John David Jackson: Physicist, Teacher, Citizen

Chris Quigg · Fermilab
CAP Annual Congress · Queen’s University · 1 June 2017

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994 Waterloo Street, London ON
“Some Snapshots from a Physicist’s Life”
Eric Vogan        JDJ        Don Hay
UWO 4th-year Radio Physics, 1946
Field Theory of Traveling-Wave Tubes

L. J. Chu, Associate, I.R.E., and J. D. Jackson, Student, I.R.E.

Summary—The problem of a helix-type traveling-wave amplifier tube, under certain simplifying assumptions, is solved as a boundary-value problem. The results indicate that the presence of the beam in the helix causes the normal mode to break up into three modes with different propagation characteristics. Over a finite range of electron velocities one of the three waves has a negative attenuation, and is thus amplified as it travels along the helix. If the electron velocity is too high or too low for net energy interaction, all three waves have purely imaginary propagation constants; no amplification occurs. Consideration of the beam substitution functions shows that, during amplification, the electron beam behaves like a generator with negative conductance, supplying power to the fields through a net loss of kinetic energy by the electrons. Curves are shown for a typical tube, and the effects of beam current and beam radius are indicated. The initial condition investigation is seen as the conditions of signal level and limiting efficiency. In the Appendix a simple procedure for computing the attenuation constant is given.

I. INTRODUCTION

The ANALYSIS of traveling-wave tubes as amplifiers has been carried out by Pierce* of Bell Telephone Laboratories and Komphor† of the Cumington Laboratory. In Pierce’s paper, the action of the field on the electron beam and the reaction of the beam back on the field were formulated. A cubic equation was obtained which yielded three distinct propagation constants corresponding to the three dominant modes of propagation. Komphor followed a different line of attack and arrived at essentially the same results.

The present analysis follows the procedure which Hahn‡ and Ramo§ used in dealing with velocity-modulated tubes. The problem of the traveling-wave tube is idealized, and such approximations are introduced that the field theory can be used throughout to correlate the important factors in the problem. Numerical examples are given for a specific tube to illustrate the effects of various parameters upon the characteristics of the tube.

* Decimal classification: R376.2. Original manuscript received by the Institute, July 30, 1948; revised manuscript received, December 25, 1947. Presented, I.R.E., Electrical and Electronics Engineers, Symposium, N. Y., June, 1947. This work was supported in part by the U. S. Army Signal Corps, the Air Material Command, and the Office of Naval Research, and appeared originally as Technical Report No. 5, Air Materiel Command, August 3, 1945.


II. SOLUTION OF THE PROBLEM

A. Formulation

In order to obtain some theoretical understanding about the behavior of the traveling-wave tube, we have to simplify the problem by making numerous assumptions. Instead of a physical helix, we shall use a longitudinal sheath of radius a and of infinitesimal thickness. The current flow along the sheath is constrained to a direction which makes a constant angle (90°-α) with the axis of the helix. The tangential component of the electric field is zero along the direction of current flow, and finite and continuous through the sheath along the direction perpendicular to the current flow. The force acting on the electrons is restricted to that associated with the longitudinal electric field only; and the electrons are assumed to have no initial transverse motion.

We shall further assume that the electrons are confined within a cylinder of radius b concentric with the helical sheath. The time-average beam-current density is assumed constant over the cross section, the
Charge-independence of nuclear forces?

\[ k \cot \delta = -\frac{1}{a} + \frac{1}{2} r_0 k^2 + P r_0^3 k^4 + \ldots \]

The Interpretation of Low Energy Proton-Proton Scattering*†

J. David Jackson‡ and John M. Blatt¶
Department of Physics and Laboratory for Nuclear Science and Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts

“a painfully thorough analysis”

Small deviation found, resolved as magnetic dipole interaction
1950: Assistant Professor of Mathematics at McGill
The world at large first became aware of radioactive fall-out as a significant aftermath of nuclear explosions nearly two years ago. Since that time much has been written on the subject in publications for the bourgeois intellectuals, if not in the mass media journals. To this physicist at least, the sequence of statements to inform the public on the nature and importance of radioactive fall-out and its implications for defensive measures in time of war presents a wonderfully conflicting and sometimes fantastic parade. Honest, factual, but unofficial, accounts have been given; conjectures have been made; official pronouncements have appeared, only to be countered by equally official pronouncements expressing divergent views. Out of it all, the
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Princeton, 1956–57
Atomic Energy Produced By New, Simpler Method

Coast Scientists Achieve Reaction Without Uranium or Intense Heat—Practical Use Hinges on Further Tests

By ALEXANDER F. PETERSON

A bomb that could be built to produce nuclear energy for use in a laboratory was described here today. The bomb is portable and can be used to produce energy for any practical purpose.

