Many physicists felt that symmetry between quarks and leptons was required—that there had to be equal numbers of both. As a fourth lepton—the muon neutrino—had just been discovered at Brookhaven, a fourth quark was needed.

Not much came of this prediction until 1970, when Glashow and two European physicists visiting him at Harvard used this hypothetical fourth quark to help explain why neutral kaons hardly ever decayed into a pair of muons. If there were only three quarks, this process should have occurred at a small but steady rate. But such an event had never been observed. With a charmed quark in the picture, however, in theory there were *two* pathways by which the kaon could decay in this way. And through an idiosyncrasy of nature, the two processes might easily cancel one another out, yielding zero net result!

A fourth quark fitted very nicely into the electroweak theory, too. The up quark can be paired with the down quark, and the charmed quark with the strange. (Actually, the relationship is more complex than with leptons, but that need not concern us here.) As with the leptons, only left-handed quarks and right-handed antiquarks feel the weak force.

Thus a beautiful, compact picture of the subatomic world had begun to emerge after the discovery of neutral currents in 1973. What was needed to clinch matters was the discovery of the charmed quark itself.

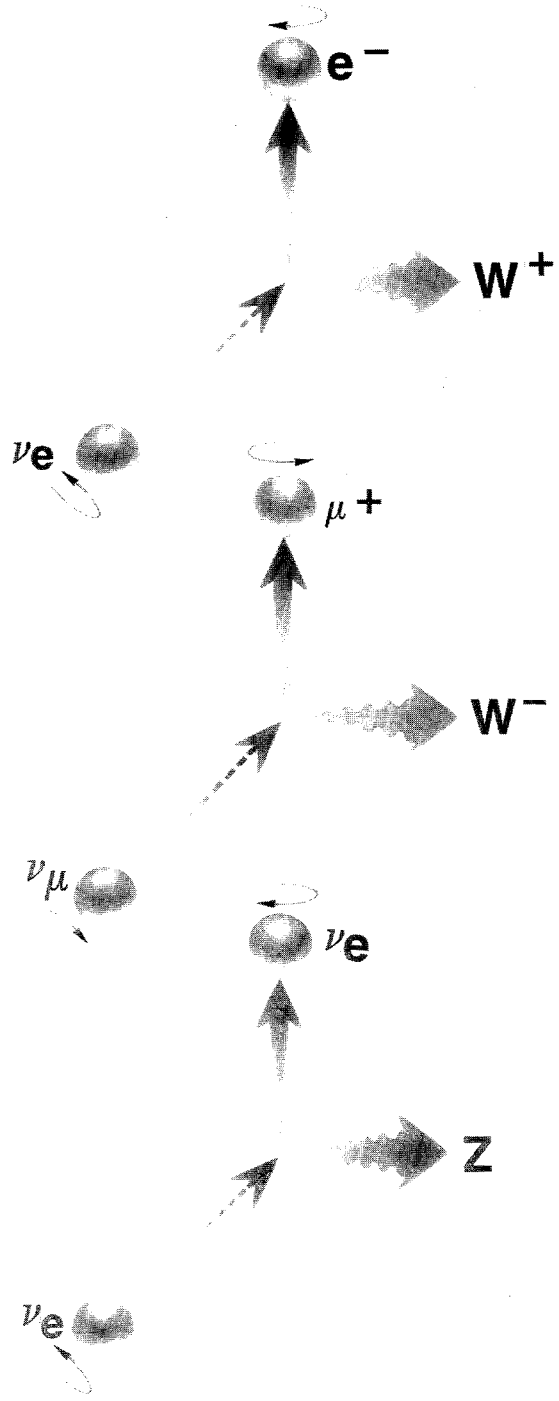

Figure 14. Neutrinos and antineutrinos interact by exchanging W and Z particles.