed from the mathematics, was that it should be possible to have single magnetic poles, monopoles. There were some very beautiful mathematics connected with these monopoles. However, monopoles have never been discovered although the experimenters have searched for them,and I'm beginning to feel doubtful whether this mathematical development is a correct one. There is room for doubt because the theory of the electrons interacting with the electric and magnetic fields is not altogether a satisfactory theory. There are some profound difficulties which show that some very deep alterations will have to be made. I don't want to go to a discussion of the difficulties, but I merely want to say that they do cast doubts on this development, and it could very well be that when we get an improved theory in the future there may be no room in it for the magnetic monopoles".

559. Eberhard H., Ross R.R., Taylor J.P. Lawrence Berkeley Laboratory, LBL-1732, Berkeley, 1973.

560. Ford K.V. Elementary Particles, Izd."Nauka",Moscow, 1973, vol.9, pp.78-89.

MAGNETIC MONOPOLES
(In Russian)

561. Honig E. Univ.Microfilms, Order No 73-19,16p, 1973. Thesis.

THOMAS PRECESSION AND MOTION OF CHARGED PARTICLES

Not principally a magnetic monopole paper but does review case for magnetic monopoles.

562. Chiang C.C. Center for Particle Theory, CPT-201, 1973.

COVARIANT THEORY OF MAGNETIC MONOPOLE

563. Shu-Yuan Chu Phys.Rev., 1973, vol. D7, No 3, p.853.

VIOLATION OF CP INVARIANCE IN THE DYON MODEL

The CP-violation mechanism proposed by Schwinger in the dyon model is discussed. It is pointed out that once dual-charged particles are introduced we have two kinds of smallest units of electric charge for magnetically neutral particles: one for purelly electrically charged particles ,the other for the magnetically neutral composites of the dyons. These two units, which apriori could be different are assumed to be the charged carried by the electron and the proton, respectively. Schwinger's mechanism can then be understood as a self-consistent condition that ensures the equality of these two units of electric charge. The analogy between this mechanism and that proposed by Berstein, Feinberg and Lee is discussed. The case of neutral -K decay is brief

ly analyzed. The magnitude of the CP-violation parameter in different proceses is estimated.

564. Klimo P. and Dowker J.S. Int.J.Theor.Phys.,1973, vol.8, No 6, pp.409-417.

DIRAC MONOPOLES FOR GENERAL GAUGE THEORIES

This paper developes a non-local potential formalism for general gauge theories. With the help of this mathematical apparatus an argument for quantization of the generalized charge is given, assuming that the Dirac monopoles are present.

565. Kuo T.T.S., Osnes E. Proceedings of the Int.Conf. on Nucl.Phys., Munich, Germany,1973. North-Holland Publ. Company, 1973, vol.1, p.310.

MICROSCOPIC CALCULATION OF MONOPOLE POLARIZATION CHARGE

566. Kurczynski M. Int.Center for Theor.Phys., Trieste, 1973.

NORMAL SUPERSELECTION RULE FOR THE MAGNETIC CHARGE

567. Kursunoglu Behram Centre for Theor.Studies, CTS-ME-73-2,Coral Gables, Florida, 1973.

GRAVITAION AND MAGNETIC CHARGE

Based on the static spherically symmetric solutions of the generalyzed theory of gravitation it is found that electric and magnetic charges are two fundamental constants of integration and that the corresponding electric, magnetic and gravitational fields are regular everywhere only if the magnetic charge $g \neq 0$. For magnetic charge $g=0$, the solutions reduce to the Nordström solution of general relativity in the limit of large r. The theory leads to elementary particles of finite self-energy, and binding energy. These particles consist of a magnetically neutral core of matter con-

taining a distribution of magnetic charge density in stratisfied layers of sharply decreasing magnitude and alternating signs so that magnetic monopoles do not exist. In addition to charged electric current, the theory yields an electrically neutral current and the corresponding fields. The neutral current and the corresponding neutral field are the classical counterparts of the vacuum polarization in quantum electrodynamics. For every positive energy solution there exists also a negative energy solution with the corresponding electric charge. For g=0 the volume integral of the neutral current density diverges. Thus, the asymmetry of Maxwell's equations with regard to the absence of a magnetic current can be understood because the neutral magnetic current and the neutral part of the electric current are localized in the core of elementary particle. The presence of negative energy solutions along with positive energy solutions point to a large scale symmetry with respect to a distribution of matter and antimatter in the universe.

568. Leinas J.M. Nuovo Cim., 1973, vol.15A, No 4, p.740.

SPACE-TIME SYMMETRIES FOR A SYSTEM OF PARTICLES WITH BOTH ELECTRIC AND MAGNETIC CHARGES

The invariance under Lorentz transformations of Maxwell-Lorentz equations for a system of particles with both electric and magnetic charges is studied. For space reflection and time reversal the possibility of symmetry is examined when the charges are restricted by Dirac's quantization condition. The symmetries are shown to require that the electric charge of any monopole -carrying particle-be an integer or half-integer multiple of the elementary electric charge.

569. Mahanthappa K.T. Phys.Rev., 1973, vol.D7, No 4, pp.1028-1031.

PARASTATICS, DYONS AND DYONIUM

It is pointed out that if the bound state of two

normal or para particles(say, dyons) having electric and magnetic charges (e_1, g_1) and (e_2, g_2) is a normal or para particle, (i) the BS is a normal or para bosons if both dyons are normal or para bosons or normal or pure fermions, and (ii) it is a normal or para fermion if one dyon is a normal or para boson and the other a normal or para fermion. This observation, combined with the regular connection between spin and statistics and the Dirac quantization condition, $e_1 g_2 - e_2 g_1 = \nu$, yields only integer values of ν for the BS. Thus the dyonium model of proton expounded by Barut is invalidated. But it can be rescued if the regular connection between spin and statistics is violated for dyons so that one of the spinless dyons of which the dyonium is made, is a normal boson and the other a spin - $\frac{1}{2}$ fermion. Comments are made concerning the significance of the O(4,2)-wave equation used by Barut in the relativistic domain.

570. Mavrychev Yu.S. Izvestia Vuzov SSSR, Fizika, No 4, p. 146,1973.

PSEUDODUAL TRANSFORMATIONS IN ELECTRODYNAMICS

571. Mignani R. and Recami E. Instituto Nazionale di Fisica Nucleare, INFN/AE-73/7, Sezione di Catania,1973, pp.55-59.

SPECIAL RELATIVITY EXTENDED TO SUPERLUMINAK FRAMES AND OBJECTS
(Classical theory of tachyons)

572. Mignani R. and Recami E. Univ.Catania, Report PP/384,Catania, Italy, 1973.

MAGNETIC MONOPOLES AND TACHYONS

573. Mignani R. and Recami E. Lett.Nuovo Cim., 1973, vol.7, No 10, pp.388-390.

TACHYONS DO NOT EMIT CERENKOV RADIATION IN VACUUM

574. Nauka i Zhizn' (Russ.),1973, No 9, p.17.

ONCE AGAIN ON MONOPOLE

575. Nielsen H.B. and Olsen P. Nucl.Phys., 1973, vol.61B, p.45.

VORTEX-LINE MODELS FOR DUAL STRINGS

Not a monopole paper. Higgs type Lagrangian allows f vortex line solutions in analogy with the vortex lines ir a type II superconductor.

576. Petukhov V.A.,Usachev Yu.D., Yakimenko M.N. Priroda, No 11, pp.54-62. 1973

MONOPOLE - PROBLEMS AND SEARCHES

Popular review of theoretical and experimental works dedicated to Dirac's hypothesis on the existence of magnetic charges - monopoles.

577. Rajput B.S. and Prakash O. Indian J.Phys., 1973, vol.47, p.641.

IMPOSSIBILITY OF REDUCTION OF GENERALIZED ELECTRO-MAGNETIC FIELDS FOR NON-ZERO MASS SYSTEM IN FREE SPACE

Symmetrical reduced expansions of electric and magnetic fields are derived in the presence of electric and Dirac's monopoles in terms of irreducible representations of proper orthochronous inhomogeneous Lorentz group for non-zero mass system. Maxwell's field equations are modified by considering the generalized charge as a complex quantity with electric and magnetic fundamental charges as its real and imaginary parts. The constancy

condition for magnetic charges on a particle has been imposed for explaining the results obtained by the requirement that generalized electromagnetic fields satisfy generalized field equations. Considering the reduced expansions in the absence of electric or magnetic charge source it has been proved that the derivation of reduced expansions for electromagnetic fields satisfying the field equations without sources is not possible for non-zero mass system.

578. Recami E., Mignani R. Univ.Catania, Report PP/401, Catania, Italy, 1973.

DO MAGNETIC MONOPOLE EXIST? CONSIDERATIONS FOR THEORY AND EXPERIMENTS

579. Ross R.R., Eberhard P.H., Alvarez L.W. and Watt R.D. Phys.Rev., 1973, vol. D8, No 3, pp.698-702.

SEARCH FOR MAGNETIC MONOPOLES IN LUNAR MATERIAL USING AN ELECTROMAGNETIC DETECTOR

The search for magnetic monopoles in lunar materials has been concluded with the exploration of an additional 11 Kg of material returned by the Apollo 11,12 and 14 missions, using a modified version of our electromagnetic detector. Again, no magnetic monopole was detected. Combining these results of our previous experiment, we set an upper limit of 1.7×10^{-4} monopoles/g for the density of isolated monopoles in the lunar surface and improve our upper limits set for the monopole flux in cosmic rays and for monopole pair-production cross section.

580. Ross.R.R., Eberhard P .H., Alvarez L.W., Watt R.D., Lawrence Berkeley Laboratory, LBL-1730,(SLAC PUB 1249), 1973.

SEARCH FOR MAGNETIC MONOPOLES IN LUNAR MATERIAL USING AN ELECTROMAGNETIC DETECTOR

The review of the modern status the problem of magnetic charge is presented. The difficulties of the theory of Dirac monopole are discussed. The possible explanations of the negative results of experimental search of magnetic monopoles is analyzed. The dual symmetry of the electrodynamics and different derivations of the charge quantization condition are discussed. The application of the theory of magnetic charge is considered, in particular, the dyonium model of hadrons.

587. Strazhev V.I., Tomil'chik L.M. Sov.J. Particles Nucl., 1973, vol.4, p.78.

CURRENT STATE OF THE DIRAC MONOPOLE PROBLEM

588. Strazhev V.I. Preprint Inst.Phys. Acad.Nauk Belorussk. SSR., No 92, Minsk, 1973.

589. Schwinger J. PARTICLES,SOURCES AND FIELDS, Izd. "MIR", Moscow, 1973, vol.1, p.288.

590. Tassie L.J. Phys.Lett., 1973, vol.46 B, No 3, p.397.

MAGNETIC FLUX AS RELATIVISTIC STRINGS

It is suggested that the relativistic string of the dual resonance model of hadrons is a line of quantized magnetic flux. Accordingly quarks have magnetic charge +g, -2g baryons are composed of there quarks will not normally occur.

591. Trinkala M.J., Inomata A., Bull.Amer.Phys.Soc., 1973, vol. 18, No 1, p.27.

DUAL AND CHIRAL ROTATIONS IN ELECTRODYNAMICS

Electrodynamics in the source free case is symmetric under the dual rotation. The same is true in general if one introduces the magnetic sources in addition to the electric

sources and rotates both, electric and magnetic currents simultaneously. It can also be shown for a source free case that a chiral rotation generates a dual rotation. We now investigate the relationship between dual and chiral rotations when a source is present. The O/2/ and O/1,1/ symmetries are considered which have a common invariant. Application of the result is made to quantization of charges.

592. Usachev Yu.D. Sov.J.Particles Nucl., 1973, vol.4, p.94.

IS THERE A THEOREM FOR THE QUANTIZATION OF MAGNETIC CHARGE?

Contains a critique of the Dirac charge quantization condition. Doesn't say it is wrong - but rather that it can be critized.

593. Usachev Yu.D. Fiz.Elem. Chast. Atomn.Yad., 1973, vol.4, pp.225-238.

IS THERE THEOREM FOR THE QUANTIZATION OF MAGNETIC CHARGE?

The theorem on quantization of magnetic charge is analyzed. The difficulties arising in different proofs of this theorem are pointed out. Some arguments against the theorem of magnetic charge quantization are present. The consequences of the validity of this theorem are discussed in connection with the experimental searches of monopoles.

594. Usachev Yu.D. P.N.Lebedev Phys.Inst.Acad. of Sci. USSR, Moscow, 1973, Preprint No 48 (FIAN).

TO THE PROBLEM OF MAGNETIC CHARGE SEARCHES

595. Vonsovskii S.V. Izdatel'stvo Nauka Glavnaya Redaktsiya Fiziko-Matematicheskoi Literatury, Moscow,1973, pp.182-208.

MAGNETISM OF MICROPARTICLES

A review of magnetic properties of particles, nuclei, and atoms. Includes discussion of the monopole conjecture.

596. Vonsovskii S.V. "ZNANIE I SILA",1973, No 10.

FOR AND AGAINST DIRAC

597. Weingarten D. Ann.Phys., 1973, vol.76, p.510.

COMPLEX SYMMETRIES OF ELECTRODYNAMICS

We prove that a set of nonsingular free solutions of Maxwell's equations forms a representation of the group obtained by analytic continuation of the Poincaré group to complex values of the group parameters and that a set of singular solutions forms a representation of the group obtained by analytic continuation of the conformal group to complex values of the group parameters. These results are obtained by constructing a theory governing 2 2 complex values of position and time; the equations of this theory are invariant with respect to complex Poincaré transforma - tions and complex conformal transofrmations but the set of nonsingular solutions is in one-to-one correspondence with a set of nonsingular solutions of Maxwell's equations and a similar correspondence exist for the singular solutions. Certain collections of solutions of Maxwell's equations for the field of a current are permitted in which case complex transofrmations provide a natural connection between electric and magnetic charge. A class of complex transofrmation also yields natural relations between sources moving slower than light and sources moving faster than light.

598. Yuan L.C., Dell G.F., Uto H., Amaldi E., Beneventano M., Borgia B., Pistilli P., Sestilli I. and Dooher J. Experiments on High Energy Particle Collisions-1973, R.S.Panvini, Ed.,1973,AIP Conf. Proc., 12,pp.194-198.

