From hypernuclei to neutron stars: looking for the pieces of the puzzle

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The onset of hyperons in the core of neutron stars and the consequent softening of the equation of state have been questioned for a long time. Currently there is no general agreement (even qualitative) among the predicted results for the equation of state and the maximum mass of a neutron star including hyperons. This has to be ascribed to the combination of an incomplete knowledge of the forces governing the system and to the concurrent use of approximated theoretical many-body techniques.

We give our contribution to the discussion by studying the general problem of the hyperon-nucleon interaction by means of accurate quantum Monte Carlo calculations. We show that within a phenomenological approach similar to the one adopted for the construction of the Argonne-Illinois nucleon-nucleon interaction, a repulsive three-body hyperon-nucleon force is needed to correctly describe the systematics of medium-light Λ hypernuclei [1]. A simple adjustment of the parameters of the ΛNN three-body force yields to a good agreement with available experimental data over a wide range of hypernuclear masses ($3 \leq A < 50$) [2] and for the Λ particle occupying different single particle state orbitals.

The derived potential has been successfully employed to determine the equation of state and the mass-radius relation of an infinite system of neutrons and Λ particles [3]. We find dramatic effects on the predicted maximum mass depending upon the details of the three-body hyperon-nucleon force. Our results suggest that stronger constraints on the hyperon-neutron force are necessary in order to properly assess the role of hyperons in neutron stars. A preliminary study of the isospin dependence of the three-body ΛNN interaction shows that the present experimental information do not suffice in constraining the hyperon-neutron-neutron force. A thorough experimental investigation in a wide range of systems, ranging from light to heavy hypernuclei and in particular for highly asymmetric systems, is clearly needed.

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