The bomb, known as the Plutonium Bomb, was developed by Dr. Enrico Fermi and his team of scientists at the University of California. The bomb was tested in a complete reaction at the university and was found to be successful.

The bomb is expected to be used for a variety of purposes, including the production of energy for homes and businesses, as well as for military use.

By WALTER H. WHITE

A new, simpler method for producing atomic energy has been achieved by scientists at the University of California. The method involves the use of uranium and intense heat.

This new method is expected to be more practical than the previous one and could lead to the development of a new generation of nuclear power plants.

The new method uses uranium to produce atomic energy. The uranium is heated to a high temperature, which allows it to react with other elements to produce energy.

In addition to the new method, the scientists have also developed a simpler way to use the energy produced. This new method is expected to be more efficient and could lead to the development of new energy sources.

By WILLIAM S. WILLIAMS

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Salvage work under way on the capsized Egyptian ship Zanaka in the harbor at Suez.

By OSBORN CARLTON

The capsize of the Egyptian ship Zanaka in the Suez Canal has led to intense efforts to salvage the vessel. The work is being carried out by a team of experts, including divers and engineers.

The vessel capsized during high winds and rough seas, and the situation was made more difficult by the close proximity of the Suez Canal to the shoreline.

The work is expected to be completed within the next few days, with the aim of removing the vessel from the canal and allowing it to be towed to a dock for repairs.

Both Egyptian and United Nations authorities are keeping a close eye on the situation, and there is a strong belief that the work will be completed successfully.

By WILLIAM S. WHITE

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Atomic Energy Produced
By New, Simpler Method

Coast Scientists Achieve Reaction Without
Uranium or Intense Heat—Practical
Use Hinges on Further Tests

Special to The New York Times.

MONTEREY, Calif., Dec. 28—A third and revolutionary way to produce a nuclear reaction fundamental research was described here today. It does not involve uranium, as in the fission reaction, or million-degree heat, as in the fusion reaction.

The new process is called "catalyzed nuclear reaction." It was discovered accidentally a few weeks ago during routine work with the huge atom-smashing bevatron at the University of California radiation laboratory.

A team of twelve scientists from the university explained the process to the American Physical Society here. The team was headed by Dr. Luis W. Alvarez, assistant director of the laboratory.

Curiously enough, it was made not at the laboratory at Livermore, where scientists are attempting to control thermal-nuclear reaction for practical

Cold Fusion of Hydrogen Atoms

Discovery of a revolutionary way to fuse nuclei of hydrogen atoms without the multi-million-degree temperature required in the thermonuclear hydrogen fusion process was announced Friday at the winter meeting of the American Physical Society at Monterey, Calif., by a team of twelve scientists at the University of California headed by Prof. Luis W. Alvarez.

The discovery, it was pointed out, is at present of pure scientific interest only, as the process can now be used only on a very small scale. However, the observation is of great scientific importance and may eventually lead to a practical and economical method for producing enormous amounts of atomic energy by the process of "cold fusion" of hydrogen nuclei.

A Fourth Method

The new phenomenon is described as a "catalyzed nuclear reaction." This adds a new and fourth way to make a nuclear reaction (a reaction to produce atomic energy) take place.

One of the older ways is to induce a thermonuclear reaction in which two nuclei of light elements, particularly hydrogen, are fused into a heavier element when the temperature is raised to about 100,000,000 degrees Centigrade. (This is the fusion reaction that takes place in the hydrogen bomb.) The second method is that of fission, the splitting of a heavy element such as uranium, by neutrons, into two lighter elements (the method used in the atomic bomb and in atomic power plants). The third method is to bombard an element with nuclear particles fired from accelerators like the cyclotron.

Pulling Together

Basically, the new discovery is that a nuclear particle known as the negative mu meson, which has an atomic mass 210 times that of an electron, can pull together the nuclei of a light hydrogen atom and a heavy hydrogen atom and make them fuse into an atom of helium. This fusion can take place at any temperature. And such "cold fusion," like the thermonuclear fusion in the hydrogen bomb and in the sun and hot stars, releases enormous amounts of energy, twice as much as that released in the fission of uranium.

