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Experimental Realization of a Relativistic Harmonic Oscillator[1]

MIKHAIL LIPATOV, KURT FUJIWARA, ZACHARY GEIGER, KEVIN SINGH, DAVID WELD, University of California, Santa Barbara — We report the experimental study of a harmonic oscillator in the relativistic regime [1]. The oscillator is composed of ultracold lithium atoms in the third band of an optical lattice, which have an energy-momentum relation nearly identical to that of a massive relativistic particle, with a reduced effective mass and speed of light. Imaging the shape of oscillator worldlines at velocities up to 98% of the effective speed of light reveals a crossover from sinusoidal to nearly photon-like propagation. Effective time dilation causes the measured period of oscillations to increase with energy; our measurements reveal beyond-leading-order contributions to this relativistic anharmonicity. Preparing oscillator ensembles, we observe an intrinsic relativistic dephasing and a breathing mode with exactly the opposite phase of that predicted for non-relativistic harmonic motion. All observed dynamics are in quantitative agreement with long-standing relativistic predictions [2,3]. [1] K. M. Fujiwara et al., arXiv:1712.09501 [cond-mat.quant-gas] (2017). [2] E. H. Hutten, Nature 205, 892 (1965). [3] W. Moreau, R. Easther, and R. Neutze, American Journal of Physics 62, 531 (1994).

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