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Lorentz Causality and the three neutrinos.

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Abstract

In the paper it is demonstrated on a purely mathematical way, based on a causality condition, that in a 4 dimensional space there is place only for one photon and three neutrino species. This result is compatible with the experiment which find from the properties of the Z a value for the number of neutrino species of N = 2.98 ± 0.07 (stat.) ± 0.07 (sys.) [3].

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Aims

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The direct general consequence is that: for a given energy (p_0) of a free system, there is a value of x^0 so that $p_0 x^0 = H$. This is valid for both massive and massless transverse systems.
For massive systems it provide a value $x^0 = H/p_0$ which (with H=ch, x^0=h/mc) correspond to the Compton wave lengths.
For transverse massless systems we obtain the relation $p_0 = H/x^0$ which we can interpret as the Planck law p_0=hν

3. Longitudinal mass-less fermion

There are two invariant structures (p and **x** being light-like vectors):
-either longitudinal PS, i.e. dual **p** is parallel or antiparallel to **x**,
-or transversal PS i.e. the three dimensional **p** is perpendicular on the direction of propagation **x** (for which we obtain from relation 3) $p_0 x^0$=H)

Then what are the observable consequences including H for the longitudinal case.

Longitudinal system means that the dual 3-vector is parallel (or anti-parallel) to the direction of propagation defined by the spatial vector **x** in the basic relation:

$$p_0 x^0 - \mathbf{p}.\mathbf{x} = H \qquad 5)$$

For positive sign of p_0 and H≠0, we can define a longitudinal system only when **p** is anti-parallel to the direction of propagation **x**.
The longitudinal (anti-parallel) polarization or helicity is given by
p.x=(-1/2) H. It represent a strictly left-handed massless system.
A free longitudinal parallel massless system having a positive sign of p_0 cannot exist compatible with the causality condition.

For negative sign of energy (p_0) one gets for helicity a value of +(1/2)H. It represent a right handed system. In this case a longitudinal (parallel) left-handed massless system cannot exist compatible with causality condition.

Helicity for the massless systems is built in the structure of the system framed in the scheme of Lorentz duality

To show that longitudinal systems are fermions we represent Lorentz causality on the matrix space. Namely instead of interpreting the set of numbers x^i (i=0,1,2,3) as being components of a vector R^{1+3} we display these numbers as the elements of a matrix

$$X = \begin{vmatrix} x^0 & 0 \\ 0 & x^0 \end{vmatrix} + \begin{vmatrix} x^3 & x^1 - ix^2 \\ x^1 + ix^2 & -x^3 \end{vmatrix} = X^0 + \mathbf{X} \qquad 6)$$

Hence we have associated a matrix to a vector in a unique way. Then, instead of using Lorentz metric in defining causality (2) we use the determinant of the associated matrices getting equivalent definition of causality

Since to the scalar product of two vectors is associated the semi-sum of the anti-commutator of the associated matrices, obviously to the scalar product in (5) is implicitly associated the anti-commutator of respective matrices X and P. We have:

$$2\,\mathbf{x}.\mathbf{p}\,I = [X,P]_+ \qquad 7)$$

where I is the unit matrix.
So it correspond to a fermion.

As we found that twice the scalar product for the longitudinal case is H, it is just the multiplying factor of the anti-commutator so we have:

$$[X,P]_+ = H\,I \qquad 8)$$

with both signs of H positive and negative.
So a longitudinal PS is a fermion (described by an anti-commutator rule) and we call it neutrino. The two signs of H indicates one of the familiar double valued representation of half-integer spin. For mass-less fermion they represent system and anti system, obviously disconnected.

(We note that the quantisation of the Dirac equation gives positive definite energy if the resulting particles obey Fermi statistics).

Now what about the commutator of associated matrices of **x** and **A.** (We use A instead of p for transverse PS). It is associated to the bivectors of the two vectors. The matrix of the commutator multiplied by i (imaginary unity) is associated to the vector product of the two respectively associated vectors. It is just the outer product of **x** and its dual, which characterize the photon. So the photon is a boson. It is equally expressed through H with both signs.
The same H is the multiplicative factor of the unity matrix in commutator and anti commutator of the associated matrices which describe equivalently Lorentz causality

4. Three neutrinos families.

All the above properties referring to the longitudinal case could be obtained starting by representing the causality by Lorentz metric (2) defined on the three dimensional space R^{1+2}. But the transverse PS requires 4 dimensionality of M.

Now there being three nonequivalent 3-dimnesional time-like subspaces [5] of M, which include light like vectors, it provide the description of three species of longitudinal massless systems, their anti-systems as well as their massive partners.

5. Leptonic numbers.

We have to look for an exact symmetry, which may supply each of the three neutrinos with its own conserving quantum numbers preserving the above properties. It is done by defining causality on matrix representation space of Clifford algebra for which cubic causal map is eigenvalue and whose automorphysm group is SU(3) [4]. There

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1 Introduction.