SEARCH FOR HIGH ENERGY MULTIGAMMA EVENTS AT THE ISR

This is a report of the preliminary results of our exploratory experiment at the CERN ISR on the search for multigamma events in proton-proton collisions. In this experiment we have observed an overwhelmingly large number of multigamma events especially at high multiplicitics. The preliminary results also show a prominent peak in the

energy distribution of the individual γ -rays as measured by the 3-radiation lengths thick lead glass Cerenkov-counters under the present triggering conditions.

599. Zrelov V.P., Kollarova L., Kollar D., Lupil'tsev V.P., Pavlovič P., Ružička J., Sidorova V.I., Shabashov M.F., Šulek P., Janik R.
Joint Institute for Nuclear Research, Dubna, 1973. E1-6946,

THE PRELIMINARY EXPERIMENTAL RESULTS ON A SEARCH FOR THE DIRAC MONOPOLE AT THE 70 GEV IHEP SYNCHRO - TRON USING VAVILOV-ČERENKOV RADIATION

The experiment is aimed at the detection of greatly intensive Vavilov-Čerenkov radiation having a peculiar polarization from relativistic magnetic charges (both stable and unstable) by means of the electronic technique.

The preliminary results of the experiment are reported: the magnetic charges with g=68.5 e, the masses up to 5 m and the lifetime $r_g > 10^{-10}$ sec are not produced below $\sigma(95\%) < 8 \times 10^{-40}$ cm^2 g in 70 GeV proton collisions with nuclear nucleons from a SiO_2 target.

600. Zrelov V.P., Kollarova L., Kollar D., Janik R., Lupil'tsev V.P., Pavlovič P., Sidorova V.I., Ružička J., Shabashov M.F., Šulek P.
Proccedings of the Second International Symposium on High Energy and Elementary Particle Physics, Strbske Pleso, CSSR, October 1972. Publ. of JINR, Dubna, 1973, D-6840, pp.154-160.

PRELIMINARY RESULTS OF EXPERIMENT ON SEARCHING DIRAC MONOPOLE ON THE SERPUKHOV SYNCHROTRON USING VAVILOV-ČERENKOV RADIATION

601. Zumino B. EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH, CERN, TH-1779, Geneva, 1973.

Lectures given at the 1973 Nato Summer Institute in Capri.

1974

602. Akhiezer A.I. and Rekalo M.P. Uspekhi Fiz.Nauk, 1974, vol.114, p.487.

ELECTRIC CHARGE OF ELEMENTARY PARTICLES
(In Russian)

Nice review of electric charges and electric dipole moments. On elementary particles cites magnetic monopole as a possible reason for quantization.

603. Arafune J., Freund P.G.O and Goebel C.J. University of Chicago, EFI 74/48, Chicago, 1974.

TOPOLOGY OF HIGGS FIELDS

604. Ashton F. In: COSMIC RAYS AT GROUND LEVEL, Ed. A.W. Wolfendale, 1974, pp.119-136.

SEARCH FOR QUARKS, MAGNETIC MONOPOLE AND TACHYONS

605. Balachandran A.P., Rupertsberger H. and Schechter J. Syracuse University Preprint ,SU-4205-41, Syracuse,1974.

MONOPOLE THEORY WITH A MASSIVE GAUGE FIELD AND NAMBU'S HAMILTONIAN

606. Balachandran A.P., Rupertsberger H. and Schechter J., Syracuse University Preprint, SU-4205-37,1974.

607. Barut A.O. Phys.Rev.,1974, vol.D10, No 8, pp.2709-2713.

SPIN-STATISTIC CONNECTION FOR DYONIUM

Discussion on the paper: Parastatics,dyons and dyonium by K.T.Mahanthappa-Author's reply.

The spin- bound state of two spinless dyons(dyonium) has additional independent (gauge) degrees of freedom

associated with an arbitrary unit vector n in the Hamiltonian. Hence it does not constitute a conter example of the normal spin-statistic connection.

608. Barut A.O. and Bornzin G.L. Nucl.Phys., 1974, vol.B81, p.477.

THE ELECTROMAGNETIC STRING WITH SPIN

The relation between a field $\overset{m}{F}_{\mu\nu}$ satisfying the usual Maxwell equations and a field $\overset{D}{F}_{\mu\nu}$ satisfying the symmetric Maxwell-Dirac equations, and the singular potential solving both of these is given. The action principle is formulated in both forms and the reality of the string is shown. A string with spin is constructed by placing electric charges at its endopoints. The motion and interactions of the string, the relation between flux and angular momentum quantization and the passage to two-body Hamiltonians are examined.

609. Barut A.O., Beker H., Nuovo Cim., 1974, vol. 19A, No 2, pp.309-323.

CLASSICAL RELATIVISTIC SCATTERING OF TWO DYONS

We report a remarkable phenomenon in the relativistic classical scattering of two particles having both electric and magnetic charged particles, i.e. the occurrence of infinitely many singularities in the differential cross-sections. These singularoties correspond to compound states formed by the scattered particle making loops n=0,1,2,3..., around the scattering center: their positions are given by eq. (3.21) for the particular case studied.

610. Baroni G., Di Liberto S., Petrera S., Romano G. Nota Interna No 595, Instituto di Fisica dell'Université Roma, 1974.

SEARCH FOR MAGNETIC MONOPOLES OF THE CERN-ISR WITH PLASTIC DETECTORS

611. Carrigan R.A.,Jr., Nezrick F.A. and Strauss B.P.
Fermi National Accelerator Laboratory ,Fermilab-Pub.,74/93 EXP, Batavia,1974.

EXTENSION OF FERMI NATIONAL ACCELERATOR LABORATORY MAGNETIC MONOPOLE SEARCH TO 400-GEV.

612. Carrigan R.A.,Jr, Giacomelli G., and Nezrick F.A.
CERN ISR Proposal No 74-33.

613. Carrigan R.A., Jr., Nezrick F.A., B.P.Strauss. Phys.Rev. 1974, vol. D10, No 11, pp.3867-3868.

EXTENSION OF FERMI NATIONAL ACCELERATOR LABORATORY MAGNETIC MONOPOLE SEARCH TO 400 GEV

In a search for magnetic monopoles an aluminum target has been exposed to 5.7×10^{16} protons of 400 GeV energy at the Fermi National Accelerator Laboratory. The search apparatus employs equipment used previously in a search for monopoles produced by 300-GeV protons where a cross section of 6×10^{-42} cm^2 was established using an iron dump. For the 400-GeV experiment the equipment was modified to detect magnetic charges down to 1/30 of the Dirac magnetic charge. No magnetic monopoles were found with magnetic charges in the interval from 1/30 to 24 times the Dirac magnetic charge. The upper limit at a 95% confidence level for the cross section per nucleon in aluminum is 5.1×10^{-42} cm^2.

614. Carrigan R.A., Jr., Nezrick F.A. Phys.Teach.USA,1974, vol.12, No 5, p.309.

SEARCH FOR MAGNETIC MONOPOLES AT NAL

An experiment on searching for magnetic monopoles at National Accelerator Laboratory (NAL,USA) is briefly described.

615. Carrigan R.A., Nezrick F.A. Fermi National Laboratory, FERMILAB-Pub.74/111-Exp., Batavia, 1974.

SEARCH FOR NEUTRINO-PRODUCED MAGNETIC MONOPOLES IN A BUBBLE CHAMBER EXPOSURE

J.Schwinger has suggested that magnetically charged particles could be produced in a magnetically charged intermediate boson process similar to the mechanism sometimes envisioned for double muon production by neutrinos. A search for magnetic monopole production by neutrinos has been made by re-examining the CERN heavy liquid bubble chamber pictures obtained during the neitrino exposures of 1963 and 1967. Five different searches were made for events which contained a free monopole with and without target nucleus excitation, and for bound monopoles which de-excited by photon emission. No events were found. Neutrino monopole production cross-section limits are given.

616. Cline David B. NEUTRINOS-1974. 4-th Int.Conf.,Philadelphia, 1974, pp.201-258.

EXPERIMENTAL SEARCH FOR NEW PARTICLE PRODUCTION IN HIGH ENERGY NEUTRINO INTERACTIONS

617. Cohen H.A. Found.Phys., 1974, vol.4, No 1, pp.115-120.

IS THERE A QUANTIZATION CONDITION FOR THE CLASSICAL PROBLEM OF CHARGE AND POLE ?

In elementary derivations of the quantization of azimuthal angular momentum the eigenfunction is determined to be exp (im ϕ), which is "oversensitive" to the rotation $\phi \rightarrow \phi + 2$, unless m is an integer. In a recent paper Kerner examined the calssical system of charge and magnetic pole and expressed Π a vector constant of motion for the system, in terms of a physical angle ψ to deduce a remarkable paradox. Kerner pointed out that $\Pi(\psi)$ is "oversensitive" to $\psi \rightarrow \psi + 2\pi$ unless a certain charge quantization condition is met. Our explicandum of this paradox highlights the distinction between coordinates in classical and quantum physics. It is shown

why the single-valuedness requirement on $\Pi(\psi)$ is devoid of physical significance. We are finally led to examine the classical analog of the quantum mechanical argument that demonstrates the quantization of magnetic charge to show that there is "no hope" of a classical quantization condition

618. Combe Ph., Richard J.L. Physica, 1974, vol.71, No 1, pp.66-74.

MINIMAL COUPLING AND MAGNETIC CHARGE

In this note, the most general form of the lagrangian of a particle in a constant and uniform electromagnetic field is derived using group-theoretical arguments based on Levy-Leblond's approach to the lagrangian gauge problem. The so-called minimal coupling is derived. In the case of a purely magnetic field, it is shown that the principle of minimal coupling by the magnetic charge breaks down if the invariance of the equations of motion under space refletion is required.

619. Coon D.D. and Suura H. Phys.Rev., 1974, vol. D10, p.348.

REGGE TRAJECTORIES AND THE QUARK-GLUON COUPLING CONSTANT

It is argued that vector gluons interacting with quarks produce logarithmic behaviour of Regge trajectories at large momentum transfer, in agreement with proton-proton scattering data. It is found that $g^2/4\pi = 14$ where g is the gluonic charge of the quarks. Some suggested relations betwee quark-gluon dynamics duality, magnetic charge and Jacobi's imaginary transformation are discussed.

620. Corben H.C. Nuovo Cimento Lett., 1974, vol.11, No 11, pp.533.

IMAGINARY QUANTITIES IN SUPERLUMINAL LORENTZ TRANSFORMATIONS

Originally contested ideas of Recami and Mignani about superluminal charges being viewed as magnetic monopoles.

621. Creutz M. Phys.Rev., 1974, vol.D10, No 8, pp.2696-2699.

HIGGS MECHANISM AND QUARK CONFINEMENT

The theory is mathematically equivalent to the quarks being magnetic monopoles moving in a superconducting vacuum. When the quarks in a hadron are pulled apart, they remain connected by vortices of magnetic flux; consequently, at large inter quark distances the energy of the system becomes proportional to the quark separation. At low energies the quarks are closer together than the penetration depth of the superconductor and thus they appear effectively free.

622. Frauenfelder H., Henley E.M. SUNATOMIC PHYSICS. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1974.

623. Dashen R.F., Hasslacher B. and Neven A. Phys.Rev.;1974, vol.D10, p.4138.

NONPERTURBATIVE METHODS AND EXTENDEND-HADRON MODELS IN THEORY FIELD:

III. FOUR- DIMENSIONAL NONABELIAN MODELS

By analogy with the magnetic vortex of the Landau-Ginzburg theory of superconductivity, we construct extended models of hadrons with SU/2/ Yang-Mills fields coupled to fermions and a spontaneous-symmetry-breaking scalar isospinor. These models are in four space-time dimensions.

624. Gaffney G.W. Phys.Rev., 1974, vol.D10, pp.374-400.

ELECTRIC AND MAGNETIC CHARGE IN EINSTEIN'S UNIFIED FIELD THEORY

Solution incorporating a length scale.

Prediction:

Gross astronomical scale differences from normal electromagnetic fields.

625. 'tHooft G. Nucl.Phys.,1974, vol.B79, No2,pp.276-284.

MAGNETIC MONOPOLES IN UNIFIED GAUGE THEORIES

It is shown that in all those range those range theories in which the electromagnetic group U(1) is taken to be a subgroup of a large group with a compact covering group, like SU(2) or SU(3), genuine magnetic monopoles can be created as a regular solutions of the field equations. Their mass is calculated and of order 137 M_W where M_W is a type vector boson mass.

626. t'Hooft G. Proceedings of the 17-th Intern.Conf.on High Energy Physics, London, Chilton, Didcot,1974, vol.3,pp.84-85.

MAGNETIC MONOPOLES IN UNIFIED THEORIES

In any system described by interacting field equations with particular symmetries one can expect solutions of a very remarkable type, even at the classical level. A well-known example is the Schwartzschild solution in General Relativity

627. 't Hooft G. European Organization for Nuclear Research, CERN Report No TH-1876,CERN,May,1974.

MAGNETIC MONOPOLES IN UNIFIED GAUGE THEORIES

628. Hosoya A. and Ishida J. Osaka University preprint, OU-HET-6,Toyonaka,1974.

NON-ABELIAN MAGNETIC CHARGES

We have obtained exact solutions of the classical isotopic gauge field equations in the static case. Our solutions have a nonlinear form in terms of the (pseudo-) scalar potential, and its space derivative and are shown to exhibit the isotopic analog of Dirac's monopoles. Our solution leads naturally to the integer valued condition for the charge quantization.

629. Howard R. Solar Phys.,1974, vol.38, p.283.

STUDIES OF SOLAR MAGNETIC FIELDS
I. THE AVERAGE FIELD STRENGTHS

The telescope, spectrograph and magnetograph at the 150-th Tower Telescope are described, and a chronology of changes in the instrumentation is given. The average magnetic field strengths over the last years are discussed. The changes in polarity at the poles of the Sun are described. The characterisitcs of these polarity reversals at both poles are similar. A reversal is not seen in the sunspot latitudes ($\sim$ 40%) but is observed to start in the 40-50° zone and proceed slowly poleward, reaching the pole wintin 12 to 18 months. At the time of the polarity reversal at the pole, field strengths over a large portion of the disk show similar behaviour. Rapid changes of solar magnetic fields over large portions of the solar disk are discussed. Two possible models are suggested to explain the frequent "monopole" appearance of the solar fields. The poleward drift of the magnetic field reversals in each hemisphere was not closely in phase with the polar filament migrations or the variations in mean latitude of high-latitude coronal activity with predominantly negative magnetic fields.

