Neutron star structure determined by nuclear physics

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Our research is related to the classical paper of Negele and Vautherin: *Neutron star matter at sub-nuclear densities* (Nuclear Physics **A 207** (1973) 298-320).

Negele and Vautherin calculated neutron star matter using density-dependent Hartree-Fock (DDHF) equations without pairing. Their aim was the construction of a reliable theory of a nucleon many-body system derived from the two-body nucleon-nucleon interaction. They obtained numerical results for nuclear configurations at various subnuclear densities.

Since this eminent work this topic has not been considered much further. On the other hand there has been considerable progress in the development of self-consistent mean-field models for nuclear structure calculations and the treatment of pairing. These phenomenology-based models containing between 6 to 12 parameters, which are adjusted to nuclear ground-state observables, allow a quantitative description of medium, heavy, and superheavy nuclei with very high accuracy. Up to now this was the only available approach that can address very heavy nuclei.

In the our research project we intend to obtain new insights into nuclear structure physics in connection with the structure of neutron stars by employing these models, predominantly by using Hartree-Fock Bogolyubov code with Skyrme forces. Special astrophysical conditions in a neutron star will be modeled by gases of free electrons and free neutrons. The nuclei subject to these conditions can be expected to possess quite different properties compared to isolated nuclei. The effects of this environment on the shell structure and on the bulk properties of these nuclei will be studied in detail. As for the choice of boundary conditions, we can compare our results with the results obtained by Baldo and Chamel. The modeling of electron and neutron gases will be systematically improved throughout this research work.

The results thus obtained will then be processed in a calculation of the neutron star crust and yield new insights in local as well as global properties of these objects. From the astrophysical point of view, we are searching for a model for the inner crust of a neutron star modeling the transition between the neutron lattice in the Wigner-Seitz approach and the neutron Fermi liquid.