Thermodynamical Properties of Nuclear Matter Applied to Protoneutron Stars and Gravitational Wave Emission.

Manfred Dillig[1], G. F. Marranghello[2], C. A. Z. Vasconcellos[2] and J. A. de Freitas Pacheco[3]

[1] *Institut für Theoretische Physik III, Universität Erlangen-Nürnberg, D91058, Erlangen, Germany*
[2] *Instituto de Física, Univ. Federal do Rio Grande do Sul,*
CP 15051, Porto Alegre, RS, Brazil
[3] *Observatoire de la Côte d'Azur, Nice, France.*

Thermodynamical properties of nuclear matter are studied in the framework of an effective many-body field theory at finite temperature, considering the Sommerfeld approximation [1]. We perform the calculations by using the nonlinear Boguta and Bodmer model, extended by the inclusion of the fundamental baryon octet and leptonic degrees of freedom [2]. Trapped neutrinos are also included in order to describe protoneutron star properties through the integration of the Tolman-Oppenheimer-Volkoff equations [3], from which we obtain, beyond the standard relations for the masses and radii of protoneutron stars as functions of the central density, new results of these quantities as functions of temperature. Our predictions include: the determination of an absolute value for the limiting mass of protoneutron stars; new structural aspects on the nuclear matter phase transition via the behaviour of the specific heat and, through the inclusion of quark degrees of freedom [4], the properties of a hadron-quark phase transition and hybrid protoneutron stars.
We also review the detectability of gravitational waves generated by oscillations excited during a phase transition from hadronic matter to deconfined quark-gluon matter in the core of a neutron star[5,6]. The maximum energy available to excite mechanical oscillations into the star is estimated by energy difference between the configurations with and without a quark-gluon matter core. On basis of the planned sensitivity of present laser interferometers (VIRGO or LIGO I) and those of the next generation (LIGO II), the maximum volume to be probed by these experiments is determined. These results are used as an indication of the potential detectability of neutron stars as sources of gravitational waves. Our results indicate that the maximum distance probed by the detectors of the first generation is well beyond M31, whereas the second generation detectors will probably see phase transition events at distances two times longer, but certainly not yet attaining the Virgo cluster.

References

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