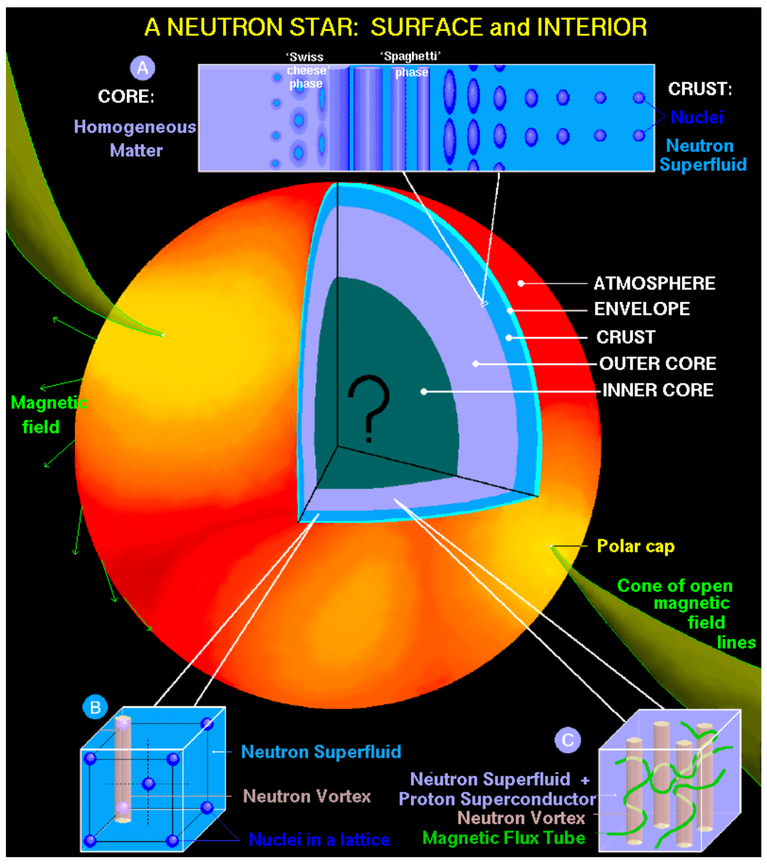
Computational Nuclear Physics

Are “free neutrons” in neutron stars free?

Although the nucleus is a microscopic object on earth, there is a gigantic nucleus in the universe, that is the neutron star (Fig.1). Near the surface of the neutron stars, a periodic crystalline structure is formed and all the protons are expected to be confined. In contrast, there are unbound neutrons which are regarded as “free”. These free neutrons play a key role in various observed phenomena, such as pulsar glitch and cooling.



We have examined properties of the “free neutrons”, with the nuclear density functional calculation. Surprisingly, at a certain density region, they are even “super-free”, which means that their mass is lighter in the neutron star than in the vacuum (Fig.2)!

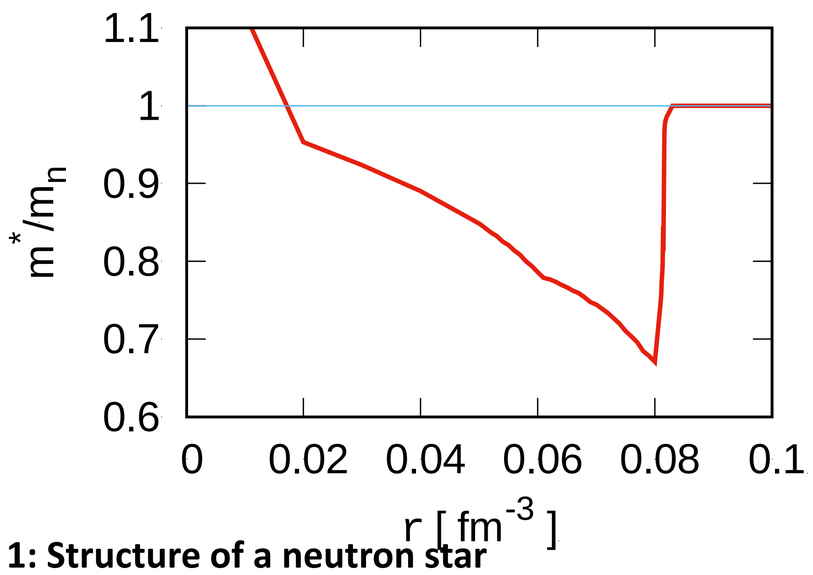


Fig. 2: Ratio of effective mass of free neutrons in the neutron-star crust (slab phase) to their bare mass.

