

search & discovery

Second-class currents in beta decay?

Denys Wilkinson has recently raised again the issue of whether or not second-class currents exist in the weak interaction. Second-class currents are defined as having the opposite behavior under G-parity as first-class currents. The G-parity operation is the product of charge conjugation and charge symmetry (which rotates the isotopic spin through 180 deg). Although known to be conserved in strong interactions, G parity might very well not be a useful symmetry for the discussion of weak interactions.

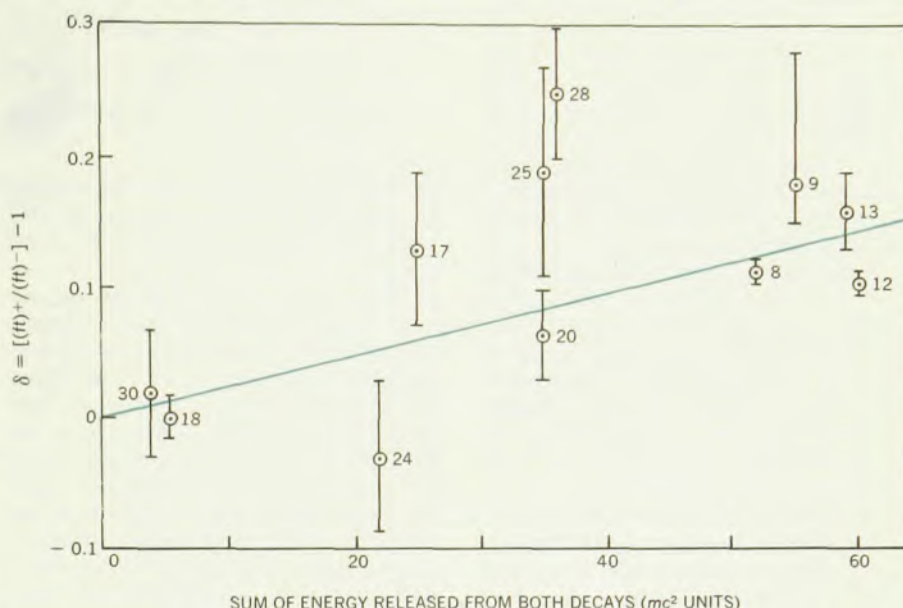
Still, the highly successful conserved vector current theory, which uses no second-class currents, has stood up exceedingly well since it was developed twelve years ago by Richard Feynman, Murray Gell-Mann, Robert Marshak, E. C. George Sudarshan and others. The more recent modification by Nicola Cabibbo, to allow for strange-particle decay, also does not include second-class currents.

If second-class currents exist, one would expect that, after correcting for nuclear and electromagnetic differences, pairs of mirror nuclei would have identical intrinsic beta-decay rates. Wilkinson analyzed existing data and, together with David Alburger (Brookhaven) has developed some new data. Wilkinson says that the present data are consistent with second-class currents, although they by no means prove that the currents exist.

The conserved vector current picture makes an analogy with electromagnetism. One thinks of two currents interacting with each other, the nucleon (or hadronic) current and the lepton current, L_μ . If the analogy were exact, the interaction strength would then just be the product of the two currents.

In beta decay, however, spin is significant. Enrico Fermi had guessed that the nucleon spin would not flip. However it was later found by George Gamow and Edward Teller that in some cases the nucleon spin does flip. If one ignored the strong interaction, the hadronic current could be written as $\gamma_\mu (1 + \gamma_5)$. The first term, the vector component, represents the spin not flipping and the second, the axial vector component, represents the spin flipping.

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Importance of second-class currents in beta decay. Each point represents a mirror pair; the number beside the point is A value. Ordinate is δ , the ratio of intrinsic decay rate for positron emission to that for electron emission, minus one. If second-class currents exist, δ should be proportional to the sum of the energy released from both kinds of decay. Straight-line behavior is consistent with second-class currents.