The difficulty that at present stands in the way of utilizing this "cold fusion" reaction on a practical scale is the extremely short life, as well as the scarcity, of the mu mesons.

W. L. L.
communicated to the writer. (See references 9 and 10.) H. Craig, Tellus (to be published).

...being accreted from the sun. Recently J. Arnold has also concluded from con-

...tion rate over that area equal to the value calculated above for

...of 1956; they now iind that their recent data on the tritium


...Engineering Department, Johns Hopkins University, 1953 kubin, U. S. Geological Survey Radiocarbon Laboratory, kindly

...consideration of the present calculations that tritium is probably

...balance in the Mississippi Valley, taking into account outward

...discussed with F. Begemann and W. F. Libby during the summer

...by comparing its curved path (in a field of 11 000 gauss)

...was observed to take place. The chamber is traversed

...by many more negative p, mesons than Emesons, so that

...pear at rest, presumably by one of the "Panofsky reac-

...decays at rest have been observed. In the same pictures,

...in the last 75 000 photographs, approximately 2500 p

...hydrogen bubble chamber, ' an interesting new reaction

...to be a p meson coming to rest in the hydrogen, and

...in which what appears (from curvature measurement)

...normal ~ and p stoppings, we have observed 15 cases

...give rise to a secondary negative particle of 1.7-

...in hydrogen. (We explored the possibility that one of the

...the p meson: there are four electrons in the energy

...these 15 secondary particles looks remarkably like that

...of the p meson—therefore, if one is to explain the new

...is ejected with 5.4 Mev by the H-D reaction, comes to rest again

...incident meson comes to rest, drifts as a neutral mesonic atom,

...endings and the subsequent decay electron; they are

...the subsequent decay electron, and not merely a statistical fluctuation in the

...between some otherwise normal-looking tt

...secondary track is parallel to the primary, but displaced

...primary. ) The energy spectrum of the electrons from

...of 1.7 cm. But, most importantly, the curvature of the

...to be the distance traveled by the small neutral

...and not merely a statistical fluctuation in the

...between the last bubble of the primary track and the

...primary track, and in another case the

...the first bubble of the secondary track. This gap is a real

...some unknown process, negative w mesons could decay

...thought to be the distance traveled by the small neutral

...endings and the subsequent decay electron; they are

...the subsequent decay electron. The prob-

...that "rejuvenates" the p, meson after it has come to rest.

...of a mass difference between the two particles than was

...allowed by the measurements. One could just stay

...within the experimental limits by assuming that the

...as it was observed to take place. The chamber is traversed

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...within the experimental limits by assuming that the
Catalysis of Nuclear Reactions between Hydrogen Isotopes by \( \mu^- \) Mesons

J. D. JACKSON

Palmer Physical Laboratory, Princeton University, Princeton, New Jersey

(Received January 10, 1957; revised manuscript received February 4, 1957)

The mechanism by which negative \( \mu \) mesons catalyze nuclear reactions between hydrogen isotopes is studied in detail. The reaction rate for the process \( (\mu + d + n) \rightarrow \text{He}^+ + \mu^- + 5.5 \text{ Mev} \), observed recently by Alvarez et al., is calculated and found to be in accord with the available data. The \( \mu^- \) meson binds two hydrogen nuclei together in the \( \mu^- \)-mesonic analog of the ordinary \( \text{He}^+ \) molecular ion. In their vibrational motion the nuclei have a finite, although small, probability of penetrating the Coulomb barrier to zero separation where they may undergo a nuclear reaction. The intrinsic reaction rates for other, more probable, reactions are also estimated. The results are \( \sim 0.3 \times 10^{10} \text{ sec}^{-1} \) for the observed \( \mu^- + d \) reaction, \( \sim 0.7 \times 10^{10} \text{ sec}^{-1} \) for the \( d + d \) reaction, and \( \sim 0.4 \times 10^{10} \text{ sec}^{-1} \) for the \( d + t \) reaction. For the reaction observed by Alvare rough estimates are made of the partial widths for nonradiative and radiative decay of the excited \( \text{He}^+ \) nucleus. The ejection of the \( \mu^- \) meson by "internal conversion" seems somewhat less likely. Speculations are made on the release of useful amounts of nuclear energy by these catalyzed reactions. The governing factors are not the intrinsic reaction rate once the molecule is formed, but rather the time spent \( (\sim 10^{-8} \text{ sec}) \) by the \( \mu^- \) meson between the breakup of one molecule and the formation of another and the loss of \( \mu^- \) mesons in "dead-end" processes. These factors are such that practical power production is unlikely. In liquid deuterium, each \( \mu^- \) meson will catalyze only \( \sim 10 \) reactions in its lifetime, while for the \( d + t \) process it will induce \( \sim 100 \) disintegrations. A longer lived particle will not be able to catalyze appreciably more reactions.

