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Deformation in nuclear matter: from finite nuclei to rapidly rotating neutron stars

P.S. Koliogiannis[1], **Ch.C. Moustakidis**[1]

[1]Department of Theoretical Physics, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

Abstract

Neutron stars are the densest known objects in the universe, with a specific structure, and an ideal laboratory for the strange physics of super-condensed matter. The simultaneously measurement of mass and radius of non-rotating neutron stars may impose strong constraints on the properties of the dense nuclear matter. However, the observation and study of rapidly-rotating ones, close to the mass-shedding limit, may lead to significantly further constraints. Although, theoretical predictions allow neutron stars to rotate extremely fast (even more than 2000 Hz), until this moment, the fastest observed rotating pulsar has a frequency of 716 Hz. There are many suggestions for the mechanism that leads to this situation. In any case, the theoretical study of uniformly rotating neutron stars, along with the accurate measurements, may offer rich information concerning the constraints on the high density part of the equation of state. Moreover, it is well-known that the angular velocity Ω of an isolated pulsar decreases very slowly with time. There is a special case where for some reasons the braking index exhibits a singularity which lead to increasing Ω with time. This is an interesting effect (which may be caused due to a phase transition in an interior of a pulsar). Such an anomalous decrease of the moment of inertia, although due to a different reasons, is analogous to the well known *back-bending* in the rotational bands of nuclei predicted by Mottelson and Valatin and observed years ago.

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