Dark Fermions in Fluctuating Valence Insulators

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A fluctuating-valence impurity in a metal is quantum-critical unlike a Kondo impurity which has the properties of a local Fermi-liquid. A systematic theory for the fluctuating-valence lattice is constructed, based on the hybridization and pairing of itinerant d-orbitals with localized f-orbitals both of which are essential parts of the solution of the impurity problem. It also uses the fact that the single-particle excitations at the Fermi-surface in any dimension can be written as orthogonal Majoranas and those with linear departures from the Fermi-surface as linear combination of bare particles and holes with the same spin. The calculations on the lattice give four spin-degenerate one-particle excitations of fractionalized fermions; two sets disperse across the chemical potential and the other two have gaps. The former are shown to be dark to any linear electro-magnetic probes of their charge and spin and observable only through probes of their free-energy such as a Fermi-liquid specific heat and magneto-oscillations characteristic of a Fermi-surface but without a Zeeman splitting. The excitations with the gaps behave as in insulators but with renormalized amplitudes. The superfluid density is zero. A magnetic field H turns the insulator to a metal with a singularity in magnetization proportional to $\sqrt{H - H_c}$, with H_c related to the gap. Beyond H_c, the usual Zeeman splitting appears in the magneto-oscillations. The properties and predictions are compared to the momentous recent discoveries in fluctuating-valence insulators. Similar excitations may be expected in transition metal chalcogenide layers at fluctuating-valence, and quite likely for Kagome lattices, and twisted multi-layer graphene near specific fillings.