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Observation of the relativistic reversal of the ponderomotive potential JEREMY AXELROD, SARA CAMPBELL, OSIP SCHWARTZ, CARTER TURNBAUGH, ROBERT GLAESER, HOLGER MUELLER, University of California, Berkeley — The interaction between a non-relativistic charged particle and a free-space electromagnetic wave can be described by the ponderomotive potential. Although ponderomotive electron-laser interactions at relativistic velocities are important for emerging technologies from laser-based particle accelerators to laser-enhanced electron microscopy, the effects of special relativity on the interaction have only been studied theoretically. We use a transmission electron microscope (beam energy $\leq$ 300 keV) to measure the position-dependent phase shift imparted to a relativistic electron wave function when it traverses a standing laser wave (continuous-wave intensity = 175 GW/cm^2). In contrast to the non-relativistic case, we demonstrate that the phase shift depends on both the electron velocity and the wave polarization. Remarkably, if the electron's speed is greater than $1/\sqrt{2}$ of the speed of light, the phase shift at the electric field nodes of the wave can exceed that at the antinodes. In this case there exists a polarization such that the phase shifts at the nodes and antinodes are equal, and the electron does not experience Kapitza-Dirac diffraction.

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