630. Hsu J.P. Phys.Rev., 1974, vol.D10, p.3836.

EXPERIMENTAL TEST FOR THE ORIGIN OF CP NON-INVARIANCE AND NEUTRAL KAON CHARGE

We discuss a theory of CP non-invariance in which the interaction is completely determined by the principle of gauge invariance. We also discuss its experimental test by observing anomalous phenomena of K^0 decay in the electric field. Moreover the experimental result can also determine an accurate upper limit for the neutral kaon charge (which has never been directly measured) if the predicted phenomena are not observed.

631. Jevicki A. and Senjanovic P. Dept. of Physics, The City College of the City Univ. of N.Y., CCNY-HEP-74/1, New York 1974.

STRINGLIKE SOLUTION OF HIGGS MODEL WITH MAGNETIC MONOPOLES

We derive a static solution of the equation of motion following from a Higgs-type Lagrangian containing in addition static magnetic monopoles representing quarks. For this purpose, we use Zwanziger's approach to magnetic monopoles and thus we are dealing with a local field theory for charge particles. We show that the solution has the form of a strin of finite length for large coupling. We exhibit the dependence of the system ($\leq$) on interquark distance (2a):

$$E(2a) = g^2/8\pi a \exp(-e|\phi_0|2a) + c\,|\phi_0|^2 a$$

which is the form found Nambu in his discussion of this type of model as a scheme which affects a mechanism for quark confirment. We therefore confirm that Nambu's results can be reached in a field-theoretic formulation.

632. Julia B. and Zee A. Princetopn Preprint, 1974.

POLES WITH BOTH MAGNETIC AND ELECTRIC CHARGES

633. Karlsson L. Nucl. Instru,. Methods, 1974, vol. 116, pp. 275-281.

MAGNETIC MONOPOLE DETECTOR

The results of a search for magnetic monopoles are presented. A new electromagnetic monopole detector has been built and used in the present search for magnetic monopoles of cosmic ray origin. This detector has made feasible the first electromagnetic real-time cosmic-ray search for isolated magnetic poles. At least one event that satisfies the instrumental criteria for being a magnetic monopole event was recorded during a four weak operation of the detector.

634. Kiselev V.V. Izvestia Vuzov, ser. fiz., 1974, No 8, pp. 148-149.

THE ESTIMATION OF A MINIMUM MONOPOLE MASS

635. Kobayashi M. Prog.Theor.Phys., 1974, vol.51, pp.1636-1637.

VORTEX-LINE MODELS FOR DUAL STRINGS AND MAGNETIC MONOPOLES

Letters to Editor

Following Nielsen and Olesen uses "magnetic" charges to terminate strings.

636. Kursunoglu B. Phys.Rev., 1974, vol. D9,No 10,pp.2723-2745.

GRAVITATION AND MAGNETIC CHARGE

Theory explaining elementary particles on the basis of general relativity using alternating layers of magnetic charge. No net magnetic charge.

637. Mahanthappa K.T. Phys.Rev.,1974, vol.D 10, p.2712.

REPLY TO SPIN STATISTICS CONNECTION FOR DYONIUM

It is indicated that despite the existence of unit vector our previous conclusion that the dyonium model of Barut is invalidated remains unaltered contrary to the claims of the preceeding paper. Also we point out that the assertions contained in the preceeding paper forbid the existence of triplet states of two protons and allow only a single state, contradicting experimental facts.Other related aspects are discussed.

638. Mignani R. and Recami E. Lett.Nuovo Cimento,1974, vol.9, No 9, p.367.

MAGNETIC MONOPOLES AND TACHYONS

The connection between magnetic monopoles and tachyons is shown in the framework of extended special relativity theory by generalizing Maxwell's equations to Superluminal sources.

639. Mignani R. and Recami E. Nuovo Cimento Lett., 1974, vol.11,No 8, pp.417-420.

POSSIBLE EXPERIMENTAL BEHAVIOUR OF TACHYON MONOPOLES

Superluminal particles behave as monopoles expected to do except for velocity.

640. Monastrykti M.I. and Perelemov A.M. ZHETF Fis.Red., 1974, vol.21, p.94.

SOME REMARKS ON MONOPOLES IN GAUGE FIELD THEORIES

641. Nambu Y. Phys.Rev.,1974, vol. D10, No 12, pp.4262-4268.

STRINGS,MONOPOLES AND GAUGE FIELDS

The Nielsen-Glesen interpretation of dual strings as Abrikosov flux lines is extended to the case open-ended strings by adapting Dirac's description of magnetic monopoles to a London-type theory. The mathematical formalism turns out to be similar to that of Kalb and Ramond. Translated to hadron physics, it implies that the quarks will act as carriers of magnetic charge, permanently bound in pairs by the string bonds. However, massive axial-vector gluons can be created by hadrons.

642. Nambu Y. In:Proceedings of the Johns Hopkins Workshop on Current Problems in High Energy Particle Theory,1974, p.1.
Ed. by G.Domokos et al. (Johns Hopkins Univ.,Baltimore, 1974)University of Chicago Preprint, EFI 74/40.

643. Nambu Y. The Enrico Fermi Institute, EFI 74/03,Chicago, 1974.

QUARKS,STRINGS AND GAUGE FIELDS

(Talk presented at the Johns Hopkins Workshop on Current Problems in High Energy Particle Theory, Ed. G.Pomoks and S.Körcsi-Domoleos, Jan.,1974, p.1.).

644. Nauenberg U., Barlett D. Programs report, 1973-1974.

ELEMENTARY PARTICLE AND HIGH-ENERGY PHENOMENA

645. Olsen P. Preprint Niels Bohr Institute, NBI-HE-74-12, Copenhagen, 1974.

646. Parkash O. and Rajput B.S. Indian J.Phys., 1974, vol.48, No 2, pp.152-160.

COMMENTS ON THE EXISTENCE OF MAGNETIC MONOPOLES

Reduction of generalized electromagnetic fields to the irreducible representations of proper ortochromous, inhomogenous Lorentz group has been carried out and it has been shown that for these fields to satisfy generalized field equations, the electric and magnetic charge and current source densities are proportional to the correpsonding fundamental charges. Considering generalized charge as a complex quantity, the real and imaginary parts of which are electric and magnetic charges, the values of electric and magnetic parameters have been derived and it is shown that the zero in the charge quantization condition is forbidden for every particle of the system to bear both the charges. It has also been proved that first allowed value in the charge quantization condition is unity.

647. Parisi G. Columbia University Report No CO-2271-24, 1974.

648. Polyakov A.M. JETP Letters, 1974, vol.20,p.194

PARTICLE SPECTRUM IN QUANTUM FIELD THEORY

Development of extremon and hedgehog picture. Spirit is similar to 't Hooft.

649. Polyakov A.M. Zh.Eksp. Teor.Fiz., Pis'ma Red., 1974, vol.20,pp.430-433.

PARTICLE SPECTRUM IN QUANTUM FIELD THEORY

650. Post E.J. Phys.Rev.,1974, vol. D9, p.3379.

RAMIFICATIONS OF FLUX QUANTIZATION

The null results in the search for magnetic monopoles and the experimentation exhibiting dipolar flux qunatization as obtained during the last two decades mildly invited a withdrawal from the Dirac-Schwinger symmetry hypothesis to the earleir position of an essentially asymmetric set of Maxwell equations. In this paper we attempt to account for the null result by a symmetry alternative that accomodates the persistence of this Maxwellian asymmetry. It is shown that a topological symmetry more hierarchil in nature, can comply with the absence of magnetic monopoles. This alternative then places the low of flux conservation on the same fundamental footing as the law of conservation of electric charge. The ensuring law statements are now global in nature and correspondingly stronger in content than the traditional local statements. The physical implications of the global conservation statements are examined in relation to the existing observational evidence of dipolar flux quantization.

651. Recami E. and Mignani R. Rivista del Nuovo Cimento,1974, vol.4, No 2, pp.209-285.

CLASSICAL THEORY OF TACHYONS (SPECIAL RELATIVITY EXTENDED TO SUPERLUMINAL FRAMES AND OBJECTS

Review of superluminal theories - similar to later articles.

652. Revami E. and Mignani R. Lett.Nuovo Cimento, 1974, vol.9, No 12, pp.479-482.

DO MAGNETIC MONOPOLES EXIST? CONSIDERATIONS FOR THEORY AND EXPERIMENTS

Review of superluminal relativity. In part contains a critique of Bartlett-Lahana search because of hypothesis on Cherenkov radiation.

653. Recami E. and Mignani R. Instituto di Fisica Teorica dell Universita-Catania, Report PP-424,Italy,1974.

ABOUT SEARCH FOR MAGNETIC MONOPOLES

The mere Special Relativity does not predict existence of (subluminal) monopoles, but on the contrary predicts existence of Superluminal (=tachyon) monopoles, with magnetic charge about 100 times less than usually assumed. This fact is quite relevant for the current looking for magnetic poles.

654. Ross D.K. J.Phys., A (London),1974, vol.7, No 6,pp.705-709.

PATH INDEPENDENCE AND CHARGE QUANTIZATION

It is shown that if quantum electrodynamics is assumed to be manifestly gauge independent and path independent, then electric charge must be quantized.

655. Sawada T. Phys.Lett.,1974, vol.B52, No 1, pp.67-70.

SEMI-EMPIRICAL DETECTION ON THE DIRAC'S MAGNETIC MONOPOLES

In order to examine whether the Dirac's magnetic monopoles exist within hadrons as their constituents, we analyze the nucleon-nucleon phase shift data of MacGregor et al in search of the strong Van der Waals type force. By making a peripheral combination of the partial wave amplitudes and separating the one and two pion exchange contribution,we observe that the residual force is exerting between the nucleons, which should be attributed to the exchange of a hypothetical scalar meson or to the long range force.The mass of such a scalar meson must be $m_s=1.1\mu$, on the other hand the power β of the long range potential, which is defined by $V^{extra}(r)=-C/r^{\beta}$ for larger, becomes $\beta=7.2\pm1.0$, and this value is consistent with Van der Waals potential of the Casimir-Polder type.

656. Sawada T. Nucl.Phys.,1974, vol. B71, No 1, pp.82-92.

NUCLEAR FORCE AND A MAGNETIC MONOPOLE MODEL OF HADRONS

The two-pion exchange potential of the nuclear force is constructed from the phase shifts of the low energy πN and $\pi\pi$ scattering. The large difference between the potentials thus constructed from the phenomenological potentials of Hamada-Johnston and of Bryan is pointed out. It is found that this difference has the form of the attractive Van der Waals potential plus an inner repulsive core. The existence of the Van der Waals force is discussed in connection with the magnetic monopole model of hadrons.

657. Sawyer C. Solar Phys.,1974, vol.35, p.37.

MAGNETIC FINE STRUCTURE AND THE SOLAR MAGNETIC MONOPOLE

Suggests ways to gain more information on sun's possible monopole field.

658. SEARCHING FOR DIRAC MONOPOLES Cesk.Cas.Fyz.,Ser.A., 1974, vol.24, No 4, p.396a.

659. Sniatnicki J. J.Math.Phys.,1974, vol.15, No 5, pp.619-620.

PREQUANTIZATION OF CHARGE

It is shown that a necessary and sufficient condition for quantization of relativistic dynamics of a particle with charge e moving in an external electromagnetic field F is tha /e/2/F should define an integral de Rham cohomology class on the space-time manifold.

660. Strazhev V.I. Izvestia Akad.Nauk Belorussk.SSR, ser. fiz.-mat.,1974, No 1, pp.69-72.

ON DUAL TRANSOFRMATIONS IN MACROSCOPIC ELECTRODYNAMICS

Physically indiscrepant formulation of dual transformations in macroscopic electrodynamics is given and physical basis for using these tranformations is cleared out (particularly when sloving the problem of the Dirac monopole interaction with a medium).

661. Strazhev V.I. Lett.Nuovo Cimento,1974, vol. 9,No 16, pp.641-644.

THE QUANTUM THEORY OF DUAL CHARGED PARTICLES

662. Stix M. and Wiehr E. Solar Phys.,1974, vol. 37, No 2, p.493.

ON THE SOLAR MAGNETIC "MONOPOLE"

A superposed epoch analysis shows that the Sun's spurious magnetic monopole varies like the solar declination. This indicates that the monopole is caused by instrumental effects.

663. Tassie L.J. Int.J.Theor. Phys.,1974, vol.9, p.167.

LINES OF QUANTIZED MAGNETIC FLUX AND THE RELATIVISTIC STRING OF THE DUAL RESONANCE MODEL OF HADRONS

The quantization of magnetic flux and the quantization of electric charge follows from requiring the same invariance properties under time reversal of both classical and quantum systems. The action integral for a line of quantized magnetic flux is the area of the surface traced out in space-time by the motion of the line. It is suggested that the relativistic string of the dual resonance model of hadrons is a line of quantized magnetic flux. Accordingly, quarks have magnetic charge. Assuming quarks of magnetic charge + g, -2g, baryons are composed of three quarks. States of one, two, four or five quarks will not normally occur. An explanation is given of the failure to produce free quarks.

664. Tyutin I.V. P.N.Lebedev Phys.Inst. Acad. of Sci. USSR, Preprint No 27, 1974,Moscow,USSR.

ELECTRON SCATTERING ON A SOLENOID

665. Usachev Yu.D. Sov.J.Part. and Nucl. (USA),1974, vol.4, No 1, pp.94-99.

IS THERE A THEOREM FOR QUANTIZATION OF THE MAGNETIC CHARGE?

666. Wadas R. Postepy Fiz. (Poland),1974, vol.25, No 3, pp.289-293.

MAGNETIC MONOPOLES

The magnetic monopoles ideas of Dirac and Schwinger are presented. The methods of their search are listed. Recent developments in experimental results are reviewed.