Experimenters vie for first crack at Batavia

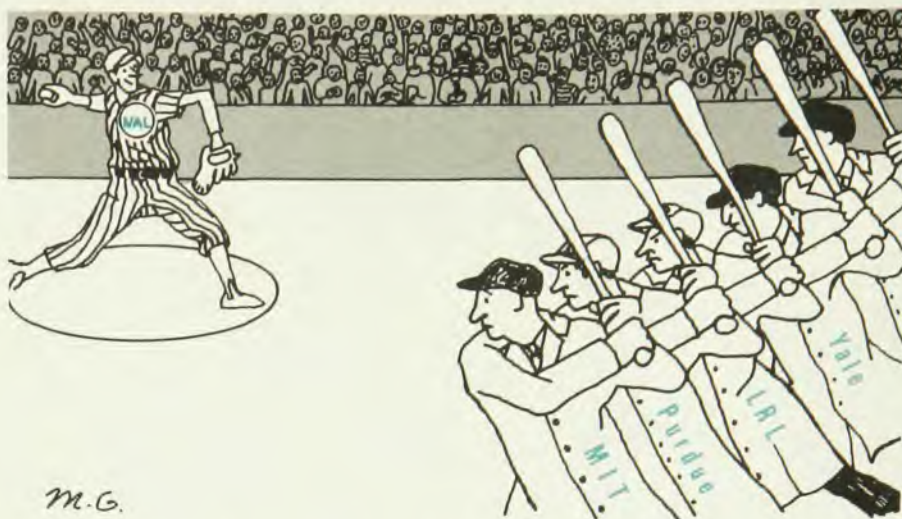
With Robert R. Wilson's recent announcement that the Batavia accelerator might have a beam in mid-1971 and that a low-intensity beam of 500 GeV could be produced not long after (PHYSICS TODAY, June, page 29), high-energy physicists are clamoring for a chance at being first to use the new machine. A call for proposals brought more than 80 replies, enough for several years' worth of experiments. Edwin Goldwasser, deputy director of the National Accelerator Laboratory, told us that some time this month NAL may tentatively accept some of the proposals—those that require a university group to start work now so that it could be ready in summer or fall of 1972.

The program advisory committee met for a week last month in an intensive attempt to find out what kinds of experiments should be the first on the accelerator. With the benefit of that advice NAL is now deciding what kind of

equipment will be needed, which apparatus should be built by university groups, which by NAL. This fall NAL will probably commit itself to one or two fairly large pieces.

What kinds of experiments do people want to do? Of course every time a new energy realm opens up, the natural thing to do is search for those mythical particles theorists continue to talk about—the magnetic monopole, the intermediate vector boson, and of course the quark (which some experimenters claim is no longer just a gleam in Gell-Mann's eye).

Total cross sections are another must, especially because preliminary results from the 70-GeV accelerator at Serpukhov on π^-p and K^-p (PHYSICS TODAY, October 1969, page 57) suggest to some observers that the Pomeranchuk theorem could be wrong. The theorem predicts that for strong interactions, in the high-energy limit, the cross



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section for a particle hitting a target is the same as for an antiparticle hitting the same target.

Serpukhov experiments show that the π^- total cross section is greater than that for π^+ and may be flattening out. Similarly the K^- cross section is greater than the K^+ and may be flattening out. The Pomeranchuk theorem requires that at still higher energies the π^- and π^+ cross sections would have to converge, as would K^- and K^+ .

Prospective NAL experimenters want to use kaon, pion, proton and antiproton beams for total cross-section measurements on proton targets. Pion beams will be available up to approximately the primary proton energy, kaon beams at somewhat less.

Checking the Pomeranchuk theorem will primarily be done with K mesons, Goldwasser said. One kind of proposal would use the highest possible energy beam of K_L^0 , bombard a target with it and look at the emerging beam. Because both K_L^0 and K_S^0 can be considered as mixtures of K^0 and $\bar{K}^0$, if these two components have different reaction cross sections with the matter in the target, the outgoing beam will have a different mixture of matter and antimatter—no longer pure K_L^0 . But if the K energy is high enough for the cross sections to be identical the emerging beam will be pure K_L^0 . Goldwasser personally does not believe the energy will be high enough; so there will be some regeneration of K_S^0 . Other experimenters want to try a regeneration experiment at 100 or 150 GeV, measuring phase angles and amplitudes.

