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Séminaire de Physique Nucléaire Théorique

Heavy nuclides as a liquid phase of $SU(2)_L \times SU(2)_R$ chiral perturbation theory : Emergence of semi-classical pion-less $SU(2)\chi$PT.

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Effective theories of nuclear structure must reflect the chiral global $SU(2)_L \times SU(2)_R$ symmetry of two-massless-quark QCD. Naive power counting enables perturbation/truncation in inverse powers of $\Lambda_{\chi SB} \approx 1$GeV, with analytic operators renormalized to all loop orders. We show that $SU(2)\,\chi$PT admits a "liquid" phase, with energy required to increase or decrease the density of constituents. "Semi- classical Pion-less" $SU(2)\,\chi$PT emerges in the chiral liquid, vastly simplifying the derivation of saturated nuclear matter (the infinite liquid phase) and of finite microscopic liquid drops (ground-state heavy nuclides). Static Chiral Nucleon Liquids (Static χNL) are made entirely of nucleons, have even parity ; total spin zero ; even proton number Z, and neutron number N ; and are arranged so local expectation values for spin and momenta vanish.
We derive the Static χNL effective Lagrangian, to order $\Lambda_{\chi SB}$ and $\Lambda^0_{\chi SB}$. Static χNL motivate nuclear matter, seen as non-topological solitons at zero internal and external pressure : the Nuclear Liquid Drop Model and Bethe-Weizsäcker Semi- Empirical Mass Formula emerge in an explicit Thomas-Fermi construction. For chosen nuclides, semi-classical nuclear Skyrme models are justified. We conjecture that inclusion of $\Lambda^{-1}_{\chi SB}$ and $\Lambda^{-2}_{\chi SB}$ operators will result in "natural" semi-classical Skyrme, No-Core-Shell, and non-exotic neutron star models, with approximate liquid structure.

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