See also "A Personal Adventure in Muon-Catalyzed Fusion"
$^{60}\text{Co} \beta$ ASYMMETRY

(At Pulse Height 10V)

Exchange Gas In

COUNTING RATE

$\langle$COUNTING RATE$\rangle_{\text{WARM}}$

TIME IN MINUTES

0  2  4  6  8  10  12  14  16  18
Possible Tests of Time Reversal Invariance in Beta Decay

J. D. Jackson, S. B. Treiman, and H. W. Wyld, Jr.

Palmer Physical Laboratory, Princeton University, Princeton, New Jersey

(Received January 28, 1957)

Noninvariance under space reflection and charge conjugation has now been established for beta decay processes. Invariance under time reversal remains an open question, however. We discuss here several possible tests for the validity of this symmetry operation. General expressions are given for the distribution function in three experimental situations, which have the possibility of detecting terms in allowed beta decay that are not invariant under time reversal: (a) experiments in which the nuclei are oriented and electron and neutrino momenta are measured; (b) experiments in which the nuclei are not oriented, but the recoil momentum and electron momentum and polarization are observed; (c) experiments in which the nuclei are oriented and the electron momentum and polarization are measured. The distribution functions obtained omit Coulomb distortion effects and relativistic corrections for the nucleons, but are otherwise complete. Such experiments should permit, in addition to the detection of terms which are not invariant under time reversal, the beginnings of a determination of the ten complex coupling constants which now characterize beta decay. An additional, somewhat surprising, result is found. If the two-component neutrino theory of Lee and Yang is correct, and if certain perhaps reasonable assumptions concerning the relative magnitudes of the various coupling constants are valid, then the longitudinal polarization of electrons in allowed beta decay even from unoriented nuclei should be almost complete (specifically, equal to $\epsilon/e$).

Search for a $T$-odd, $P$-even triple correlation in neutron decay

Peripheral model with absorption, $t$-channel frame, density matrix, phenomenological analysis of resonances. Mountains!

1957–1967: University of Illinois

Summer schools: Edinburgh (1960) dispersion relations; Brandeis (1962) weak interactions; Les Houches (1965) decay angular distributions

The Physics of Elementary Particles (1958)
Mathematics for Quantum Mechanics (1962)
Classical Electrodynamics (1962)

1963–1964: CERN

Peripheral model with absorption, $t$-channel frame, density matrix, phenomenological analysis of resonances. Mountains!
1967–1993: University of California, Berkeley emeritus from 1993
Dynamics of strong interactions, Regge theory
“Born a century too late!”
Spez TRIUMF (K0 decay, 4 GeV
Park an e+e- cross section at
$W = 2\ (1.552)\ GeV = 3.104\ GeV$

$\frac{1}{W} > 1.5$,

$0^+ \sim 1500\ MeV$

(FWHM) observed = 2\ MeV

$\Delta E \sim 3 \times 10^{-5}$

Presently mapping out the peak.

Yield of hadrons at peak is qualitatively similar to yield at nearby energies.

For $e^+e^- \rightarrow \pi^+\pi^-h$ resonance cross section is

$$\sigma = \frac{(23+1)\pi^2}{(2\pi)^4} \frac{\Gamma_e \Gamma_m}{(M-W)^2 + \frac{1}{4} \frac{W^2}{\Gamma^2}}$$

where $\Gamma = \sum \Gamma_m$ is the total width.

We have $23+1 = 3, (2\pi)^4 = 4, \pi^2 = \frac{4}{4} W^2$

The total cross section in therefore

$$\sigma = \frac{3\pi^2}{W^2} \frac{\Gamma_e \Gamma_m}{(M-W)^2 + \frac{1}{4} \frac{W^2}{\Gamma^2}}$$

$$\sigma_{max} = \frac{12\pi}{W^2} \left( \frac{\Gamma_e \Gamma_m}{\Gamma} \right)$$

With $\sigma_{max} = \frac{4\pi^2}{3W^2}$ we have $K = 9(137)^2 \left( \frac{\Gamma_e}{\Gamma} \right)$

$$\Gamma_{max} = 2.35 \quad \therefore \quad \frac{\Gamma_{max}}{\Gamma} = 0.620$$

$$\frac{\sigma_{max}}{\sigma} = \left[ 1 + \frac{0.420}{\lambda - 1} \right]^2 + 0.385 \frac{(\Delta W)^2}{(1 + x^2)}$$

where $x = (M-W)^2 / (\Gamma + \Delta W)$.

