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Michelson-Morley test for electrons using a trapped ion decoherence-free subspace

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Lorentz symmetry is one of the corner stones of modern physics. As such it should not only hold for photons, but also for other particles such as the electron. Here we search for violation of Lorentz symmetry by performing an analogue of a Michelson-Morley experiment for electrons. We split an electron-wavepacket bound inside a calcium ion into two parts with different orientations. As the Earth rotates, the absolute spatial orientation of the wavepackets changes and anisotropies in the electron dispersion would modify the phase of the interference signal. To remove noise, we prepare a pair of ions in a decoherence-free subspace, thereby rejecting magnetic field fluctuations common to both ions. After a 23 hour measurement, we limit the energy variations to 11 mHz, verifying the isotropy of the electron's motion at the 10^{-18} level, a 100 times improvement over previous work. Alternatively, we can interpret our result as testing the rotational invariance of the Coulomb potential. Assuming Lorentz symmetry holds for electrons and that the photon dispersion relation governs the Coulomb force, we obtain a fivefold improved limit on anisotropies in the speed of light.