Polarized Muon Decay: Measurement of the Polarization Vector of the Decay Positrons as a Test of Time Reversal Invariance

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In the standard model (SM) of electroweak interactions the positron from the decay of polarized positive muons is mainly longitudinally polarized. The measurement of the two transverse polarization components, therefore, is a sensitive tool for contributions from additional, exotic, interactions.
The energy dependence of the transverse polarization component P_{T_1}, which lies in the plane spanned by muon-spin and positron momentum, yields the low energy parameter η and thus an improved model-independent value of the Fermi coupling constant. A non-zero value of the transverse component P_{T_2}, which is perpendicular to the above mentioned plane, would be the first observation of time reversal violation in a purely leptonic decay.
The $\mu_{P_{\mathrm{T}}}$ experiment at the Paul Scherrer Institute determines the three polarization components simultaneously with the same apparatus by making use of three different reactions (spatial and temporal dependence of annihilation-in-flight with polarized electrons as well as muon decay asymmetry). The use of a stroboscopic method greatly reduces systematic errors. The measurement of the longitudinal polarization serves mainly as a test of the sensitivity of the apparatus, while the measurement of the two transverse components will improve the current experimental limits $P_{\mathrm{T}_1} = (16 \pm 22) \times 10^{-3}$, $P_{\mathrm{T}_2} = (7 \pm 23) \times 10^{-3}$ by almost one order of magnitude. First results of the experiment will be given.