667. Yueh W.R. Thesis, Columbia Univ.,New York, 1974.

PAIR PRODUCTION PROCESSES AND FINAL-STATE INTERACTION

Principally a discussion of general radiative processes - but also considers case of magnetic monopole.

Prediction

Discussion of Laboratory production of pole pairs with a laser. Concludes it is not feasible.

668. Yueh W.R. Print -74-0344,Columbia,1974.

SPONTANEOUS DUALITY SYMMETRY BREAKING,NON-CLASSICAL MONOPOLE THEORY AND FINITE QUANTUM ELECTRODYNAMICS

669. Zrelov V.P., Kollarova L.,Kollar D., Lupil'tsev V.P., Pavlovic P., Ruzicka J., Sidorova V.I.,Shabashov M.F., Janik R. Joint Institute for Nuclear Research,P1-7996, Dubna, 1974.

SEARCH FOR THE DIRAC MONOPOLE OVER THE VAVILOV-CHERENKOV RADIATION USING THE 70 GEV IHEP PROTON SYNCHROTRON

At the proton energy of 70 GeV on the internal target of the IHEP proton synchrotron the search was made for magnetic charges over the Vavilov-Cherenkov radiation and

characteristic polarization. Eight Cherenkov counters of a special construction served as detectors. Possible events were recorded with two fast five-ray oscillographs triggered by six -fold coincidences. The efficiency of the mangetic charge recording was about 10%.

The proton beam of 6.4×10^{16} intensity traversed the target-radiator; and not a single case of the production of the Dirac monopole with the magnetic charge from minimal one of about $2/3\ g_D$ ($g_D = 68.5$ e) up to $2\ g_D$ was recorded. This means that in the conditions of our experiment the upper boundary of the cross section of the Dirac monopole production by 70 GeV protons per nucleon of Si and O nuclei for magnetic targets of masses from 3 up to 5.5 m_p was found to be $\sigma\,(95\%) \leq 10^{-40}\,cm^2$.

1975

670. Adair R.K. In: LEPTON AND HADRON STRUCTURE. International School of Subnuclear Physics, Erice, Italy, 1975, vol.12, pp.318-374.

MISSING PARTICLES

Review of particle searches in some detail.

671. Ahlen S.P. Contract NGR-05-003-376,1975 (NASA-CR-146806).

MONOPOLE TRACK CHARACTERISITCS IN PLASTIC DETECTORS

Total and restricted energy loss rates were calculated for magnetic monopoles of charge g=137e Lexan polycarbonate Range-energy curves are also presented. The restircted energy loss model is used to estimate the apperance of a monopole track in plastic detectors. These results should be useful for the design and analysis of monopole experiments.

672. Akhiezer A.I. and Rekalo M.P. Soviet Physics - Uspekhi 1975, vol.17, p.864.

ELECTRIC CHARGE OF ELEMENTARY PARTICLES

673. Alvarez L.W. Lawrence Berkeley Laboratory,LBL-4260,Berkeley 1975.

ANALYSIS OF A REPORTED MAGNETIC MONOPOLE

Criticism of PSOP suggesting event may be a heavy ion undergoing several interactions. Points out that thickness above Cherenkov detector was 0.3 gm/cm^2 lexan equivalent rather than reported 0.7 gm/cm^2.

674. Alvarez L.W. Invited talk presented at the Stanford International Conference on Leptons and Photons,Stanford, California, 1975.

ANALYSIS OF A REPORTED MAGNETIC MONOPOLE

It is shown that there are several substantive errors

in a previous work on a cosmic ray event which is consistent with the hypothesis that it was caused by a magnetic monopole. It is shown that the data points fit to the hypothesis that the responsible particle is a platinum nucleus fragmenting to osmium and then to tantalum.

675. Anderson P.W. In: GAUGE THEORIES AND MODERN FIELD THEORY, Proceed. of a Conf. held on Notheastern Univ., Boston, 1975, pp.311-335.

USES OF SOLID STATES ANALOGES IN ELEMENTARY PARTICLE THEOREM

The solid state background of some the modern ideas of field theory is reviewed, and additional examples of modern situations in solid state or many-body theory which may have relevance to fundamental theories of elementary particle are adduced.

676. Andreev V.A. Sb. Kratkh. Soobshch. Fiz. AN SSR, Fiz.Inst. P.N.Lebedeva, 1975, No 2, pp.32-35.

ALGEBRAIC PROPERTIES OF THE SCATTERING AMPLITUDE FOR A MAGNETIC MONOPOLE
(In Russian)

677. Andreev V.A. Sov. Phys.Lebedev Inst.Rep (USA), 1975, No 2, pp.39-46, (Transl. of: Sb.Kratkh.soobshch. Fiz. ANSSSR, Fiz. Inst. P.N.Lebedeva, 1975, No 2, pp.32-35).

ALGEBRAIC PROPERTIES OF THE SCATTERING AMPLITUDE FOR A MAGNETIC MONOPOLE

678. Andreev V.A. Sb.Kratk.Soobshch. Fiz. AN SSSR, Fiz.Inst. P.N.Lebedeva, 1975, No 8, pp.3-8.

METHODS OF SUMMING UP OF THE KLEIBSH-GRODON COEFFICIENTS AND THEIR APPLICATION IN THE THEORY OF MAGNETIC MONOPOLE

The method of summing the Kleibsh-Gordon coefficients (group /03/) has been developed. Some sums, obtained in calculations are obtained according to perturbation theory

by means of this method in the models of the hydrogen atom and magnetic monopole.

679. Andreev V.A. Sov.Phys.-Lebedev Inst.Rep.(USA),1975, No 8 pp.1-6,(Translation of : Sb.Kratk.Soobshch. Fiz. AN SSSR Fiz.Inst.P.N.Lebedeva,1975, No 8, pp.3-8).

METHODS FOR SUMMING THE KLEIBSCH-GORDON COEFFICIENTS AND THEIR APPLICATION IN THE THEORY OF MAGNETIC MONOPOLE

680. APPARENT DISCOVERY OF LONG-SOUGHT MONOPOLE: "CONTROLLED EXCITEMENT", Sci.News,1975, vol.108, No 8/9, pp.118 -120.

681. Arafune J., Freund P.G.O. and Goebel C.J. J.Math.Phys., 1975, vol.16, No 2, pp.433-437.

TOPOLOGY OF HIGGS FIELDS

It is shown that the conserved magnetic charge discovered by 't Hooft in non-Abelian gauge theories with spontaneous symmetry breaking is not associated with the invariance of the action under a symmetry group.Rather it is a topological characteristic of an isotriplet of Higgs fields ina three-dimensional space; the Brouwer degr of the mapping between a large sphere in configuration, space and the unit sphere in field space provided by the normalized Higgs field $\hat{\Phi}^a = \Phi^a (\Phi^b \cdot \Phi^b)^{-1/2}$. The use of topological methods in determining magnetic charge configurations is outlined. A peculiar interplay between Dirac strings and zeros of the Higgs field under gauge transformations is pointed out. The monopole-antimonopole system is studied.

682. Arafune J., Freud F.G.O., Goebel C.J. International Symposium on Mathematical Problems in Theoretical Physics, 1975, pp.240-241. Lecture notes in Physics, 1975, vol.39.

TOPOLOGY OF HIGGS FIELDS

683. Artru X. Nucl.Phys.,1975, vol.B 85, p.442.

STRING MODEL WITH BARYONS: TOPOLOGY, CLASSICAL MOTION

We consider the model in which a meson is an open string with a quark at one end, an anti-quark at the other end; a baryon is made of three strings joining at a point an carrying quarks at their free ends. The triality condition is ensured by orienting the strings according to simple rule These rules suggest the existence of an underlying magnetic monopole theory. Independently of this explanation we investigate first the topological properties of the model by looking at the duality diagrams: existence of exotic hadrons of five basic interactions between strings. Some normalization diagrams are assigned a negative power of the Veneziano coupling constant. Then taking the same action (the world-sheet area) as in the conventional string model we set down the equations of motion of a junction. We argue that the slo of the leading baryonic Regge trajectory is the same as that for the mesons. As an example of an application, we study the sticking together of two colliding strings; we find that it is classically forbidden at relation velocities greater than $(\frac{6}{7})^{1/2}$.

684. Badhwar G.D., Golden R.L., Lacy J.L.,Stephens S.A. 14-th International Cosmic Ray Conf., Muenchen,1975, vol.12, pp.4068-4071.

ENERGIES OF MONOPOLE PRODUCTION

In this paper we explore the relativistic kinematics of monopole production and mechanism of energy loss and gain for monopoles in free space and in the upper atmosphere. We conclude that a monopole produced in a nuclear interaction must have a laboratory energy greater than approximately 2×10^5 GeV if its mass is greater than 600 GeV/c^2. A study of energy loss mechanism of such an energetic monopole in the earth's magnetic field and atmosphere rules out the possibility of observing such a monopole with the parameters observed by Prince et al. The very low velocity of the observed monopole also makes an extraterrestrial production mechanism very unlikely.

685. Bais F.A. and Russell R.J. Phys.Rev., vol.D11,1975, No 10, pp.2692-2695.

MAGNETIC-MONOPOLE SOLUTION OF NON-ABELIAN GAUGE THEORY IN CURVED SPACETIME

A magnetic monopole solution of a non-Abelian gauge theory as proposed by 't Hooft is studied in curve space-time. Einstein's equations are solved for the case of a magnetic point charge yielding a metric identical to the Reissner-Nordström metric, except that a nonvanishing cosmological constant is involved.

686. Balachandran A.P., Rupertsberger H. and Schechter J. Phys.Rev., 1975, vol. D11, No 8, pp.2260-2271.

MONOPOLE THEORIES WITH MASSLESS AND MASSIVE GAUGE FIELDS

We investigate magnetic-monopole-type theories, including those where the gauge field acquires a mass. The study is based on a modification of Awanziger's local Lagrangian formulation of the usual (zero-mass) theory. The quantization is carried out by using Dirac's general method. For the mass-zero case the known results are recorded including the charge-quantization condition. The Hamiltonian and angular momentum for the massive case are derived and sicussed. Further, it is shown how Numbu's static phenomenological Hamiltonian can be derived as a special case of the massive theory. Certain difficulties associated with the rotational invariance of such theories are pointed out.

687. Balachandran A.P., Ramachandran R., Schecter J., Wali K.C. and Rupertsberger H. Proceedings of the Second Orbis Sciential, University of Miami, ed. Perlmutter A. and Widmayer S.M.,Plenum, New York, 1975,pp.341-347. SU-4205-47, Coral Gables, Florida, 1975.

MONOPOLE' STRINGS AND CHARMONIUM

We shaw that the strength of the potential which varies as the distance between quarks can be related to the universal Regge slope parameter α' . This relation is in

excelent agreement with the phenomenological analysis of the newly discovered resonances ψ (3.1) and ψ (3.7) by Eichten et al.

688. Balachandran A.P., Ramachandran R., Schechter J.,Wali K.C., Rupertsberger H. Syracuse Univ., N.Y. (USA), Dept. of Phys., SU-4206-54,1975.
Vienna Univ.(Austria). Inst. fuer Theoretische Physik. COO-3533-54.

STRINGS,MONOPOLES AND MESON STATES

Dirac's formulation of the monopole theory modified by an additional mass term for the gauge field has been considered as a possible simplified model for quark binding. Methods are discussed for the consistent regularization of the infinities present in the resulting action and equations of motion. This leads to an action which is the same as that suggested by previous authors. It is shown that the expression for the energy of the modified action still has infinities unleas the mass of the gauge field is infinite. Thus the regularization procedure is in complete when the gauge field has finite mass. Applications of the regularized model to charmonium and other meson states are discussed.

689. Balachandran A.P., Ramachandran R., Schechter J., Rupertsberger H. Syracuse Univ., N.Y. (USA), Dept. of Phys., SU-4206 53, COO-3533-53,1975.

HAMILTONIAN FORMULATION OF MONOPOLE THEORIES WITH STRINGS

We consider the Hamiltonian formulation of the theory resulting from Dirac's monopole action supplement by a mass term for the gauge field. The original (zero mass gauge field) theory is also discussed and its Hamiltonian is shown to be essentially the same as that of the two potential formalism. In this case, the coordinates of the string are absorbed into what turn out to be the physically meaningful variables for the particles and the field. In the massive cas

the string does play a significant role and gives rise to a static linear potential and a Yukawa potential between the monopole. Such a potential has also been found by Nambu and others and may lead to an acceptable model for interactions of quarks.

690. Barut A.O. Phys.Blätter, 1975, vol.31, No 8, pp.352-361.

THE PHYSICS OF MAGNETIC MONOPOLES.A CONTRIBUTION TO THE MAGNETIC MODEL OF MATTER

General review of Barut's position on magnetic monopoles.

691. Biza Yu. S. and Tomil'chik L.M. Vestsi Akad.Navuk BSSR, Ser. Fiz.-mat navuk, 1975, vol.2, pp.110-113.

EFFECT OF THE NON-UNIVERSALITY OF THE RATIO g/e ON THE SPECTRUM OF A HYDROGEN-LIKE SYSTEM AND EVALUATION OF THE MAGNETIC CHARGE

Within the frame-work of the first approximation of perturbation theory the influence of quantity g/e shift from the universal one at the energy spectrum of the non-relativistic hydrogen-like system comprising to dually charged particles is calculated. The numerical calculation of the magnetic charge of proton, muon, pion and kaon is made on the basis of spectroscopic data for hydrogen atoms and mesoatoms .

692. Biza Yu.S., Tomil'chik L.M. Teoret. i Matemat. Fizika, 1975, vol.24,pp.325-332.

NON-UNIVERSALITY OF THE g/e REACTION IN THE RELATIVISTIC KEPLER PROBLEM

Effect of g/e relation non-universality on the energy spectrum of a relativistic hydrogen-like system is investigated. The first order correction to the energy eigenvalues for 1/2 spin case (the Dirac equation) is calculated. It is shown that in this case the two-fold degenracy which takes place in the ordinary relativistic Kepler problem removes itself, which can be interpreted as a peculiar Lamb shift imitation. Direct evaluation of the upper limit

for possible magnetic proton and muon charges is made with the aid of the comparison between the results obtained and known experimental and theoretical data concerning Lamb shift numerical value in ordinary atoms and mumesonic atoms.

