A solvable 3D Kondo lattice exhibiting pair density wave, odd-frequency pairing and order fractionalization

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The Kondo lattice model plays a key role in our understanding of quantum materials, but a lack of small parameters has posed a long-standing problem. We present a 3 dimensional $S = 1/2$ Kondo lattice model describing a spin liquid within an electron sea. Strong correlations in the spin liquid are treated exactly, enabling a controlled analytical approach. Like a Peierls or BCS phase, a logarithmically divergent susceptibility leads to an instability into a new phase at arbitrarily small Kondo coupling. Our solution captures a plethora of emergent phenomena, including odd-frequency pairing, pair density wave formation and order fractionalization. The ground-state state is a pair density wave with a fractionalized charge e, $S = 1/2$ order parameter, formed between electrons and Majorana fermions.

[1] P. Coleman, A. Panigrahi, and A. M. Tsvelik, *A solvable 3D Kondo lattice exhibiting odd-frequency pairing and order fractionalization*, Phys. Rev. Lett. **129**, 177601 (2022).