LNGS SEMINAR SERIES

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Dense matter in core-collapse supernova and neutron-star physics

The properties of dense matter and exotic nuclei are of fundamental importance in compact stars, especially in core-collapse supernovae (that represent the end point of stellar evolution for stars whose mass exceeds about 8-10 solar masses) and in neutron stars (their compact remnant). Supernova and neutron-star physics requires the knowledge both of the microphysics of nuclei and nuclear matter, and of complex hydrodynamical phenomena in hot and dense medium. Notably, the determination of the equation of state and the treatment of the electro-weak processes (beta-decay and electron-capture rates, and neutrino interactions) are among the most challenging tasks in nuclear astrophysics. These are also among the most important microscopic ingredients in compact star modelling. An accurate treatment of the microphysics, based on the latest available experimental data, is indeed essential for modelling these stellar objects, and thus for interpreting astrophysical observations.

In this talk, I will present a family of unified equations of state for neutron-star matter, based on the generalised Skyrme energy-density functionals developed by the Brussels-Montreal collaboration. The underlying functionals and the equations of state will be discussed in connection with constraints coming from both nuclear physics and astrophysics. In particular, the nuclear physics constraints include atomic masses, the analysis of experimental data from heavy-ion collisions, neutron skins in nuclei, as well as microscopic calculations. On the other hand, astrophysical observations provide valuable constraints on the high density part of the equation of state, especially neutron-star mass measurements.

I will also present weak-interaction rates (specifically, electron-capture rates) for stellar conditions, calculated within a self-consistent microscopic approach (finite-temperature Skyrme Hartree-Fock plus charge-exchange random-phase approximation approach). The results obtained using different Skyrme interactions for various stellar conditions will be presented. Some properties of collective modes (e.g. of Gamow-Teller type) will be also discussed.

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