693. Bludman I.A., Ruderman M.A. University of Pensylvania, Dept. of Phys., UPR-0053T, Philadelphia, 1975.

THEORETICAL LIMITS ON INTERSTELLAR MAGNETIC POLES SET BY NEARBY MAGNETIC FIELDS

The persistence of the nearby interstellar magnetic field limits the monopole birth rate in our galaxy to $< 10^{-37}$ poles $cm^{-3}s^{-1}$, and flux to $< 10^{-16}$ poles $cm^{-2}s^{-1}$ For magnetic monopoles more energetic then 3×10^4 GeV, thi theoretical flux limit is lower than that set by monopole searches in lunar rocks. Since the average energy gained by cosmic monopoles from the interstellar field is $> 10^{11}$ GeV they can be detected non-relativistically only if their mass $M \geq 10^{11}\,GeV/c^2$. Such large masses may be concievable for elementary 't Hooft monopoles. They can, however, be produced in collisions on stationary nucleons only at $E > 10^{22}$ GeV and then require at least 10^{21} g m cm^{-2} matter for ionization loss to make them non-relativistic. Such massive monopoles can therefore only be primordial or cosmologically produced. Low mass monopoles trapped in one micron dust grains and released only in the earth's atmosphe are possible, but their flux must be far below that deduced by Price et al.

694. Boal D.H. and Moffat J.W. Phys.Rev.,1975, vol.D11, No 8, pp.2026-2030.

PHYSICAL CONSEQUENCES OF A SOLUTION OF THE NON-SYMMETRIC UNIFIED FIELD THEORY

The physical consequences and possible tests of our solution of the non-symmetryc unified field theory of gravitation and electromagnetism are discussed. It is found in general that a universal constant k introduced in the unification of the theory shows itself as a fourth-order effect in the propagation of light near a charged body.

Further, it is shown that magnetic monopoles are not an allowed solution of the theory.

695. Budnev V.M., Ginzburg I.F., Meledin G.V., Serbo V.G., Phys.Rep.,1975, vol.15, p.181.

THE TWO-PHOTON PARTICLE PRODUCTION MECHANISM. PHYSICAL PROBLEMS. APPLICATIONS. EQUIVALENT PHOTON APPROXIMATION

Reviews how photon spectrum from virtual excitation of monopole pairs should go.
Prediction:
Cross section and distributions from virtual excitation of $M\bar{M}$.

696. Burke D.L., Gustafson H.R., Jones L.W. and Longo M.L. Phys.Lett., 1975, vol. B60, p.113.

SEARCH FOR ANOMALOUS MULTIPHOTON PRODUCTION AT 100-300 GEV

We have carried out a search for anomalous multiphoton production in neutron-CH_2 collisions at Fermilab. Both anomalous γ events as might be produced in the annihilation of a magnetic monopole pair, as well as events with smaller opening angles, such as those observed in cosmic ray emulsions by Schein et al. and others were sought. No evidence for either type of event was found. An upper limit ~ 2.7 μb is placed on the production cross section for "Schein" events or $\sim 10^{-2}$ that deduced from the cosmic ray data.

697. Campbell W.B., Finkler P., Jones C.E. and Misheloff M.N. Print-75-1005, Nebraska, 1975.

DIRAC MONOPOLES, THE AHARANOV - BOHM EFFECT AND FLUX QUANTIZATION IN SUPERCONDUCTORS

698. Cabera B. In: LOW TEMPERATURE PHYSICS, M.Krusins and M.Vurio, Ed., North-Holland,1975, vol.IV.

GENERATING ULTRA-LOW MAGNETIC FIELD REGIONS WITH SUPERCONDUCTING SHIELDS AND THEIR USE WITH A SENSITIVE MAGNETIC CHARGE DETECTOR

699. Carrigan R.A.,Jr., and Nezrick F.A. Nucl.Phys.,1975, vol. B91, No 2, pp.279-288.

SEARCH FOR NEUTRINO-PRODUCED MAGNETIC MONOPOLES IN A BUBBLE CHAMBER EXPOSURE

J.Schwinger has suggested that magnetically charged particles could be produced via a magnetically charged intermediate boson process similar to the mechanism sometimes envisioned for double muon production by neutrinos. A search for magnetic monopole production by neutrinos has been made by reexamining the CERN heavy liquid bubble chambe pictures obtained during the neutrino exposures of 1963 and 1967. Five different searches were made for events which contained a free monopole with and without target nucleus excitation and for bound monopoles which deexited by photon emission. No events were found. Neutrino monopole production cross section limits are given.

700. Carrigan R.A.,Jr., Nezrick F.A. and Strauss B.P. FERMI NATIONAL LABORATORY, FERMILAB-pub-75/83-EXP,Batavia, 1975.

SEARCH FOR MISPLACED MAGNETIC MONOPOLES

The quoted flux in recent report of a detected magnetic monopole is inconsistent by factor on the order of five hundred thousand with ocean-bottom searches. One resolution of this incongruity is that monopoles are trapped somewhere between the top of the atmosphere and the ocean bottom.We have searched for monopoles in the atmosphere and ocean water and have found none at levels substantially below the numbers expected if the monopoles were trapped.

increased a factor of 35 by using a sensitive magnetometer (SQUID) to measure changes in current. The modifications, new measurement techniques, and implications for past and future experiments are described.

711. Eberhard P.H., Ross R.R.,Taylor J.D.,Alvarez L.W., and Oberlack H. Phys.Rev.,1975, vol. D11, No 11, pp.3099-3104.

EVIDENCE AT THE 10^{-18} PROBABILITY LEVEL AGAINST THE PRODUCTION OF MAGNETIC MONOPOLES IN PROTON INTERACTIONS AT 300 GEV/C

An electromagnetic search for magnetic monopoles that requires very few assumptions about their properties has been performed in material exposed for protons accelerated at FERMILAB to electrons at SLAC, and to pp interactions as the CERN ISR. The most significant irrediation (Fermilab 300 GeV/c) produced 2.5×10^{18} primary proton-aluminum interactions. No monopoles were found. If monopoles exist with masses less than 12 GeV, the probability of pair production in a proton-nucleon collision is of the order of 10^{-18} or less with 95% confidence.

712. Eberhard P.H. Lawrence Berkeley Laboratory, LBL-4289, Berkeley,1975.

STATUS OF SEARCHES FOR MAGNETIC MONOPOLES

Review of PSOP event and problem of reconciling with existing cosmic searches.

713. Eberhard P. Meeting of the ASP division of particles and fields, Seattle, Washington, USA, 27 Aug 1975.

STATUS OF SEARCHES FOR MAGNETIC MONOPOLES

The recent experiment reporting the discovery of a monopole is compared to the negative experiments performed previously. The different determinations of the flux of monopoles are contradictory. It is likely that the event reported as a monopole may be given another interpretation.

714. Eberhard P.H. and Ross R.R. LBL-4614, Lawrence Berkeley Lab., Berkeley, 1975.

ARE MONOPOLES TRAPPED BY FERROMAGNETIC MATERIAL?

Reviews arguments of binding of monopoles to ferromagnetic materials and concludes they are plausible.

715. Eguchi T. Phys.Lett., 1975, vol.B59, No 1, pp.73-78.

COLOURED MAGNETIC MONOPOLES

We extend Dirac's theory of magnetic monopoles to the case of non-Abelian color gauge groups. Exact classical solution is obtained by making use of the gauge-independent method of Yang-Mills field. The case of broken gauge symmetry is also briefly discussed.

716. Eguchi Tohru. The Enrico Fermi Institute, The University of Chicago, EFI 75-16, Chicago, Illinois, 1975.

COLOURED MAGNETIC MONOPOLES

717. Ezawa Z.F. and Tze H.C. Nucl.Phys., 1975, vol.B100, No 1, pp.1-20.

TRIALITY MONOPOLES, HADRONIC VORTICES AND THE YANG-MILLS CONNECTION

In the context of a colour SU(N) gauge theory, we formulate a scheme for courless Dirac monopoles with thier associated strings. Its distinct feature lies in the introduction of a covariant constant measuring operator C with which a relativistic gauge invariant flux is constructed for the monopoles. This flus is defined only by modulo N. Furthemore, the existence of C leads to a reduction in the colour degrees of freedom and specifies the holonomy group classifying a new monopole solution to the field equations. Since the Dirac strings become physical vortices in an SU(N) superconducting vacuum we shaw that N quark-monopole are confined at the ends of N legged vortices, thus fulfilling the Mandelstam-Polyakov topological "triality". The Nambu-London equations for these interacting vortices are derived in the three approximation.

718. Faddeev C.D. JETP Letters, 1975, vol.21, p.64.

719. Fleischer R.L. and Walker R.M. Phys.Rev.Lett., 1975, vol.35, pp.1412-1419.

PROBABILITIES FOR AN ALTERNATIVE EXPLANATION OF THE MOVING MAGNETIC MONOPOLE

The cosmic-ray track that has been interpreted as a magnetic monopole may in principle be from a nucleus that underwent nuclear interactions. The apriori probability of this Catter process is calculated to be $\sim 10^{-13}$ if the particle moved at the reported velocity of $< 0.6c$, but rises to $\sim 10^{-3}$ if 0.7 is allowed. Among the number of cosmic rays already examined, the total predicted probabilities for observing such an interacting event would have been 7×10^{-13} at $< 0.6c$ and $\sim 2\%$ at 0.7c.

720. Frampron P.H. Phys.Rev.,1975, vol. D12, No 2,pp.538-545.

STRING APPROACHES TO HADRON STRUCTURE

Two principle string approaches to a more realistic dual resonance model are discussed. Firstly, Nambu's proposal of 1974, identifying the Dirac magnetic monopole string with the dual string, after spontaneous break-down and the Higgs mechanism in a strong-coupling limit is investigated. The mathematics underlying Nambu's rather intuitive derivation has been further investigated by Balachandran,Rupertsberger and Schechter (who put in the vector mass by hand) and independently by Levicki and Senjenovic (who fully exploit spontaneous breaking and the Higgs mechanism).Here we show that in a leading approximation to the Nambu monopole action the fenomenologically desirable linearity of the leading Regge trajectory seems to be badly violated. Secondly, alternative quantization procedures for the original 1970 Nambu relativistic string action (area of the wordly sheet) are treated in particular a timelike identific

tion of the string time τ which has recently been advocated by Patrascioiu ,by Rohrlich, and by Goddard ,Hanson and Ponzeno. The most novel of this discussion seems to be that of Rohrlich who ses a quite different representation for the canonical algebra and the Poincaré group. Here we demonstrate, however, that the usual unphysical level spectrum with a massless first excited state emerges as a fully consistent solution even in this approach, and that probably no other solution exists. Finally, the various Nambu string approaches are compared to other attempts to discover the "right" model of strong interactions.

721. Frampton P.H. Univ.of California Preprint, UCLA/75/TEP/23, Los Angeles,1975.

RADIAL EXCITATIONS OF THE 'T HOOFT MONOPOLE

722. Frzier K. Sci.News,1975, v.108, No 14, pp.222-223.

HIGH STAKES IN THE MONOPOLE CLAIM GAME;
ALVAREZ: "TOO BAD IT WASN'T RIGHT"

723. Frenkel A. and Hrasko P. Central Research Institute for Physics, KFKI-75-82,Budapest,Hungary,1975.

See also: Ann.Phys.,1977, vol.105, pp.288

INVARIANCE PROPERTIES OF THE DIRAC MONOPOLE

The qunatum mechanical motion of a spinless electron in the external field of a magnetic monopole of magnetic charge g is investigated. It is shown that Dirac's quantum condition $2ge(\hbar c)^{-1} = n$ for the string being unobservable ensures rotation invariance and correct space reflection properties for any integer value n .The rotation and space reflection operators are found and their group theoretical properties are discussed. A method for constructing conserved quantities in the case when the potential is not explicitly invariant under the symmetry operation is also presented and applied to the discussion of the angular momentum of the electron-monopole system.

724. Friedlander M.W. Phys,Rev.Lett., 1975, vol.35, No 17, pp.1167-1169.

COMMENTS ON THE REPORTED OBSERVATION OF A MONOPOLE

It is shown that the cosmic-ray event recently interpreted as the track of a Dirac monopole can instead be plausibly described in terms of the interaction of an ultraheavy cosmic-ray nucleus, having $Z \sim 96$ and velocity $\sim 0.72c$.

725. Fronsdal C. Phys.Rev.,1975, vol.D12, No 12, pp.3819-3930.

ELEMENTARY PARTICLES IN A CURVED SPACE. IV. MASSLESS PARTICLES

Is physics is stable with respect to a class of perturbation of the spacetime metric, including that of "small" constant four -dimensional curreture, then it may be shown that (1) left-handed and right-handed neutrinos are distinguished by a superselection rule, (2) magnetic monopoles cannot exist, (3) the confirmal symmetry associated with the field equations for massless particles with spin 0,1/2 and 1 is pontaneously broken except in the case of neutrinos with fixed chirality.

726. Giacomelli G., Rossi A.M.,Vannini G.,Bussiere A., Baroni G., Di Liberto S., Petrera S., Romano G. Nuovo Cimentro A, 1975, vol.28A, No 1, pp.21-28.

SEARCH FOR MAGNETIC MONOPOLES AT THE CERN-ISR WITH plastic detectors

A search for Dirac's magnetic monopoles produced in pp collisions was performed at the CERN-ISR employing plastic detectors. The search was sensitive to poles with a mass $m_g \leq 30$ GeV. For $m_g < 20$ GeV and a magnetic charge $0.4g_o < g < 2.5g_o$ the search yielded in upper limit on the production cross-section of $\sigma < 2.10^{-36} cm^2$ (95% confidence level).

727. Giacomelli G. and Thorndike A. Proceedings of the 1975 Isabelle Summer Study, July 14-25,1975, Brookhaven National Laboratory, BNL-20550, vol.2, pp.301-315.

MONOPOLE SEARCHES AT ISABELLE

Contains a discussion of possible monopole search experiments that could be carried out at the Isabelle storage rings.

728. Glashow S.L. In: GAUGE THEORIES AND MODERN FIELD THEORY, Proceedings of a Conference held at Northeastern University Boston,1975, pp.222-227.

