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Francis M. Pipkin Award Talk: Lorentz and CPT Symmetry Tests with Atomic Co-Magnetometers

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Deviations from Lorentz symmetry naturally arise in many extensions of the Standard Model seeking to include quantum gravity effects. One of the common features of such models is coupling to a particle spin that violates local Lorentz invariance. We have developed a co-magnetometer using spin-polarized K and ^{3}He atoms to perform a sensitive search for such effects. The co-magnetometer measures the difference between spin interactions of electrons and ^{3}He nuclei, thereby canceling the signals from ordinary magnetic fields. The apparatus is rotated every 20 seconds to search for a spatial anisotropy. We have placed a limit on neutron interaction energy with a background Lorentz-violating field below 3.7×10^{-33} GeV, improving the previous limit by a factor of 30. Because of close connection between CPT and Lorentz symmetry, this measurement also represents the most stringent test of CPT for a fermion. One can also test Lorentz-violating theories that do not break CPT symmetry by using particles with a spin greater than 1/2 to search for a tensor spin anisotropy. We are currently using a co-magnetometer with ^{21}Ne atoms to perform such a search.