VERNON HUGHES: "TO LEARN FUNDAMENTAL THINGS". 1921–2003

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Abstract

A presentation in Vernon's words, attempting to capture his sense of seriousness, humor, and justice.

The quotations used here are from the memoir written by Vernon Hughes, "Various Researches in Physics," in the Annual Review of Nuclear and Particle Science 2000, 50:i-xxxvi (2000).

Vernon (I apologize for my informality, but I have a difficult time continually refering to "Professor Hughes" or whatever.) divided his life chronologically into several stages – the titles of the following sections are his.

"My Unprecocious Entry into Physics"

Vernon grew up in New York City, brought up by his mother, Jean Parr Hughes (his memoir is dedicated to her). He attended school at a small private school on the upper west side, the school having an "idealistic and humanistic orientation."

Vernon first went to Columbia College in pre-law: "I planned a pre-law course of study with the intention of going to law school and then eventually doing good things for the world." "A pre-law course entitled "Analysis of the Written Word" was particularly stimulating and valuable with its emphasis on the exact meaning of the written word." My realization from this emphasis is that every word that Vernon uses in his memoir (and in his publications) has been carefully chosen, for example in the quotations above and below.

Vernon took his first physics course in his sophomore year (2nd year). In his third year he majored in physics, and graduated, in 1941.

Vernon went to Caltech for graduate school. "President Robert Milikan gave a spirited but not humble course on modern physics." Then, in December, Pearl Harbor was bombed. Vernon then went to work at the MIT Rad Lab–on radar, 1941–1945.

"World War II Years and Columbia Graduate School"

After the war ended, in 1946, Vernon went back to graduate school, but at Columbia. This was the period of QED, g-2 (electron), beta decay (Rabi, Lamb, Wu, ..). Vernon decided to work on nuclear electric quadrupole moments from the polarization of the nuclear core by an outer nucleon–his thesis used molecular beams, with Rabi his advisor. "I was particularly interested at the time in building an apparatus by myself from scratch." "I then worked out the theory for this two-photon transition for our case. At that time at Columbia theoretical course work was extensive and one was expected to handle the theory relevant to ones experiments." "As a teacher, I found Rabi most inspiring, helpful, encouraging, and basically sane."

Vernon laments missing doing hyperfine structure of hydrogen for his thesis (this led to the first observation of a discrepancy with QED, before the Lamb shift discovery). "My thesis was certainly satisfying and instructive. And it contributed a bit of new knowledge. This experience did instill in me the firm view that, to learn fundamental things, it is best to study a simple system where the theory should be adequate."

Vernon received his Ph.D. in 1950: "Launched with a Ph.D. in 1950."

"Atomic Physics Research"

Vernon joined Yale in 1954. He did helium research for 30 years, many ppm measurements: $\mu(^3He)/\mu(^1H)$= 0.761 812 37 (46) (0.6 ppm), to provide a test of modern QED theory of the two-electron system. He found good agreement at the ppm level.

$(e^+ - e^-)$: positronium was discovered in 1951 by Deutsch at MIT. Vernon measured the hyperfine interval with C.S. Wu to 3.6 ppm. Wu et al. then discovered parity violation in 1957. Vernon then did an experiment to measure the polarization of electrons from ^{60}Co decay. "Furthermore, believing that polarized electron sources would prove useful generally in atomic and high-energy physics, I began to study methods of producing a beam of polarized electrons with reasonable intensity." This led to an electronically polarized K beam (via 6-pole magnets), with polarized electrons from photo-ionization. This new source, PEGGY, achieved P=.8, 2 x 10^8 electrons in 1.5 μsec pulse.

"Muonium"

$(e^- - \mu^+)$: Vernon's search for muonium started within weeks of the parity violation discoveries (beta decay; π to μ to electron). Parity violation provided a tool to identify the muon spin state. Attempts from 1957-1960: a spin exchange between muonium and oxygen (an impurity in argon gas of apparatus) depolarized electrons and blocked discovery. Vernon and his group discovered muonium in 1960. "Muonium brought something new, interesting, and substantial into our world."

Vernon developed plans for a meson factory at Yale using a linear accelerator that wasn't built; but LAMPF was, following the Yale scheme (1972). Vernon then worked on developing the muon facility at LAMPF from the mid-1960s, leading to muonium experiments.

Gisbert zu Putlitz came to Yale, collaborating on muonium from 1967. "Gisbert and I, as well as our families, have been close friends for over 30 years. Our collaboration and friendship have been among the better experiences in my life."

"Polarized Leptons at High Energy"

The next chapter in Vernon's career led to the work that we are discussing at this meeting: polarized leptons at high energy. The Yale polarized source was brought to SLAC, leading to the development of a new field. "A second area in which our Yale group was able to bring something new, interesting, and important into the world was high energy polarized lepton-nucleon scattering." In 1968: the famous SLAC-MIT experiment with unpolarized e + p discovered quarks. Vernon was initially interested in measuring the polarized proton structure function to provide the polarizability contribution to the hyperfine structure interval in hydrogen. This resulted in a plan to do a polarized electron-polarized proton scattering at SLAC. He used the Yale polarized electron source, and polarized target. This first measurement of $A_1(p)$ confirmed naive quark model expectations–the quarks carried much of the proton spin at large momentum fraction.