FUNDAMENTAL THEORY:NEW PARTICLES,NEW IDEAS

729. Goldhaber A.S. and Smith J. Rep.Prog. Phys., 1975, vol.38, pp.7310770.

HYPOTHETICAL PARTICLES

A review is given of the status of hypotheses about various undiscovered particles.Magnetic monopoles,interme - diate bosons, heavy leptons, scalar particles, quarks,tachyons and protons are discussed, along with speculations about the newly discovered neutral mesons.

730. Greub W. and Petry H.R. J.Math.Phys.,1975, vol.16,No 6, pp.1347-1351.

MINIMAL COUPLING AND COMPLEX LINE BUNDLES

The concept of minimal coupling, which leads to the Schrödinger equation of a particle in an external electro-magnetic field, is reformulated within the theory of complex line bundles. The possible generalizations are discussed and the case of magnetic monopole is investigated with the help of the new formalism.

731. McGuire P., Ruffini R. Phys.Rev.,1975, vol. D12,No 10, pp.3019-3025.

SOME MAGNETIC AND ELECTRIC MONOPOLE ONE-BODY SOLUTIONS OF THE MAXWELL-EINSTEIN EQUATIONS

We examine the electromagnetic structure of a

one-body solution of the coupled Einstein-Maxwell equations endoved with mass m , charge Q , specific momentum a, and a parameter l. It is shown how the parameter introduced by Newman, Tamburino and Unti is related to the magnetic monopole charge distribution of the solution. A relation is presented between the total mass energy of the system and its irreducible mass. The total mass energy can be much smaller than the irreducible mass. A general solution charac terized by the four parameters m,Q,a, and l is here intro duced.

732. Gürsey F. In: GAUGE THEORIES AND MODERN FIELD THEORY, Proceedings of a Conf. held at Northeastern University, Boston,1975, pp.369-376.

SUPERSYMMETRIC ANSATZ FOR SPONTANEOUSLY BROKEN GAUGE FIELD THEORIES

It is shown that a new type of Ansatz involving spinors in a gauge theory with Higgs fields based on SU(3) leads to 't Hooft type monopole solutions with finite energy which carry fractional charges of the quarks.

733. Hagstrom R. Phys.Rev.Lett., 1975, vol.35, No 25,pp.1677-1678.

PRACTICABLE DISCRIMINATION OF RAPIDLY MOVING ELECTRIC AND MAGNETIC CHARGES

A method of discriminating between rapidly moving electric and magnetic charges is proposed. The scheme relies on detection of the polarization of Cherenkov radiation.

734. 't Hooft G. Rapporteur's talk given at EPS Int.Conf. on High Energy Physics, Palermo,1975, pp.1225-1250.

GAUGE THEORIES WITH UNIFIED WEAK,ELECTROMAGNETIC AND STRONG INTERACTIONS

735. Hosoya A. and Ishida J. International Symposium on Mathematical Problems in Theoretical Physics, Kyoto, 1975. Lecture Notes in Physics, No 39, 1975.

NEW EXACT SOLUTIONS OF THE CLASSICAL YANG-MILLS FIELD EQUATIONS

736. Hsu J.P. Nuovo Cimento Lett., 1975, vol.14, No 6, pp.189-192.

MAGNETIC MONOPOLES AND DISTORTED GAUGE SYMMETRY

Magnetic monopoles exist in vector-boson theories with intrinsic symmetry break down rather than spontaneously broken symmetry.

Prediction :

Possibly mass = M/e^2 (M= vector boson mass)

No strings

737. Hsu J.P. Texas Univ., Austin, USA, Centre for Particle Theory, Oct.1975, ORO-3992-236.

MAGNETIC MONOPOLES AND DISTORTED GAUGE SYMMETRY

It is shown that magnetic monopoles occur in massive vector boson theory with an intrinsic symmetry break down while still possessing distorted gauge symmetry. The exact static spherically symmetric solutions for the monopole are obtained. Their meaning is discussed on the basis of gauge symmetry.

738. Hsu J.P. Center for Particle Theory, Texas Univ., Austin, USA, ORO-3992-254, 1975.

MIXING ANGLE THETA AND MAGNETIC MONOPOLE IN WEINBERG'S UNIFIED GAUGE THEORY

Gauge symmetry admits a local unit isovector and leads to the magnetic monopoles in Weinber's unified theory. One predicts $\sin^2\theta = 1/2$ for the mixing angle θ on the basis of Dirac's condition for charge quantization. This interesting result should be tested experimentally.

739. Hsu J.P. Texas Univ.,Austin,USA, Center for Particle Theory, ORO-3992-223,1975.

EXACT MAGNETIC MONOPOLE SOLUTIONS IN YANG-MILLS AND UNIFIED GAUGE THEORIES

We study the magnetic monopoles in non-Abelian gauge theories. The exact static spherically symmetric solutions of the magnetic monopoles in both Yang-Mill's and unified gauge theories are obtained. The energy E of the static system is calculated and it is either zero or infinite. The existence of the magnetic monopole solution is a consequence of symmetry rather than dynamics. We propose a new definition of the electromagnetic field tensor which relates the static solution of gauge fields and the magnetic monopole solution. Experimental implications are discussed.

740. Hungerford E.V. Phys.Rev.Lett.,1975, vol.35, No 19, pp.1303-1305.

COMMENT ON THE OBSERVATION OF A MOVING MAGNETIC MONOPOLE

It is determined that if the recent observation of a cosmic-ray track is accepted as produced by a magnetic monopole than the magnetic charge must correspond to a south-seeking pole for a monopole mass less than 6.6×10^3 GeV/c^2. In addition, the pole could not have been produced by a primary cosmic ray in the upper atmosphere.

741. Ivanenko D.D. and Burinskii A.Ya. Izv.Vyssh.Uchebn.Zaved., Fiz.,1975, vol.5, p.135.

GRAVITATIONAL STRINGS IN ELEMENTARY PARTICLE MODELS

742. Jackiw R. In: GAUGE THEORIES AND MODERN FIELD THEORY, Proceed. of a Conference held at Northeastern University, Boston, 1975, pp.377-401.

CHARGE AND MASS SPECTRUM OF QUANTUM SOLUTIONS

A perturbative method for solution sectors in quantum field theory is reviewed and the solution mass spectum is

discussed. It is shown that quantizing the Yang-Mills monopole forces the presence of charge-bearing monopoles, which are almost degenerate in mass

743. Jackson J.D. CLASSICAL ELECTRODYNAMICS. Second edition, Willey-New York,London,Sydney,Toronto,1975, p.251.

ON THE QUESTION OF MAGNETIC MONOPOLES

Contains an excellent introduction to the monopole conjecture.

744. Jehle Herbert. Phys.Rev.,1975, vol. D11, No 8,p.2147.

FLUX QUANTIZATION AND FRACTIONAL CHARGES OF QUARKS

745. Jevicki A. and Senjanovic P.I. Phys.Rev.,1975, vol. D11, No 4, pp.860-865.

STRING-LIKE SOLUTION OF HIGGS MODEL WITH MAGNETIC MONOPOLES

We derive a static solution of the equations of motion following from a Higgs-type lagrangian containing in addition static magnetic monopoles representing quarks. For this purpose, we use Zwanziger's approach ot magnetic monopoles, and thus we are dealing with a local field theory for charged particles. We show that the solution has the form of a string of finite length for large coupling. We exhibit the dependence of the energy of the system (E) on interquark distance $(2a)$, $= E(2a) = -(g^2/8\pi a)\exp(-e|\varphi_1|2a) + c|\varphi_1|^2 a$, which is the form found by Nambu in his discussion of this ty of model as a scheme which offers a mechanism for quark confinement. We therefore confirm that Numbu's results can be reached in field-theoretic formulation.

746. Julia B. and Zee A. Phys.Rev., 1975, vol. D11, No 8, pp.2227-2232.

POLES WITH BOTH MAGNETIC AND ELECTRIC CHARGES

IN NON-ABELIAN GAUGE THEORY

We show that a non-Abelian gauge theory with Higgs fields exhibits classical solutions which are both electrically and magnetically charged. This represents a specific realization of the dyons discussed some years ago by Schwinger. At the classical level the electric charge of the dyon does not appear to be quantized. We present some remarks in this connection.

747. Kerner R. Int.J. Theor.Phys.,1975, vol.12, No 3, pp.177-182.

GENERALIZED MAGNETIC MONOPOLE FOR THE YANG-MILLS FIELD

By analogy to the magnetic monopole first proposed by Dirac (1931), a generalized magnetic monopole, being a source of the Yang-Mills field, is constructed. The gauge invariance and the rotational symmetry lead in a natural way to the quantization not only of the electric charge but also of the hypercharge number Y . It is shown that the generalized magnetic charges are not arbitrary, and some restrictions on the values are deduced.

748. Klein O. Nucl.Phys.,1975, vol. B92, No 3, pp.541-546.

ELECTROMAGNETIC THEORY TREATED IN ANALOGY TO THE THEORY OF GRAVITATION

As a further contribution to the program of Klein the present paper treats electromagnetic theory as an analogue to that of gravitation, introducing two extra dimensions not belonging to space and time, one space-like and one time-like. The difficulty concerning unitarity mentioned there is surmounted by a rational generalization of Bargman's needed for the same purpose for the Lagrangian density belonging to the Dirac equation.Moreover, the treatment of the inversion relations, using one extra dimension, is extended to two such dimensions. These two dimensions lead to the possibility of a natural avoidance of the difficulty present in the so-called five-dimensional representation of electromagnetism of an enormously large mass term, at

least for states of so-far known masses. Finally, these two dimensions lead to the introduction of two sets of electromagnetic potentials corresponding to the equations given by Schwinger in developing Dirac's idea of magnetic monopole defining thereby a further background.

It should be stressed that what has been said here about particle states belongs to the primary empty particles without normalization. Hence it is probably premature yet to try to explain these most interesting symmetries which belong to " ono-empty" statea.

749. Kursunoglu B. In:THEORIES AND EXPERIMENTS IN HIGH ENERGY PHYSICS, Orbis Scientice, 1975, vol.9, pp.131-233.

ON THE CONSEQUENCES OF NON-LINEARITY IN A UNIFIED THEORY OF FUNDAMENTAL INTERACTIONS

The coupling strength between the field and particle is found to be described by $\Theta_n^2/\hbar c$ $(= e^2/\hbar c + g_n^2/\hbar c)$ n=0,1,2,.. where the partial magnetic charges generate short range fields only and where $g_n \to 0$ for $n \to \infty$ or $r \to \hbar/mc$. The sign of the total magnetic charge g_0 $(\sum_{n=0}^{\infty} g_n = (-1)^S g_0)$ correlates with the spin direction, where $S = 0$ and $S = 1$, correspond to spin up and spin down states, respectively. At short distances a strongly interacting particle-anti particle system with antiparallel spins becomes via single spin flip $\hat{p}$, a weakly interacting system in which the spins are parallel. The infinite spectrum of "bare fundamental lengths" $r_{0n} = \sqrt{(2G)}/c^2 \sqrt{(e^2+g^2)} \approx (10^{-33}\text{cm})$ measure the deviation of the theory from general relativity plus classical electrodynamics and induce a structure of stratified layers of magnetic charges, g_n ,of alternating signs, within a particle. The solutions of the field equations, as a result of the non-linearity and genral covariance, produced an inderterminancy in the localizability of the neutral surfaces (and therefore in the g_n)separating magnetic charge densities of opposite signs in the stratified layers. The size of the magnetic structure is of the order of $\hbar/mc$ .For $e = 0$ the corresponding solutions break the symmetries of charge conjugation and parity and lead to the prediction of two massive neutrinos with different masses. The equations

of motion are derived and the results lead to mass relations for the four-massive fundamental particles p, e, ν_e, ν_μ and their anti-particles as half the difference of the "bare gravitational mass" $m \sim \sqrt{(\hbar c/2G)}$ and their finite self energies. Based on the extremum value properties of the vacuum magnetic field (generated by q_0) it is conjectured that the p-e and ν_μ-ν_e mass ratios are equal. All elementary particles can be constructed as sub-nuclear bound or resonance states of the fundamental particles p, e, ν_e, ν_μ and $\bar{p}, e^+, \bar{\nu}_e, \bar{\nu}_\mu$. It is further shown that the mass and charge appearing in the Nordström solution of general relativity correspond, for an elementary particle, to the bare gravitational mass and the observed electric charge and therefore they do not refer to either the bare or observed particles.

750. Mandelstam S. Phys.Lett., 1975, vol.B53, No 5, pp.476-478.

VORTICES AND QUARK CONFINEMENT IN NON-ABELIAN GAUGE THEORIES

It is shown that finite-length vortices in an SU(n) Nielsen-Olsen model require explicit introduction of monopoles, which are confined in multiples of n by the Meissner effect. The model therefore possesses a natural explanation of quark confinement.

751. MAGNETIC MONOPOLE CERN Courier, Sept.1975, vol.15, No 9, p.261.

752. Marciano W.J. and Pagels Heinz Phys.Rev.,1975, vol. D12, No 4, pp.1093-1095.

CLASSICAL SU(3) GAUGE THEORY AND MAGNETIC MONOPOLES

We construct a topologically stable solution to the pure Yang-Mills SU(3) gauge field equations (without scalar fields) which corresponds to a point magnetic monopole. There is no SU(2) analog to this solution.

753. Marion J.B. Physics and the Physical Universe, 1975, MIR, Moscow, p.611.

QUARKS,MAGNETIC MONOPOLES AND TACHYONS - DO THEY EXIST?

754. McGuire P., Ruffini R. Phys.Rev.,1975, vol.D12,No 10, pp.3019-3025.

SOME MAGNETIC AND ELECTRIC MONOPOLE ONE-BODY SOLUTIONS OF THE MAXWELL-EINSTEIN EQUATIONS

We examine the electromagnetic structure of a one-body solution of the coupled Einstein-Maxwell equations endowed with mass m, charge Q, specific angular momentum a, and a parameter l. It is shown how the parameter l, introduced by Newman, Tamburino and Unti, is related to the magnetic monopole charge distribution of the solution. A relation is presented between the total mass energy of the system and its irreducible mass. A general solution characterized by the four parameter m,Q,a and l is here introduced.

