DAMOP16-2016-000043

Abstract for an Invited Paper
for the DAMOP16 Meeting of
the American Physical Society

Test of Lorentz symmetry with trapped ions[1]

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The outcome of an experiment should not depend on the orientation of the apparatus in space. This important cornerstone of physics is deeply engrained into the Standard Model of Physics by requiring that all fields must be Lorentz invariant. However, it is well-known that the Standard Model is incomplete. Some theories conjecture that at the Planck scale Lorentz symmetry might be broken and measurable at experimentally accessible energy scales. Therefore, a search for violation of Lorentz symmetry directly probes physics beyond the Standard model. We present a novel experiment utilizing trapped calcium ions as a direct probe of Lorentz-violation in the electron-photon sector. We monitor the energy between atomic states with different orientations of the electronic wave-functions as they rotate together with the motion of the Earth. This is analogous to the famous Michelson-Morley experiment. To remove magnetic field noise, we perform the experiment with the ions prepared in the decoherence-free states. Our result improves on the most stringent bounds on Lorentz symmetry for electrons by 100 times. The experimental scheme is readily applicable to many ion species, hence opening up paths toward much improved test of Lorentz symmetry in the future.

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