Search for Physics beyond the Standard Model via a Polarization-Asymmetry correlation experiment on ^{118}Sb

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Although the Standard Model (SM) of the electroweak interaction agrees with all experimental data [1], it has too many free parameters and ad hoc assumptions to be accepted as an "ultimate" description of nature. Parity violation in particular is "explained" by the assumption that only left-handed fermions and leptons participate in the charged current weak interaction. In the description of the weak interaction, parity violation is built in by introducing the helicity projection operator $(1-\gamma_5)$ in the Hamiltonian. Left-right symmetric (LRS) extensions of the SM, based on the $SU(2)_L \otimes SU(2)_R \otimes U(1)$ gauge group have been proposed to restore parity symmetry at high energies. Parity violation as observed at lower energies is then caused by a Higgs-type mechanism. The simplest extension of the SM is offered by the so called Manifest left-right symmetric model [2] which introduces a second charged gauge boson W_2. It acquires, by spontaneous symmetry breaking, a mass m_2 that is higher than the mass m_1 of the observed gauge boson. The two bosons are proposed to couple with the same coupling constant g to the left- and right-handed fermions with a mixing angle ζ.

$$W_L = W_1 \cos\zeta + W_2 \sin\zeta \qquad W_R = -W_1 \sin\zeta + W_2 \cos\zeta \tag{1}$$

From the propagators of the interaction $(q^2 + m_{1,2}^2)^{-1}$ it is easily seen that for $q^2 >> m_2$, i.e. at high energies, parity violation is restored. More general extensions [3] allow for different coupling constants and different Cabbibo-Kobayashi-Maskawa mixing matrices in the left- and right-handed sectors. In these general LRS models, experiments in β decay are complementary to μ decay measurements or to to direct searches for heavy W bosons because other combinations of parameters are probed.

We report on a recent experiment searching for right-handed currents in the ^{118}Sb nuclear β-decay that may be found in a small deviation from the full (100%) parity violation. For this purpose we have determined the correlation between the longitudinal spin polarization P and the β-emission asymmetry of the positrons from the ^{118}Sb decay. In general, the parameter P reflects the helicity structure of the weak interaction involved. When the decaying nucleus is polarized, it is possible to select the positrons that are emitted in the parity-forbidden direction. In this way the the contribution of "normal" particles associated with W_L is decreased while the amount of positrons coming from W_R is enhanced. As a result, the sensitivity of our method to right-handed currents is significantly improved. Moreover, by comparing positron spin polarization data from a polarized and unpolarized nuclear source, the measurement becomes independent of the precise knowledge of the analyzing power of the polarimeter. In this experiment the ^{118}Sb ($t_{1/2} = 3.5$m) activity was obtained as a daughter of ^{118}Te ($t_{1/2} = 6.0$d) produced at the ISOLDE isotope separator at CERN. The nuclei were polarized by means of low temperature nuclear orientation in the NICOLE on-line refrigerator at temperatures of about 8 mK. The emitted positrons were transported by an energy selective magnetic spectrometer to the polarimeter where the spin polarization of the positrons was measured by time resolved positronium spectrocopy. At the time of writing the analyses of the data is not fully completed. However, a preliminary assessment of the data indicates that a lower mass limit for the W_R of 350 GeV is within reach. This result makes the current experiment the best precision test of parity violation in nuclear β decay.

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