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Electron mediated magnetism in two-dimensional spin-ice JORN W. F. VENDERBOS, MARIA DAGHOFER, IFW Dresden, SANJEEV KUMAR, IISER Mohali, ZOHAR NUSSINOV, Washington University, St. Louis, JEROEN VAN DEN BRINK, IFW Dresden — In this work we study the magnetic phase diagram of classical spins which interact with itinerant electrons on a checkerboard lattice, a lattice that constitutes a two-dimensional equivalent of the three-dimensional spin-ice pyrochlore lattice. We explore both the strong coupling and weak coupling limit and find a rich ground state phase diagram as function of interaction strength and electron doping. The strong coupling limit allows for unbiased Monte Carlo simulations of the classical spins combined with exact diagonalization of the fermionic Hamiltonian. For half filling we find a very robust coplanar orthogonal spin state, the robustness of which originates from the strong geometrical frustration of the checkerboard lattice. In the weak coupling approach this double-Q spin state is a consequence of fermi-surface nesting. The electronic spectrum is this state consists of two Dirac points in full analogy with graphene. For other special electron filling fractions such as $n = p/q = 1/4, 3/4, 3/8, 5/8$, we find collinear "loop" states, where the spins order in disconnected loops of fixed length q. Interestingly, for intermediate fillings the ground state is a mixture of loops of different size, which can be captured by an emergent electromagnetic theory with fractional charge.

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