The existence of the muon and latter of the taon and consequently that of the corresponding neutrinos was and remain a puzzle in physics.

Why the families are only three? Many peoples and groups searched an answer to this question. I will mention here only the assiduous work of the LEP experiments and that of the L3 experiment [1] for finding of, the number of light neutrinos, it means of the existing families.

The number of light neutrinos determined experimentally till now from the properties of the Z is N = 2.98 ± 0.07 (stat.) ± 0.07 (sys.) which is a remarkable result.

We tried, on a completely other basis, to find the number of neutrinos (leptons) families which is compatible with the actual concepts about the causal world in which we live.

We interpret causality mainly based on Edington's concept of knower [2] and Weil's concept of locality [3].

The number three is imposed by the transverse massless system - the photon - existing in a causal space.

Because the properties of the transverse system require at least 4-dimensional R^{1+3} space and being only one photon the space must be just 4-dimensional

The properties of a longitudinal system –the neutrino– are amenable to 3-dimensional space R^{1+2} and since there are 3 nonequivalent such subspaces of the R^{1+3} there must exist three neutrino families

2 The constant H as merely conversion factor which relate the Lorentz concepts of energy to distance.

We represent all physical systems (PS) in the points of a four-dimensional space (M) endowed with Lorentz metric.

Light-like vectors $x(x^0,\mathbf{x})$and $y\ (y^0,\mathbf{y})$are causally related if:

$$x^0 < y^0 \qquad 1)$$

and

$$(x^0 - y^0)^2 - (\mathbf{x} - \mathbf{y})^2 = 0 \qquad 2)$$

Such points provide what we call a ray in the space M [4].

A special importance for physics presents the dual space of M namely M*.
Then we can construct the real linear form:

$$p(x) = p_0\, x^0 - \mathbf{p.x} \qquad 3)$$

where $p = (p_0,\mathbf{p})$ and $\mathbf{p}(= p_1,p_2,p_3,)$ with $\mathbf{p.x}$ the usual Euclidean scalar.

For a given 4-vector p in (3) we discuss p(x) as a functional defined on causally related 4-vectors x. We call it the PRIACTION

Lorentz metric being non singular the coefficients of the components of x in 3) represent the components of vector p in the dual space M*.

Let denote by G_c the group whose elements preserve causality. The invariant I under the dual causal group G^*_c of $p \in M^*$ is: defined by:

$$p_0^2 - \mathbf{p}^2 = I \qquad 4)$$

We have I = 0 if and only if causality on M is defined by (1) and (2).

The invariance of priaction means that if we pass from x to x'=gx, $g \in G_c$, then p must be transformed into p' by a transformation $g^* \in G^*_c$ so that p'(x')=p(x).
The priaction for a given x is a real number. This number, for a certain 4-vector p, is zero if only if x is a spacelike vector which is obviously acausal. Hence zero value for priaction is excluded just being defined only on causal related points [5]

Very important for what follows is that the same value of priaction for any $p \in M^*$ with $I \geq 0$ is compatible with the above structure [6]. We denote it by H.

The point at issue is to find the "measurable" properties of PS which follow from the above setting expressed through H.

are two fundamental bases of SU(3), a triplet and a complex conjugate antitriplet. Each elements of fundamental basis of SU(3) labels one of the three neutrinos and the elements of the complex conjugate basis labels the three antineutrinos. The big problem is to relate the above to the so diverse masses of the partners: electron, muon and tau. Can we relate SU(3) leptonic with SU(3) color both representing exact symmetries?

We summarize the main points. Inductive logic leads us to define the concept of causality [6]. It is expressed in particular by Lorentz metric. We represent PS on causal related points. The properties of longitudinal free system are the consequences of this representation. The properties of a free transversal system are obtained in the same way [6]. More relevant is that the Coulomb Law and so properties of electric charge are also consequences of Lorentz duality.

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7. References

[1] L3 Collaboration. M Acciarri et al., Phys. Lett. B 431 (1998) 199

[2] A. Eddington. The Philosophy of Physical Science. Cambridge Press (1939)

[3] H. Weil, Ann. Phys 59 (1919) 101

[4] El. Mihul, Rev- Roum. Phys 28 N1 Bucarest (1983) 3

[5] C. Gheoghe, El. Mihul Commun. Math. Phys 14 (1969) 165 and El. Mihul X-th Winter school of Theor. Phys. Karpacz (1970)

[6] El. Mihul Consequences of Causality. preprint DFPD 94-Th-33 (1994)

[12] J.H. Kühn, E. Mirkes, J. Steegborn, Z. Phys. **C57**, 615 (1993).

[13] M. Drees, M. Krämer, J. Zunft, and P.M. Zerwas, Phys. Lett **B306**, 371 (1993).

[14] R. Gastmans and Tai Tsun Wu, *The Ubiquitous Photon: Helicity method for QED and QCD*, Oxford: Clarendon, 1990.