Thermal Evolution of Compact Stars

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A collection of modern, field-theoretical equations of state is applied to the investigation of cooling properties of compact stars. These comprise neutron stars as well as hypothetical strange matter stars, made up of absolutely stable 3-flavor strange quark matter. Various uncertainties in the behavior of matter at supernuclear densities, e.g., hyperonic degrees of freedom, behavior of coupling strengths in matter, pion and meson condensation, superfluidity, transition to quark matter, absolute stability of strange quark matter, and last but not least the many-body technique itself are tested against the body of observed cooling data.

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Impact of Medium Effects on the Cooling of Non-Superfluid and Superfluid Neutron Stars

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Neutrino emission from the dense hadronic component in neutron stars is subject to strong modifications due to collective effects in the nuclear medium. We implement new estimates of the neutrino emissivities of two processes operating in the nuclear medium into numerical cooling simulations of neutron stars. The first process is the modified Urca process, for which the softening of the pion exchange mode and other polarization effects as well as the neutrino emission arising from the intermediate reaction states are taken into account. The second process concerns neutrino emission through superfluid pair breaking and formation processes. It is found that the medium effects on the emissivity of the modified Urca process result in a strong density dependence, which gives a smooth crossover from the standard to the nonstandard cooling scenario for increasing star masses. For superfluid stars, the superfluid pair breaking and formation processes accelerate mildly both the standard and the nonstandard cooling scenario. This leads to a good agreement between the theoretical cooling tracks and the rather low temperatures observed for objects like PSRs 0833-45 (Vela), 0656+14, and 0630+18 (Geminga). The robustness of our findings against variations in both the underlying equation of state of baryonic matter and the used fast cooling processes is demonstrated. Hence we conclude that the two recalculated neutrino emissivities studied here allow to reproduce theoretically most of the observed pulsar temperatures by varying the masses of neutron star models.

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Differences in the Cooling Behavior of Strange Quark Matter Stars and Neutron Stars

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The cooling behavior of hypothetical strange (quark matter) stars and neutron stars is compared. It is found that the surface temperatures of strange stars are more or less indistinguishable from those of neutron stars if both types of stars cool via the standard process. However, in the case of enhanced cooling, strange stars cool significantly more rapidly than neutron stars within the first ~ 30 years after birth. This feature could become particularly interesting if continued observation of SN 1987A would reveal the temperature of the possibly existing pulsar at its center.

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