Beitrag ID: **32** Typ: **Talk**

Renormalization Group Invariant Parametrization for Parity Doublet Model

Mittwoch, 17. September 2025 16:40 (15 Minuten)

The Parity Doublet Model is a effective theory describing nucleon and negative parity resonances associated with each other in the parity doubling framework.
We present a renormalization group invariant formulation of the model, describing baryons and their negative-parity chiral partners in dense hadronic matter. By constructing the mesonic potential in terms of fermion masses and absorbing all divergences into a single running coupling, we define a fully multiplicatively renormalizable mean-field framework.
We investigate the thermodynamics of symmetric and asymmetric nuclear matter, including the impact of fermionic vacuum fluctuations, the role of chiral invarian mass of fermions and chiral symmetry breaking. Physical parameters are fitted to hadron vacuum properties and empirical nuclear matter observables at saturation. We show that vacuum fluctuations delay and soften the chiral transition, turning it into a smooth crossover in β-equilibrated matter at densities above $7n_0$. Consequences for the QCD phase diagram and neutron star cores are discussed.

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Sitzung Einordnung: Talks