Dirac's theory and pair production

The following is excerpted from "What Really Happens in Pair Production and Beta Decay? Why Neutrinos Don't Exist," Fusion, *Nov.-Dec. 1985.*

English theoretical physicist Paul Dirac developed a relativistic theory of the electron in 1927 that defined positive and negative energies of electrons, independent of their positive and negative charges. Negative energies proved necessary to account for observed physical processes.

Dirac's theory had the Special Theory of Relativity as its point of departure and took its fundamental features from it, including the fundamental postulate that positive and negative energies are equally warranted. This heritage, together with the fact that positrons normally do not occur in nature as stable—that is, as permanently existing particles—was the basis for Dirac's forumlation of his famous Hole Theory.

Dirac postulated that the physical world has a double structure with positive and negative electron energy states. The positive energy state is the condition of the observable "upper world," while the negative state is in the "anti-world" (or Dirac sea) and is initially unobservable. According to Dirac, given the full occupation of negative energy states, it can be demonstrated mathematically that the interactions of all electrons exactly compensate for one another.

Dirac reasoned that if an electron from the anti-world is hit by a highly energetic photon (gamma quantum) of the upper world, the electron can absorb the photon's energy by interaction in the electron's electromagnetic field. The electron then appears in the upper world. Simultaneously, a hole appears in the anti-world that represents a disturbance of the condition of full occupancy. This deficit in negative charge in the anti-world is observed in the upper world as a positron.

With conceptions developed in this manner, Dirac explained the production of electron-positron pairs by gamma quanta, and simultaneously explained why a positron of the upper world can vanish when an electron from the upper world refills the hole in the anti-world, with both particles then becoming unobservable. Both processes are totally easily observable in physical experiments.

Dirac's interpretation of pair production and annihilation automatically gives the quantum theoretician a rule for calculating the frequencies of the corresponding processes. Following preliminary work by the theoretical physicist F. Sauter in 1933, and calculations by Sauter and W. Heitler, these computations were done in an extremely comprehensive and detailed investigation by Hans Bethe and Heitler. Their results, the Bethe-Heitler theory, have played a major role in modern physics.—*Erich Bagge*

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chanical methods, it emerges that the neutron has a lifespan of the order of magnitude—as is known today—of 800 seconds. Back then, Fermi could not calculate that, he didn't have this concept. In 1934, he thought there must be another interaction, a so-called weak interaction, as he called it then, that set off this beta decay. The neutrino that he had taken over from Pauli was, so to speak, switched on in this weak interaction. But he didn't know the constant; he had to determine it from empirical data.

This constant isn't at all needed in the methods as I used them. The magnetic interaction that is obtained is exactly large enough so that the right lifespan of the neutron and the right spectral distribution for the beta decay is produced. I said to myself, this conception could not work so well if it were not a good representation of reality.

I was thus involved in these things and had calculated everything when I got an invitation from Leningrad. The head of the Joffe Institute in Leningrad, who is still alive, invited me for a lecture on cosmic radiation. But I thought at the time, why should I always talk about cosmic radiation; for once, I'll give a report on these other things. And that is what I did, and the following happened: On their own, the Russians had brought an Italian physicist, Pontecorvo, who had quietly gone to Russia after the war. He was present at my lecture. He asked me questions that I could answer without difficulty. Nonetheless, Pontecorvo, as a student of Fermi, said, "I don't believe it." What could I do?

One or two years later, I was, however, invited back to Leningrad to present these things more precisely. The Russians took my work from me, translated it without asking me, and published it in the academic reports out of Moscow under my name! They didn't say a word to me about any of that! I later heard of it from a Russian colleague. Thus the Russians learned very early of what I had done.

At this latter lecture, one of those who attended said, if all of this exists, couldn't experiments be done? In between, I additionally considered that pair production must be interpreted fundamentally from the way that Bethe and Heitler had done.

I knew the Bethe-Heitler theory well, since I had become acquainted with it as a student under Heisenberg. I had also always presented the Bethe-Heitler theory in my lectures as the *nec plus ultra* of modern physics, because to a certain extent, it correctly represented the effective cross-section of