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Title:

A New Type of Quantum Criticality in the Pyrochlore Iridates

Abstract:

Magnetic fluctuations and electrons couple in intriguing ways in the vicinity of zero temperature phase transitions -- quantum critical points -- in conducting materials. Quantum criticality is implicated in non-Fermi liquid behavior of diverse materials, and in the formation of unconventional superconductors. Here we uncover an entirely new type of quantum critical point describing the onset of antiferromagnetism in a nodal semimetal engendered by the combination of strong spin-orbit coupling and electron correlations, and which is predicted to occur in the iridium oxide pyrochlores. We formulate and solve a field theory for this quantum critical point by renormalization group techniques, show that electrons and antiferromagnetic fluctuations are strongly coupled, and that both these excitations are modified in an essential way. This quantum critical point has many novel features, including strong emergent spatial anisotropy, a vital role for Coulomb interactions, and highly unconventional critical exponents. Our theory motivates and informs experiments on pyrochlore iridates, and constitutes a singular realistic example of a non-trivial quantum critical point with gapless fermions in three dimensions.