For $\Delta W = 1.3\ MeV$, $\Gamma = 52-63\ MeV$

Observes peak value is $\sim 80-100\ mbl$ whereas QED value is $9$. This mean

$$\frac{(\Gamma + \Delta W)}{\Gamma} \approx 0.385 \sim 20-25$$

With $\Delta W = 1.3\ MeV$, $\Gamma = 37\ MeV$

This mean $\Gamma_{max} = 8.9 \times 10^3$

Now $K = \frac{9}{137} \frac{\Gamma_e}{\Gamma} \therefore \Gamma_e = \frac{8.9 \times 10^3}{9(137)} = 0.053$

$$\left( \frac{e^+e^- \rightarrow h} {\sigma_{max}} \right) \approx \frac{1}{4} \frac{3(3-12)}{3} \approx 1.8-2.2$$

Beautiful! $\Gamma \approx 40-60\ MeV$

Note $\Gamma = \frac{R}{q(137)} = \Delta W = 2.0 \times 10^{-3}\ MeV\ for\ \Gamma = 255,\ \Delta W = 1.3,\ MeV$. 

$R$ independent of value of $\Gamma$. 

23
Use of Dipole Sum Rules to Estimate Upper and Lower Bounds for Radiative and Total Widths of $\chi(3414), \chi(3508),$ and $\chi(3552)$

J. D. Jackson
Department of Physics and Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720
(Received 18 August 1976)

Upper and lower bounds on the widths for $\gamma \rightarrow \chi(3095)$ can be estimated by assuming $E1$ transitions and approximate Russell-Saunders coupling for the $c\bar{c}$ system. Experimental widths for $\gamma(3684)$ made the lower bound more restrictive, giving radiative widths of 160-240, 230-400, and 280-480 keV for 3414-, 3508-, and 3552-MeV states, respectively. Cascade branching ratio data permit estimation of the total widths as $\geq 1.6$, $0.3-1.5$, and $0.6-4$ MeV, respectively.

In the spectroscopy of new particle states uncovered in $e^+e^-$ annihilation it is now rather clearly established that the three states generically labeled as $\chi$ have $J^P = 0^+, 1^+, 2^+$ for the 3414-, 3508-, and 3552-MeV states, respectively. The spin and parity values and ordering of these states are just what is expected of the triplet $p$ states in any $q\bar{q}$ bound-state model that parallels positronium. The $\chi$ states are formed by the radiative decay $\gamma(3684) \rightarrow \chi$. They are observed to decay into hadrons and also, for the $J = 1$ and $J = 2$ (and marginally for the $J = 0$) via the two-photon cascade, $\gamma(3684) \rightarrow \gamma \chi \rightarrow \gamma \phi(3095)$. Recently, branching ratios have been reported for the $\gamma(3684) \rightarrow \gamma \chi$ transitions and also products of branching ratios for the cascade transitions. These are summarized in Fig. 1.

The view that these states are describable to a good approximation by a nonrelativistic potential model, with $\alpha^2/c^2$ corrections, receives increasing support from the data. I adopt this picture here. In the Russell-Saunders limit $(J_1, J_2, L_1,$ and $S_1$ diagonal) the states have the designations shown in Fig. 1. The details of the binding potential need not concern us, but I make the assumption from the outset that tensor forces, relativistic effects, coupled channel effects, etc. are unimportant enough that they do not vitiate my use of the dipole sum rules to estimate upper and lower limits on the radiative widths.
The Women Graduate Students of the Department of Physics of the University of California confer upon

John David Jackson

the title of HONORARY WOMAN, with all rights and privileges thereto pertaining, in recognition of outstanding achievements as chairman of the Department of Physics 1978-1981.

