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Qualitative Implications of a Nondegenerate Dirac Lagrangian in Riemann-Cartan Spacetimes

Nondegenerate matter Lagrangians (i.e. with an invertible Legendre transform) are a structural requirement of the de Donder–Weyl (covariant Hamiltonian) approach to field theory. For fermions, the Dirac Lagrangian is rendered non-degenerate via terms quadratic in the derivatives of the spinors. For free fields this reduces to a surface term and maintains the equations of motion unaltered, however, after minimal coupling to gauge fields, the quadratic piece becomes physical: it yields an anomalous Pauli coupling in electromagnetism and induces nontrivial curvature and torsion couplings in gravity. We outline the qualitative implications in Riemann–Cartan geometry and show that, in an appropriate WKB regime, these couplings lead to, among other things, geometric-optics–like phenomena, such as gravitationally-induced refraction and birefringence.

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