

An Inhomogeneous Phase in Quark Matter without the Sign Problem

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Recently, it was shown that the ground state of quantum chromodynamics in sufficiently strong magnetic fields and at moderate baryon densities carries a crystalline condensate of neutral pions: the chiral soliton lattice (CSL). This phase cannot be realized from first principles using standard lattice Monte Carlo simulations due to the infamous sign problem. On the other hand, we show that CSL, or a similar inhomogeneous phase, also appears in the phase diagram of a class of vector-like gauge theories that do not suffer from the sign problem even in the presence of a baryon chemical potential and external magnetic field. Hence, we give a class of explicit counterexamples to the long-standing conjecture that positivity of the determinant of the Dirac operator (that is, absence of the sign problem) in a vector-like gauge theory precludes spontaneous breaking of translational invariance, and thus implies the absence of inhomogeneous phases in the phase diagram of the theory.

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