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

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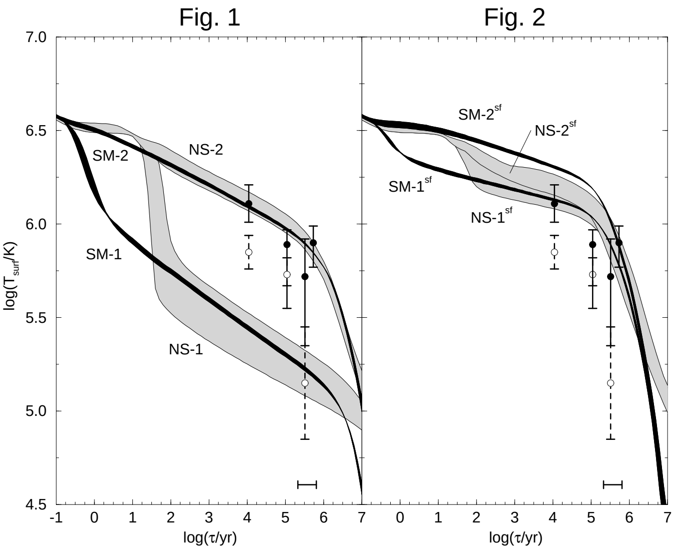
The general statement that hypothetical strange (quark matter) stars cool more rapidly than neutron stars is investigated in greater detail. The theoretical predictions are compared with the body of observed data taken by ROSAT and ASCA. In the realistic case of finite strange-quark mass m_s, the electrons can vanish above some density which depends on the value of the strong coupling constant α_c. The quark direct Urca process can therefore be forbidden not only in neutron stars but also in strange stars. We introduce two different, complementary parameter sets denoted SM-1 and SM-2, by means of which standard and enhanced cooling of strange stars, respectively, is explored. Fig. 1 shows the cooling of non-superfluid strange star models SM-1 (lower solid band) and SM-2 (upper solid band), and neutron star models which are enhanced cooling (NS-1, lower dotted band) and standard cooling (NS-2, upper dotted band). Fig. 2 is the analogue to fig. 1 but for superfluid models. All calculations are performed for a star mass of $M = 1.4 M_\odot$, about which the observed pulsar masses tend to scatter. The band-like structure of the cooling curves is supposed to reflect the uncertainties inherent in the equation of state of neutron-star and strange-star matter.

One sees from figs. 1 and 2 that, except for the first $\sim$ 30 years of the lifetime of a newly born pulsar, both neutron stars and strange stars may show more or less the *same* cooling behavior, provided both types of stars are made up of either normal matter or superfluid matter. This is made possible by the fact that both standard cooling (NS-2) as well as enhanced cooling (NS-1) in neutron stars has its counterpart in strange stars too (SM-2 and SM-1, respectively). The point of time at which the surface temperature drop of a strange star occurs depends on the thickness of the nuclear crust that may envelope the strange matter core. In the present calculation, strange stars possess the densest possible nuclear crust, which is about 0.2 km thick. Thinner crusts would lead to temperature drops at even earlier times. Figs 1 and 2 indicate that the cooling data of observed pulsars do not allow to decide about the true nature of the underlying collapsed star, that is, as to whether it is a strange star or a conventional neutron star. This could abruptly change with the observation of a very young pulsar shortly after its formation in a supernova explosion. In this case a prompt drop of the pulsar's temperature, say within the first 30 years after its formation, could offer a good signature of a strange star. This feature, provided it withstands a rigorous future analysis of the microscopic properties of quark matter, 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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Are Strange Stars Distinguishable from Neutron Stars by Their Cooling Behaviour ?

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The general statement that strange stars cool more rapidly than neutron stars is investigated in greater detail. It is found that the direct Urca process could be forbidden not only in neutron stars but also in strange stars. If so, strange stars would be slowly cooling and their surface temperatures would be more or less indistinguishable from those of slowly cooling neutron stars. The case of enhanced cooling is reinvestigated as well. It is found that strange stars cool significantly more rapidly than neutron stars within the first $\sim$ 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 centre.

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