Exotic orders in heavy electron systems

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abstract

Some f-electron systems such as URu_2Si_2 and $PrFe_4P_{12}$ show ordered phases where the order parameter is difficult to identify. These systems are characterized by the non-Kramers configuration where the number of f-electrons per site is even. We have studied generalized Kondo lattice models for such non-Kramers systems, and have found a new kind of orders by combining the dynamical mean-field theory and the continuous-time quantum Monte Carlo calculation. In the case of two-channel Kondo lattice with two conduction electrons per site, for example, a strange order emerges where the one-body quantities such as magnetization and charge density remain the same as in the high-temperature phase. The (hidden) order parameter Ψ at each site is given by

$$\Psi = \langle \boldsymbol{S} \cdot (\boldsymbol{s}_1 - \boldsymbol{s}_2) \rangle$$

where $\boldsymbol{S}$ is the localized pseudo spin and $\boldsymbol{s}_i$ $(i = 1, 2)$ is the pseudo spin of conduction channel i at the same site. This order can be interpreted as itinerant higher multipoles of electrons, and also as analogue of the composite superconducting order with odd frequency pairing amplitude. We also discuss other exotic orders and implication of our results in actual f-electron systems.