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A New Limit on Time-Reversal-Invariance Violation in Beta Decay: Results of the emiT-II Experiment

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We have measured the D-coefficient in the triple correlation of the neutron spin with proton and electron momenta by observing coincidences in the decay of polarized neutrons. A non-zero value of D can arise due to parity-even-time-reversal-odd interactions that imply CP violation due to the CPT theorem. (Final-state effects also contribute to D at the level of 1e-5 and can be calculated with precision of 1% or better [1]. The D coefficient is uniquely sensitive to the phase, φAV, of the ratio of axial-vector (A) and vector (V) amplitudes: λ=gA/gV as well as to scalar and tensor interactions that could arise due to beyond-Standard-Model physics such as leptoquarks [2].

The experiment was performed with the NG-6 cold-neutron beam at the NIST Center for Neutron Research in Gaithersburg, Maryland. The neutron beam is polarized, passes through a spin flipper and is collimated into a spectrometer, which measures proton-electron coincidences in an octagonal detector array concentric with the neutron beam. The recoil protons were accelerated to ~28 keV and detected by surface barrier detectors. The electrons were detected in plastic scintillators. The detector is highly segmented, allowing the triple correlation to be isolated and separated from a variety of systematic effects due to the parity-odd-time-reversal even correlations [3].

A 14-month run in 2002-2003 produced a sample of over 300 million proton- electron coincidence events. A blind analysis and extensive study of all significant systematic effects has recently been completed with the result D = (-0.96±1.89 (stat)±1.01(sys))e-4. The corresponding upper limit on D is a factor of three improvement over the previous upper limit for neutron decay [4,5] and over the upper limit measured in 19Ne decay [6], and thus our result represents the most sensitive test of time- reversal invariance in beta decay. Assuming only vector and axial vector interactions in beta decay, the result can be interpreted as a measure of the phase φAV = (180.013±0.028)°. This result also improves constrains on certain non-VA interactions.

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