Fig. 1: Structure of a neutron star
Courtesy of http://www.astroscu.unam.mx/neutrones/

Interactive Plot of Atomic nuclei and Computed Shapes (InPACS)

Measuring nuclear properties is very expensive using accelerators. The obtained data are precious for various technologies of human beings, thus, compiled by nuclear data centers in the world, then, open to public. We have calculated almost all kinds of nuclides in the universe, using the energy density functional theory. The computation complements missing experimental data. In order to publicize the computational nuclear data, we have opened a web site, InPACS, in which you may interactively obtain various nuclear data/information.

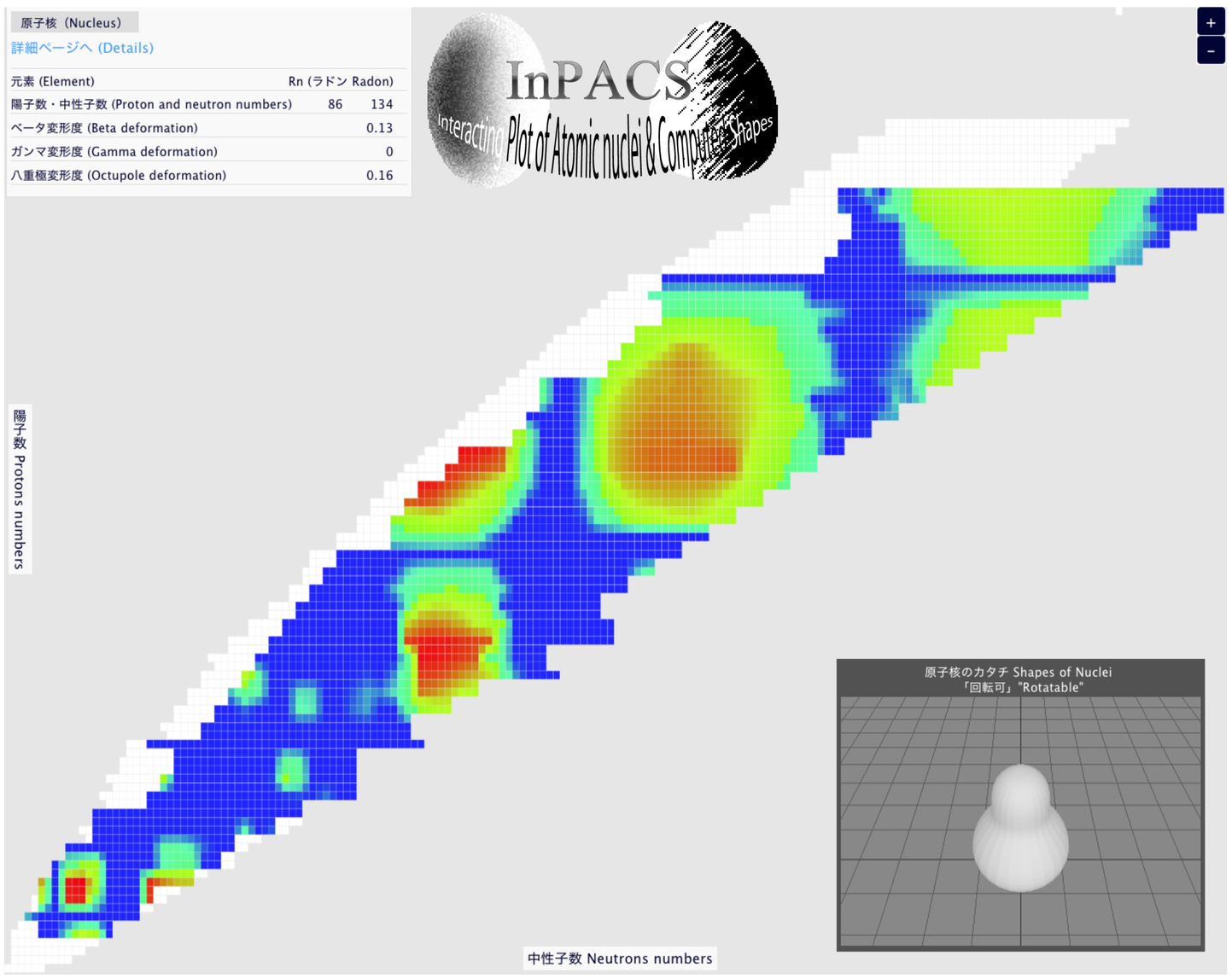


Fig. 3: Snapshot of InPACS web site.

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