755. Mignani R. and Recami E. Nuovo Cimento, 1975, vol. 30A, No 4, pp.533-540.

COMPLEX ELECTROMAGNETIC FOUR-POTENTIAL AND THE CABIBBO-FERRARI RELATION FOR MAGNETIC MONOPOLES

Within "extended relativity" we generalize the Maxwell equations in terms of four-potential for both ordinary and faster-than-light charges. We succeed in giving a physical meaning to the complex electromagnetic four-potential(and to complex electromagnetic four-current tensor and field) and in giving a new interpretation to the Cabibbo-Ferrari relation for magnetic monopoles.

756. Mignani R., Recami F. International Atomic Energy Agency and United Nations Educational Scientific and Cultural Organization, International Centre for Theoretical Physics, IC/75/88,PP-449.

COMPLEX ELECTROMAGNETIC FOUR-POTENTIAL AND THE CABIBBO-FERRARI RELATION FOR MAGNETIC MONOPOLES

757. Mignani R., Recami E. Instituto di Fisica Theorica dell Universita-35129, Catania, Carso Italie,57,1975.

POSSIBLE EXPERIMENTAL BEHAVIOUR OF "TACHYON MONOPOLES"

758. Mignani R., Recami E. Lett.Nuovo Cimento,1975, vol.13, No 15, pp.589-590.

CONNECTION BETWEEN MAGNETIC MONOPOLES AND FASTER-THAN-LIGHT SPEEDS: ANSWER TO THE COMMENTS BY CORBEN AND HONIG

759. Mignani R. Instituto Nazionale di Fisica Nuclare, INFN-643, Roma,1975.

SYMMETRIES OF ELECTRODYNAMICS WITH MAGNETIC MONOPOLES AND THE HERTZ TENSOR

760. MIXED RECEPTION FOR MAGNETIC MONOPOLE ANNOUNCEMENT Phys.Today,1975, vol.28, No 10, pp.17-20.

761. Monastyrsky M.I. and Perelomov A.M. ZhETF Fiz.Red., 1975, vol.21, pp.94-96.

SOME REMARKS ON MONOPOLES IN GAUGE FIELD THEORIES

Simple topological criterion of monopole existence in the gauge -invariant theories with a G symmetry compact group is given.

762. Monastyrsky M.I. and Perelomov A.M. JETP Letters,. 1975, vol.21, p.43.

SOME REMARKS ON MONOPOLES IN GAUGE FIELD THEORIES

763. MONOPOLE CLAIM Storm of Scrutiny Sci.,News, 1975, vol.108, No 11, pp.164-165.

764. MONOPOLES NO, ACTION AT A DISTANCE YES. New Scientist, 1975, vol.68, No 974, p.318.

765. Parisi G. Phys.Rev.,1975, vol.D11, No 4, pp.970-971.

QUARK IMPRISONMENT AND VACUUM REPULSION

We describe a classical field theory in which infinitely long-rang-forces are presented. These forces do not from a direct interaction among particles. They have their origin in a rather peculiar phenomenon, which we call vacuum repulsion.

766. Parker L. Phys.Rev.Lett.,1975, vol.34, No 7, pp.412-415.

NON-LINEAR GRAVITATIONAL EFFECTS AND MAGNETIC MONOPOLES

The Einstein-Maxwell equations for systems of particles possessing electric and magnetic charge are considered. The consequences of the linear and non-linear theories are contrasted by considering a known class of exact solutions. In particular, for these systems of dually charged particles, angular momentum quantization leads to charge quantization only in the linear theory. Furthermore, if "strut" singularities are excluded, then isolated magnetic monopoles are forbidden in these solutions by non-linear gravitational effects.

767. Patkós A. Nucl.Phys.,1975, vol.B97, No 2, p.352.

ON THE LANDAU-GINZBURG TYPE OF QUARK CONFINEMENT

We present a detailed investigation of the interaction of "magnetically" charged quarks in the vacuum of type II superconductivity (represented in a relativistic theory by a Higgs field). The analysis of confining forces is given in details. Spin dependence, relationship to other confining mechanisms and first quantization are discussed.

768. Patkós A. In :NEUTRINO 75, 5-th Int.Conf.,Balatonfüred, Hungary,1975, vol.II, pp.281-289.

HIGGS THEORY WITH MONOPOLES AND QUARK CONFINEMENT

769. Patrascioiu A. Phys.Rev.,1975, vol.D12, No 2, pp.523-530.

EXTENDED PARTICLES AND MAGNETIC CHARGES

It is shown that in more than two space dimensions a field theory having no massless particles cannot have solutions of the field equations which are periodic in time, have finite energy, and are separated from the vacuum by an infinite potential barrier. In three space dimensions an infinite potential barrier can exist only between solutions with different magnetic charge. In any gauge theory in three space dimensions the magnetic charge is shown to have an intrinsic topological nature. The group SU(n) is analyzed in detail and is shown to have n-1 types of magnetic charges. The infinite nature of the potential barrier is shown to be relevant for the semiclassical approximation to the path-integral quantization.

770. Patrascioiu A. Inst. for Advanced Study, COO 2220-45, Princeton, New Jersey, 1975.

EXTENDED PARTICLES AND MAGNETIC CHARGES

771. Perrier P. Recherche, 1975, vol.6, No 61, pp.965-966.

THE FIRST MAGNETIC MONOPOLE (In French)

The value of the experiments of Berkeley and Houston scientists, who claim to have detected the first magnetic monopole, is discussed.

772. Pinsky L.S., Hagstrom R. 14-th Intern. Cosmic-Ray Conf., Munchen, 1975, vol.12,pp.4044-4048.

A METHOD FOR UNIQUE IDENTIFICATION OF RELATIVISTIC ($> 0,5$) MAGNETIC MONOPOLES WITH A FAST FILM CHERENKOV DETECTOR

773. Polyakov A.M. Phys.Lett.,1975, vol.B59,No 1, pp.82-84.

COMPACT GAUGE FIELDS AND THE INFRARED CATASTROPHE

It is shown that infrared phenomena in the gauge theories are guided by a certain classical solutions of the Yang-Mills equations. The existence of such solutions can lead to a finite correlation length which stops infrared catastrophe. In the present paper we deal only with theories with a compact but Abelian gauge group. In this case the problems of correlation length and charge confinement are completely solved.

774. Polyakov A.M. ZhETF,1975,vol.68, No 6, pp.1975-1990.

ISOMERIC STATES OF QUANTUM FIELDS

It is shown that in theories with spontaneously broken gauge symmetry there exist particles of a special type which are classical field blocks with small quantum fluctuations. Such blocks can exist only if the state of the field of arbitrarily large distances from the block cannot be continuously deformed in ordinary vacuum. Because of this the isomers under consideration possess exactly conserved quantum numbers, called topological, which were not present in the initial Lagrangian. The problem of identifying the isomers with observable particles is discussed.

775. Prasad M.K. and Sommerfield C.M. Phys.Rev.,1975, vol.35, No 12, pp.760-762.

EXACT CLASSICAL SOLUTION FOR THE 'T HOOFT MONOPOLE AND THE JULIA-ZEE DYON

We present an exact solution to the nonlinear field equations which describe a classical excitation possessing magnetic and electric charge. This solution has finite energy and exhibits explicitly those properties which have previously been found by numerical analysis.

776. Price P.B., Shirk E.K., Osborne W.Z., Pinsky L.S. Phys.Rev.Lett.,1975, vol.35, No 8, pp.487-490.

EVIDENCE FOR DETECTION OF A MOVING MAGNETIC MONOPOLE

A very heavy partic le passed through a balloon-born stack of Cherenkov film, emulsion, and Lexan shetts. In 33 Lexan sheets it produced tracks expected of either a nucleus with $125 \leq Z \leq 137$ and $\beta \leq 0.92$ or a magnetic monopole with g=137e. Its track structure in emulsion indicated it was moving downward with $\beta = 0.5^{+0.1}_{-0.05}$ and it was either a nucleus with $Z \approx 80$ or a monopole with g=137e. These facts strongly favour identification of the particle as a magnetic monopole of strength g=137e and mass $> 200m$.

778. Price P.B., Shirk A.K., Osborne W.Z.,Pinsky L.S. 14-th Intern.Conf. on Cosmic-Ray, Munchen,1975, vol.12, pp.4033-4040.

EVIDENCE FOR DETECTION OF A MOVING MAGNETIC MONOPOLE

779. Price P.B. Calif.Univ.,Berkeley (USA), Dept. of Phys., NASA-CR-146807,1975.

STATUS OF THE EVIDENCE FOR A MAGNETIC MONOPOLE

The experimental evidence supporting the detection of a moving magnetic monopole, by using a balloon-borne array of track detectors, was presented. Although the results cannot be proved to have been produced by a monopole, they do not seem to have been produced by any nucleus. The very high,roughly constant ionization rate inferred from track etch rate measurements in a stack of Lexan detectors implied passage of a minimum-ionizing particle more highly charged than any known nucleus, yet the Cherenkov film detectors indicated a velocity less than about 0.68 times the speed of light and the size of the track in the nuclear emulsion indicated a velocity approximately equal to 0.5 times the speed of light. At this velocity the ionization rate of a highly electrically charged particle would have changed dramatically with pathlength unless its mass to charge ratio

780. Recami E. and Mignani R. International Center for Theoretical Physics, IC/75/83, Trieste, 1975.

CONNECTION BETWEEN MAGNETIC MONOPOLES AND FASTER-THAN-LIGHT SPEEDS

The mere special relativity does not predict existence of (subluminal) monopoles, but on the contrary, predicts existence of Superluminal (tachyon) monopoles, with magnetic charge about 100 times less than usually assumed. This fact is quite relevant for the current experiments looking for magnetic poles.

781. Recami E., Mignani R. Catania Univ., Instituto di Fisica Teorica, PP-448, Italy, 1975.

MAGNETIC MONOPOLES AND TACHYONS IN SPECIAL RELATIVITY

The mere special relativity does not explicitly predict existence of (sub-luminal) monopoles, but on the contrary explicitly predicts existence of Super-luminal (tachyon) monopoles, with magnetic charge about 100 times less than usually assumed. This fact is relevant also at the light of current experiments looking for magnetic poles.

782. Robinson A.L. Science, 1975, vol. 190, No 4210, p. 137.

MAGNETIC MONOPOLE RECONSIDERED ANOTHER INTERPRETATION

783. Sawada T. Department of Physics, Tokyo Univ. of Education, TUETP-75-13, Tokyo, Japan, 1975.

SEPARATION OF THE STRONG VAN DER WAALS INTERACTION FROM THE NUCLEAR FORCES

In order to separate the missing spectral functions, we analyse the partial wave amplitudes of the ^1So and $^3S_1$ states of the nucleon-nucleon scattering. In the analysis we use the dispersion relations for $h_\ell(\nu)\ \exp.[-\alpha(-\nu)^\beta]$ with $\alpha > 0$ and $0 < \beta < 1/2$ instead of the dispersion for the partial wave amplitudes $h_\ell(\nu)$ to suppress the contributions from the spectral function gap $h_\ell(\nu')$ on the left hand cut at large value of $-\nu'$. After subtracting

the contributions of the one pion and the two pion exchange spectral functions which are constructed from the low energy π-N and H-π-π phase shift data, and then eliminating the right hand spectra, we obtain the large arising spectral function gap $\rho_{10}^{Miss}(\nu')$ in $\nu'<0$.

The shape of this missing spectral function indicates the existence at the long range force exerting between the nucleons which can be interpreted as the strong van der Waals interaction. The appearance of the strong van der Waals force has been anticipated from the magnetic monopoles model of hadrons, where the hadrons are regarded as the magnetically neutral "atoms". The superstrong Coulomb force acting among the magnetic monopoles is responcible to the formation of such bound states.

784. Sawada T. Department of Physics, Tokyo Univeristy of Education, TUETP-75-16, Tokyo, Japan, 1975.

ANOMALY OF THE $\pi-\pi$ PHASE SHIFT AND THE STRONG VAN DER WAALS INTERACTION

It is pointed out that there exist a very long discrepancy between the P-wave phase shift of the scattering and the dispersion on theoretic determination, especially in the low energy region at $\sqrt{s} < 650$ MeV. We explain why the introduction of the long range force acting between the two pions is inevitable in order to reconcile such a discrepancy. Since in the magnetic monopole model of hadrons the apperance of the universal van der Waals force in the hadron-hadron interaction has been expected, we interpret the extra long range interaction as the strong van der Waals potential of the $\pi-\pi$ scattering and than compare it with the additional long range potential separate from the N-N scattering.

785. Schwinger J. Phys.Rev., 1975, vol.D12, p3105.

MAGNETIC CHARGE AND THE CHARGE QUANTIZATION CONDITION

Description of Schwinger charge quantization.

786. Schwinger J. Science,1975, vol.188, pp.1300-1301.

PSI PARTICLES AND DYONS

A hypothetical magnetic model of matter provides a natural setting for the newly discovered psi particles. This supplements a phenomenological description of such particles that had appeared prior to their experimental recognition.

787. Schwinger J. In: GAUGE THEORIES AND MODERN FIELD THEORY. Proceed. of a Conf. held at Northeastern Univ., Boston,1975, pp.337-367.

MAGNETIC CHARGE

788. Senjanovic P.I. Thesis Ph.D., New York Univ.,N.Y.(USA), 1975, University Microfilms,Order No 75-25,209.

PATH INTEGRAL FORMULATION OF FIELD THEORIES WITH SECOND-CLASS CONSTRAINTS

Faddeev's Hamiltonian path integral method for singular Lagrangians is generalized to the case when second-class constraints appear in the theory. The general formalism is then applied to a variety of problems: quantization of the first-order field theories, quantization of the massive Yang-Mills field theory, light-cone quantization of the self-interacting scalar field theory and quantization of a local field theory of magnetic monopoles.

789. Sokolov V.V. Preprint Inst. of Nuclear Physics, IYaF-75-88, Novosibirsk, 1975.

THE THEORY OF MAGNETIC POLE AND THE DIRAC-SCHWINGER QUANTIZATION CONDITION WITHOUT STRING

The motion of nonrelativistic system of a point-like charge and monopole is considered. Lagrange and canonical formalism free from difficulties of the usual Dirac theory with s string is established without an introduction of a potential simgular along a string. In particular, from the

from the very beginning the theory is invariant under rotations.

