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Lagrangian geometrical optics of classical vector waves and particles with spin[1] D.E. RUIZ, Princeton University, I.Y. DODIN, Princeton University, PPPL — Linear vector waves, both quantum and classical, experience polarization-driven bending of ray trajectories and polarization dynamics that can be interpreted as the precession of the "wave spin." In this work, we present a universal Lagrangian theory that describes these effects by extending the geometrical-optics approximation to small but nonvanishing λ/ℓ, where λ is the wavelength, and ℓ is the characteristic inhomogeneity scale (arXiv:1503.07829; arXiv:1503.07819). When applied to classical waves, this theory correctly predicts, for example, the difference between the polarization-driven bending of left- and right-polarized electromagnetic wave rays in isotropic media (arXiv:1507.05863). When applied to quantum waves, the same general theory yields a Lagrangian point-particle model for the Dirac electron, i.e. the relativistic spin-1/2 particle. The model captures both the Bargmann-Michel-Telegdi spin precession theory and the Stern-Gerlach spin-orbital coupling theory. Moreover, we present, for the first time, a calculation of the fully relativistic ponderomotive Hamiltonian for a Dirac electron in a vacuum laser field. This Hamiltonian captures not only the usual relativistic mass shift but also spin effects.

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