Some people are proposing classical electron-machine-type experiments, using beams of electrons or photons produced from neutral pion decay. One could get very close to 500-GeV electrons. Goldwasser noted that "electromagnetic-interaction proposals are not so numerous as strong-interaction proposals. In part this is because fewer machines and fewer physicists have been working in that area." Experi-

ments at NAL could check the validity of quantum electrodynamics at still smaller distances than are possible with SLAC.

Other proposals would like to use muon beams, which are often a better tool for studying electromagnetic interactions than electrons. For one thing, muons don't radiate as readily as electrons because of their larger mass; so radiative corrections, which are often difficult to calculate, are smaller. Experiments are possible that look at charge structure and magnetic structure of the proton. Of course if the muon turns out to be something more than just a heavy electron one may be seeing effects caused by some strange properties of the mu meson, which would have to be sorted out.

A major effort will be on neutrino interactions at high energy, using a 15-foot-diameter hydrogen bubble chamber, which NAL recently started building, and arrays of counters. First-order classical neutrino theory predicts that the neutrino interaction cross section will increase in direct proportion with energy.

Goldwasser commented, "Such an increase in cross section with energy is almost certainly not true, because if it were the cross sections would go to infinity. In fact there are divergences in weak-interaction theory which we hope can be removed theoretically on the basis of NAL experiments." He expects that NAL experiments will find the region in which the cross section ceases to increase, as predicted by first-order theory.

As detection devices, besides the bubble chamber, NAL will have counters, ordinary-sized scintillation counters, spark chambers, wire chambers, and so on. The usual beam-transport systems will be needed, as well as spectrometer magnets for precise momentum analysis, some of which will be built during the next two years.

One of the reasons NAL called for proposals this summer, Goldwasser said,

was "to test our ideas about the kind of equipment we might produce against the requirement of real experimenters, who are willing to commit two years of their lives to an experiment, rather than just having us sit back in an arm chair and imagine what experiments might be done."

NAL will try not to commit itself firmly on accepting proposals until the last possible moment, "because physics changes and technology changes," and it does not want to do "an obsolete experiment with obsolescent equipment."

Two Soviet physicists from Serpukhov, Adolph Mukhin and Pavel F. Yermolov, participated in the 1970 summer-study program. Goldwasser says, "We believe that the whole elementary-particle effort is and should be an international one—it's an effort of man, not of Americans or Russians or French." —CBL

US-Soviet collaboration to measure pion charge radius

This month four UCLA physicists hope to arrive at the High-Energy Physics Institute in Serpukhov to participate in the first joint experiment between Soviet and US physicists there. Darrell Drickey will head the US group and Edouard N. Tsyganov heads a group from Dubna. The collaboration will attempt to measure the charge radius of the pion by bombarding electrons with negative pions.

It is generally believed that pions and protons have the same charge radius. Vector-meson dominance predicts an electromagnetic radius of 0.64 fermi. However electron-proton scattering experiments show a radius of 0.81 fermi. Unfortunately the pion does not hold still long enough to be hit with electrons, and one must use the electrons as targets instead to determine pion radius. The Dubna-UCLA experiment will be the first to try determining the radius directly. Drickey says that a measurement of the pion radius would help towards understanding whether this disparity is caused by some peculiarity of the nucleon or to a breakdown of vector dominance.

Hints that the pion might even act like a point particle have been coming from the Frascati electron-positron storage ring, but the experiment on two-pion production is still in an early stage.

In the Serpukhov experiment 50-GeV negative pions will hit electrons in the liquid-hydrogen target, then wire chambers and shower counters will identify the pion and electron and determine their position before and after they enter a magnet (which measures their momenta).

The experimenters hope to determine