Also at this time Charles Prescott, with Vernon, did one of the most beautiful experiments: parity violation for polarized electron-unpolarized nucleon scattering, "which decisively established the validity of the unified electroweak theory."

Following the proton measurement of A_1, a polarized electron-polarized neutron experiment was proposed and rejected by SLAC. Vernon attempted to develop interest in a polarized muon-polarized nucleon experiment at Fermilab with no success.

Vernon then joined the EMC experiment at CERN: polarized muon-polarized proton scattering, Gabathuler, Sloan, Hughes et al. The experiment uncovered the spin surprise/crisis/puzzle!

The SMC experiment was then proposed to focus on the polarized muon experiment. "Since NMC did not have anyone who had been active in the spin structure field (the British having left after EMC), it turned out that I became spokesman of SMC." The experiment obtained beautiful results-the Bjorken sum rule was confirmed to 10%. "The large amount of data on spin structure functions obtained by SMC and by SLAC confirmed but did not resolve the spin puzzle. Interest has focused on the polarized gluon contribution to nucleon spin."

Vernon's next step was to push to collide polarized electrons with polarized nucleons, at HERA. He advocated studies for polarized protons at HERA that were carried out; later, he supported studies for polarized electrons at RHIC. Vernon joined a collaboration for polarized proton beam polarimetry for RHIC and for a future polarized HERA.

RHIC Spin came in large part from the physics uncovered by Vernon on the spin structure of the proton. Vernon also played a direct role: he first suggested to Ernest Courant to study whether acceleration of polarized protons in a strong-focusing accelerator would be possible. He also supported the waveform digitizers from Yale (Satish Dhawan) that are a crucial part of proton polarimetry at RHIC. Vernon never joined polarized proton-polarized proton collision physics. I believe he thought protons too complicated as a probe.

"Muon g-2"

"The anomalous magnetic moment or g-value of the muon, like that of the electron, is a fundamental quantity of great interest." By 1979 the third CERN muon g-2 experiment obtained a 7 ppm precision (syst. error 1 ppm). In 1978, R.W. Williams presented "Muon g-2-the Last Word." Vernon seemed to take this title as a challenge! In 1982, at the LAMPF II workshop, Vernon and others studied mounting a new g-2 experiment (the LAMPF II intensity was expected to be 100 x CERN). This work led to the formation of a new muon g-2 experiment at the AGS, when the AGS booster had been proposed, which would give a proton intensity for the AGS of about 30 x CERN.

"The value of the muon anomalous magnetic moment may be considered a sum rule of present physics. Any deviation of a_μ(experiment) from a_μ(theory) indicates physics beyond the standard model." While writing the paper showing a 2.5 sigma deviation from theory (the 1999 BNL result), Vernon told me "we are very lucky." However, while preparing a press release, Vernon was quoted that a deviation can come from 1) we are wrong, 2) the theory is wrong, and 3) new physics (this is paraphrased).

The last result from the present BNL experiment, announced in January, 2004, reached a precision of 0.5 ppm. Whether there is a significant difference from theory is uncertain at present, due to ongoing theoretical work. The present difference between theory and experiment is 2.7 standard deviations, using the standard e^+e^- data to obtain the hadronic contribution. The theory is closer to experiment when τ data are used, but there are now questions about the assumptions necessary to use the τ data.

"An Administrative Addendum"

Associated Universities Incorporated (AUI) established BNL in 1947, and Vernon was trustee from 1962. AUI was removed from managing BNL in 1998 by the U.S. Department of Energy, due to a furor over a High Flux Beam Reactor tritium leak. The leak amounted to about 1 exit sign worth of tritium (tritium is used in common exit signs for buildings). This was not fought legally by AUI. "I regret this lack of legal response because I believe that a vigorous AUI defense could have clarified many aspects of the situation and would have been a positive move toward strengthening a spirit of mutual respect and trust between federal agencies and the scientific community."

Finally, from "A Festschrift in honor of Vernon W. Hughes" edited by M.E. Zeller, World Scientific 1991 (on the occasion of Vernons 70th birthday): "Being descended from Iowa stock, which included an evangelical Methodist minister, I should probably have some moral, wise thoughts to offer. However, I don't have anything very original to say. Surely the important driving force for research is one's own interest in the topic. One shouldn't be too influenced by other people's opinions, or by current fads or speculations. I have found, on several occasions, progress in research has been slowed at least partly due to the injection of criteria extraneous to the research itself, e.g. consideration of credit to individuals, a teaching objective or some political funding matter. Effective collaboration in small or large groups requires the closest possible communication among their members and maximum input from everyone. I have derived great satisfaction from the warm human relationships with physicists with whom I have worked or shared common interests."

"I have felt for a long time, as I believe many of us do, that a particular importance of our profession is its international aspect. We have a rather unique opportunity, largely independent of politics, to communicate and work and to become friends with physicists from almost any country which has activity in our field. Our collaborations are not only a great professional and personal pleasure but also an important contribution to international understanding and peace."