Quantization of the equations of motion was carried out by standard methods. The Dirac condition $eg/4\pi = 1/2 n$ (n -integer) is obtained as a consequence of the quantization of the systems angular momentum projection on symmetry axis.

790. Strazhev V.I. and Tomil'chik L.M. Vestsi Akad. Nauk Belorussk.SSR, ser. fiz.-mat., 1975, No 2, pp.51-58.

POSSIBILITY OF THEORY OF MAGNETIC CHARGE WITHOUT CHARGE QUANTIZATION CONDITIONS

(In Russian)

Critical role of the charge-quantization (43k) condition in gauge-invariant electrodynamics with two types of sources is analyzed. It is shown that the scheme not accounting the 43k lacks as experimental, as theoretical bases.

791. Strazhev V.I. Inst.J. Theor.Phys.,1975, vol.13,No 2, pp.113-123.

GALILEAN INVARIANCE AND MAGNETIC CHARGE

The Galilean and "dual" invariant electrodynamics with magnetic charges is formulated. The definition of the main feature of relativistic electromagnetism is given. Consideration of different aspects of Galilean electromagnetism with magnetic charges is presented. It is shown in particular that the conclusion of Bacry & Kubar-Andre(1973) that the existence of the magnetic monopole is incompatible with Galilean invariance in general appears to be incorrect.

792. Strazhev V.I., Tomil'chik L.M. MAGNETIC CHARGE ELECTRODYNAMICS , "Nauka i Tekhnika", Minsk,1975.

ELECTRODYNAMICS WITH MAGNETIC CHARGE

793. Strazhev V.I. Inst. of Physics AN BSSR,Minsk,1975, Preprint

ON INNER SYMMETRIES OF MASSLESS PARTICLE THEORY

An inner symmetry of a field theory with massless particles is studied. It is shown that this theory possesses an inner symmetry group $U(1) \otimes_s Aut\, U(1)$. Dual conversion of the electric field and γ_5 conversion of the neutrino field corresponds to the reduced representation of the group $U(1)$. An operation of the combined parity corresponds to the element second order cyclic group $Aut\, U(1)$. Reformulation of the Price's theorem is given basing on the developed approach. statistical properties of the compound photon in neutron theory of light are uncompitable with the γ_5 symmetry of the neutrino and electromagnetic fields. Within the framework of the group consideration determination of operations of dual and charge conjugation of electric and magnetic fields and charges are suggested. Dually-symmetrical quantum theory of dually-charged particles is built on the basis of Mandelstamm formulation of electrodynamics.

794. Strazhev V.I. Institute of Physics Acad.Sci.Belorussk. SSR, IF-No-92, Minsk, 1975, (In Russian).

SYMMETRIES OF ELECTROMAGNETIC INTERACTIONS AND DYONIUM MODEL OF HADRONS

The new approach to the problem of magnetic monopole is given. It is based on the consideration of the dual symmetry of the quantum electrodynamics from the group theoretical point of view. The hypothesis about the existence in nature of magnetic monopole follows from the requirement of the invariance of electromagnetic interactions under discrete operation of dual conjugation. The following results of the approach can be noted: in case the second quantum of electric charge exists its value must be obligatory smaller than the value of the charge of electron; a particle which bears fractional electric charge must also bear a magnetic charge, the possibility of theoretical description and the existence of a magnetic monopole depends on possibility of the existence in nature of the Higgs particles.

It is shown that the dyonium model of hadrons naturally comes out from the developed approach. It is remarkable that

self-consistency of the approach demands the confinement of dyons.

The discussion of the Larmor symmetrical generalization of the quantum electrodynamics is given. It is shown that as in the case of dual symmetrical formulation, the restriction on the possible value of the second quantum of electric charge can be given.

795. Strazhev V.I. Izv. Akad. Nauk Belorussk. SSR, ser. fiz.-mat., 1975, No 6, pp. 110-112.

ON DISCRETE SYMMETRIES OF ELECTROMAGNETIC INTERACTIONS

A new approach to the problem of a monopole based on the analysis of electromagnetic interaction discrete symmetries with dual-symmetrical formulation is suggested. Form this approach it follows in particular that the value of the second quantum of electric charge should be necessarily less than that of an electron. It is also shown that the existence of the magnetic monopole suggests the existence of Higgs particles.

796. Swank J.H., Swank L.J., Dereli T. Phys. Rev., 1975, vol. D12, No 4, pp. 1096-1102.

FERMIONS IN YANG-MILLS POTENTIALS

It is shown that the magnetic monopole of 't Hooft and an isospinor fermion do not have any bound states. Further, the dyon of Julia and Zee, considered as a fixed field configuration, does not bind an isospinor fermion. An example is given of an infinite-energy solution of the pure Yang-Mills theory which when taken as a potential in a wave equation will confine the wave function.

797. Swank J.H., Swank L.J., Dereli T. Yale University Preprint, 1975.

FERMIONS IN YANG-MILLS POTENTIALS

798. Swank J.H., Swank L.J., Dereli T. Phys.Rev.,1975, vol.D11,No 12, pp.3541-3544.

FERMIONS IN YANG-MILLS ELECTRIC AND MAGNETIC POLE POTENTIALS

Solutions are given for the Dirac equation with a Yang-Mills magnetic monopole potential and with combined Yang-Mills electric and magnetic pole potentials.

799. Tamm I.E. A collection of scientific works, Izd-vo NAUKA, Moscow, 1975, vol.1, pp.186-195.

THE GENERALIZED SPHERICAL HARMONICS AND THE WAVE FUNCTIONS OF AN ELECTRON IN A FIELD OF A MAGNETIC POLE (In Russian)

In connection with recently obtained by Dirac wave-equation for the electron in a field of an isolated magnetic pole the properties of generalized spherical harmonics are investigated which are defined by eq.(3). In the particular case m=3, they transfer into ordinary spherical harmonics. §1. Physical formulation of a problem. §2. Proper values and the form of generalized spherical harmonics (GSH). §3. Different representations of GSH. §4. Singularities. §5. GSH are the rotational variants with an accuracy to a general phase. §6. Normalization. §7. Electron proper functions.

§1 gives physical formulation of the problem which led to the appearance of this article. The rest of the work is dedicated to purely mathematical problems.

800. Tarasenkov V.I., Tomil'chik L.M. Vestsi Akad. Nauk Bel.SSR, Ser. fiz.-mat.,1975, No 6, pp.106-109.

ON DIFFERENTIAL TECHNIQUES WITH POTENTIALS IN A MAGNETIC CHARGE THEORY

Within the frame-work of generalized harmonics theory formalism a technique is developed for differentiating the potentials containing the singularity line. It is shown, that the confecuitive taking into account of singular contribu-

tions aliminates the known difficulty with breaking the Jacobi uniformity for the kinetical momenta of charged particles.

801. THE SCEPTICS HIT OUT AT MONOPOLE CLAIM. New Scientist, 1975, vol.67, No 967, p.631.

802. Tevikian R.V. Nucl.Phys.,1975, vol. B93, No 1,pp.74-84.

DYNAMICAL MODEL OF SPIN-1 AND SPIN-0 PARTICLES

Equations are proposed that completely describe S =0,1/2,1 particles, i.e. specify 2_s+2 liminating states in the $E \to \infty$ limit. A set of states closed with respect to the $E \to \infty$ limiting procedure is considered, whence follows the necessity for the introduction of a λ -state corresponding to one-dimensional unitarity representation of the Lorentz group. It is shown further, that a cosmological term proportional to the square of the λ -state strength should be introduced in gravitation theory. On the basis of the Lorentz group, a table of fundamental interaction is proposed and a dual transformation for the interacting system is introduced. Appendices deal with a genralization of the Duffin-Kemmer formalism and a new method for the introduction of interactions.

803. Tipler F.J. Nuovo Cimento, 1975, vol.28B, No 2, pp.446-452.

DIRECT ACTION ELECTRODYNAMICS AND MAGNETIC MONOPOLES

It is shown that direct-action electrodynamics cannot be generalized to include magnetic monopoles. Consequently, experimental searches for magnetic monopoles constitute a test of the theory.

804. Tompkins D.R.,Jr, and Rodney P.F. Phys.Rev.,1975, vol. D12, No 9, pp.2610-2616.

ORION-ARM MAGNETIC MONOPOLES AND GAMMA RAYS

It is shown that galactic-disk monopoles could yield air-showers which are stochastically aligned with the local Orion-arm magnetic field and which are above the energies of similarly aligned galactic heavy nuclei. In the absence of a cosmic-ray anisotropy this method sets limits on the flux of galactic monopoles and on their production cross section limits based on the cosmic-ray anisotropy at 10^{19}eV are presented. The possibility of a stochastic alignment of inverse Compton photons from monopoles and 2.7 °K -black-body photons is considered. The resulting monopole-flux limits, based on the same data as those calculated by Osborne differ significantly from Osborne's limits where mechanism of spiral-arm alignment and galactic containment are ignored.

805. Trinkala M.J. Albany-State University of Dissertation, University Microfilms Order No 75-25,1975,786.

MONOPOLES GRAVITY: A SYMMETRY APPROACH

Electromagnetism with monopoles combined with gravity. Some comments on possible applications to elementary particle models.

806. Tyupkin Yu.S., Fateev V.A. and Schwartz Zh. Eksp. i Teor Fiz., Pis Red.,1975, vol.21, No 1, pp.91-93.

EXISTENCE OF HEAVY PARTICLES IN GAUGE FIELD THEORIES

Conditions of heavy particle existence in gauge theories with a G-one-bound random compact group is formulated in the paper. A case of oktet representation of the group SU(3) is studied in detail.

807. Tyupkin Yu.S., Fateev V.A., Schwarz A.S. JETP Lett., 1975, vol. 21, p.42.

EXISTENCE OF HEAVY PARTICLES IN GAUGE FIELD THEORIES

808. Venkatavaradan V.S. Phys.News,1975, vol. 6,p.164.

CONTINUING THE MONOPOLE STORY

809. Venturi G. Nuovo Cimento Lett.,1975, vol.14, No 7, pp.233-236.

MONOPOLES IN A NON-ABELIAN GAUGE FIELD THEORY

Shows that introduction of "magnetic" monopoles in non-Abelian case can proceed in same manner as Abelian case.

810. Venturi G. Nuovo Cimento Lett.,1975,vol.12, No 8, pp.257-260.

PROTOTYPE NON-ABELIAN GAUGE FIELD THEORY. MONOPOLES AND STRINGS

Examines the effect of the introduction of two magnetic charge of opposite sign in a prototype non-Abelian gauge field theory.

811. Venturi G. Nuovo Cimento,1975, vol. 26A, No 2, pp.97-104.

STRINGS AND FIELDS

A system consisting of a scalar field localized on a string is examined. We suggest how such a system could arise and exhibit the equations of motion and boundary conditions obtained on treating string co-ordinates and field as independent dynamical variables. In the case of a static solution for the field we show that the classical system can give rise to a linearly rising trajectory with a physical (negative) intercept.

812. Venturi G. University of Bologna preprint,1975.

MONOPOLES AND THE HIGGS MODEL

813. Wilson L.W. Phys.Rev.Lett.,1975, vol. 35, No 17, pp.1126-1128.

KINEMATIC CONSTRAINTS ON THE PRODUCTION OF MAGNETIC MONOPOLES

A lower limit for lab energy of a magnetic monopole produced from a stationary target is derived and used to study implications of the data of Price et al .

814. Winterberg F. Nuovo Cimento Lett.,1975, vol. 13, No 18, pp.697-703.

QUARKS,MAGNETIC MONOPOLES, AND NEGATIVE MASS

Using Parker's result suggests monopoles have negative mass. Goes on to discuss possibilities of idea. Predictions

Monopoles have negative mass. Magnetic quarks set free in strong magnetic fields.

815. Winterberg F. Atomkernenergie,1975, vol.26, No 1, pp.43-47.

QUARKS POSSIBLY ARE NEGATIVE MASS MAGNETIC MONOPOLES

Non-linear effects require magnetic monopoles to have negative mass. We therefore propose the hypothesis that quarks are magnetic monopoles of negative mass. The positive mass of hadrons is explained as a result of the positive binding energy from the interaction of magnetic mass quarks. The production of free quarks would be accomplished by the delivery of a very large amount of energy in excess of the hadronic rest mass energy.Consistently with the smallness of the CP violation the interaction is assumed to be a Heisenberg-type magnetic charge echange force. The negative mass hypothesis may explain the difficulty to produced free quarks. Free quarks could be produced in very strong magnetic fields of the order 10^{17} Gauss which may occur in the forms of short wave x-ray laser beams and in the gravitational collaps of massive astronomical objects, explaining the

large energy output believed to be associated with quasers.

By doping solid material with negative mass quarks one could obtain superstrong materials and macroscopic bodies approaching arbitrarily close a state of zero rest mass. The most profound consequence of such a state of matter would be in the attainability of relativistic velocities for macroscopic bodies.

816. Wu T.T. and Yang C.N. Phys.Rev., 1975, vol. D12, No 12, pp.3845-3857.

CONCEPT OF NON-INTEGRABLE PHASE FACTORS AND GLOBAL FORMULATION OF GAUGE FIELDS

Through an examination of the Bohm-Aharonov experiment an intrinsic and complete description of electromagnetism in a space-time region is formulated in terms of nonintegrable phase factor. This concept, in its global varifications, is studied through an examination of Dirac's magnetic monopole field. Generalizations to non-Abelian groups are carried out, and result in identification with the mathematical concept of connections on principle fiber bounds.

817. Yang C.N. Proceedings of the Sixth Hawaii Topical Conference in Particle Physics, Dobson et al., Ed., Hawaii 1975, p.487.

GAUGE FIELDS

Review of Wu-Yang development of non-qunatized guage fields including developments on magnetic monopoles.

818. Yueh W.R. Phys.Rev.,1975,vol.D12, No 10,pp.3221-3224.

COMMENTS ON VACUUM POLARIZATIONS OF MAGNETIC MONOPOLES

We calculate the electric vacuum polarizations induced by the action of a static monopole charge and find out that there is no induced vacuum currents at all to all orders of the external field and to all orders of the radiative corrections.We also argue that the superstrong Coulomb-type potential screens itself into a short-range one so that there is no magnetic charge renormalization.