Given at Cragmont Park
May 31, 1981
CED Fig. 7.9—“The reader may meditate on the fundamental question of biological evolution on this water-soaked planet, of why animal eyes see the spectrum from red to violet and of why the grass is green.”
Sunrise over Illecillewaet glacier from Balu Pass, BC
Three peaks of Nilgiri from Kalopani, Nepal
Jet d'eau, Genève
From Alexander of Aphrodisias to Young and Airy

J.D. Jackson
University of California, Berkeley, CA, USA and Lawrence Berkeley National Laboratory, University of Berkeley, Berkeley, CA, 94720, USA

Abstract
A didactic discussion of the physics of rainbows is presented, with some emphasis on the history, especially the contributions of Thomas Young nearly 200 years ago. We begin with the simple geometrical optics of Descartes and Newton, including the reasons for Alexander’s dark band between the main and secondary bows. We then show how dispersion produces the familiar colorful spectacle. Interference between waves emerging at the same angle, but traveling different optical paths within the water drops, accounts for the existence of distinct supernumerary rainbows under the right conditions (small drops, uniform in size). Young’s and Airy’s contributions are given their due. © 1999 Elsevier Science B.V. All rights reserved.

PACS: 01.30.Rt; 42.15.Dp; 42.25.Fx; 42.68.Ge

This pedagogical piece on rainbows is dedicated to Lev B. Okun, colleague and friend, on his 70th birthday. On an extended visit to Berkeley in 1990, Lev saw on my office wall a picture of a double rainbow with at least three supernumerary bows visible inside the main bow. As part of my “lecture” on the photograph, I showed Lev a copy of these 1987 handwritten notes prepared for a class. He said, “Are these published somewhere?” My answer was no, but now they are, in augmented form. Lev is an amazing man, a physicist-mensch – a brilliant researcher, mentor, and warm human being. I have a vivid memory of a wonderful trip to Yosemite National Park with an allegedly ailing Lev. In the early morning hours, we found Lev outside our tent in Curry Village perched on a sloping rock doing vigorous calisthenics! Lev, may you have Many Happy Returns!

The rainbow has fascinated since ancient times. Aristotle offered an explanation (not correct), as did clerics and scholars through the ages. Newton and Descartes established the elementary theory, according to what e now know as geometrical optics. But long before Newton and Descartes, as early as the 13th century, the puzzling occasional phenomenon of supernumerary rainbows was noted. These “aberrations” were inexplicable in terms of geometrical optics. It was not until the beginning of the 19th century that Thomas Young, promoting the wave theory of light against acolytes of Newton, offered the correct explanation of the supernumeraries as results of interference. Airy put the theory on a firm mathematical footing in 1836. A scholarly treatment of the

\[ \frac{d\theta}{dn} = \frac{1}{n^2} \left( \frac{4 - n^2}{\sqrt{n^2 - 1}} \right) \]

For \( n = 4/3 \), \( d\theta /dn \) = 2.536. With \( \Delta \theta = 1.3 \times 10^{-2} \), we find \( \Delta \theta_0 = 3.3 \times 10^{-2} \) radians = 1.89°. The colors of the rainbow are spread over about 2° out of the 42° away from the anti-solar point (180° − 138°). Since \( d\theta /dz < 0 \), the red light emerges at a smaller angle than the violet.
Lake Ediza, 1978          Kurt Gottfried photo

Near Lake Tahoe, August 2011          Nan Jackson photo
JDJ’s home page

Commemoration at Lawrence Berkeley Laboratory

CQ, Obituary in Physics Today

Gottfried & Tigner, Obituary in the CERN Courier

Wikipedia article

JDJ’s Articles in American Journal of Physics

R. N. Cahn, Biographical Memoir (NAS, to appear)

Thanks to Maureen & Nan Jackson, Bob Cahn, Kurt Gottfried
Del Rumbold, David Jackson, Gar Woonton, Don Hay, Harold Tull, Eric Vogan
4th-year Radio Physics students and staff at UWO, 1946
My Ph.D. and M.Sc. students

In my seven and one half years at McGill, one on leave, I supervised two Ph.D. students and three M.Sc. students. Their names and thesis topics and photographs are given in chronological order:

Schiff, Harry, Ph.D., 1953
Theoretical calculations of electron capture cross sections.

Vosko, Seymour H., M.Sc., 1953
Theoretical interpretation of radiation emitted in neutron capture reactions.

Betts, Donald Drysdale, Ph.D., 1955
A theoretical investigation of resonance electron capture cross sections.

Reeves, Hubert, M.Sc., 1956
The formation of positronium in hydrogen and helium gases.

Chapelaine, J. L. Marc, M.Sc., 1956
Scattering of positrons by hydrogen atoms and formation of Positronium.