Researchers suggest changes to theories regarding neutron star crust structure

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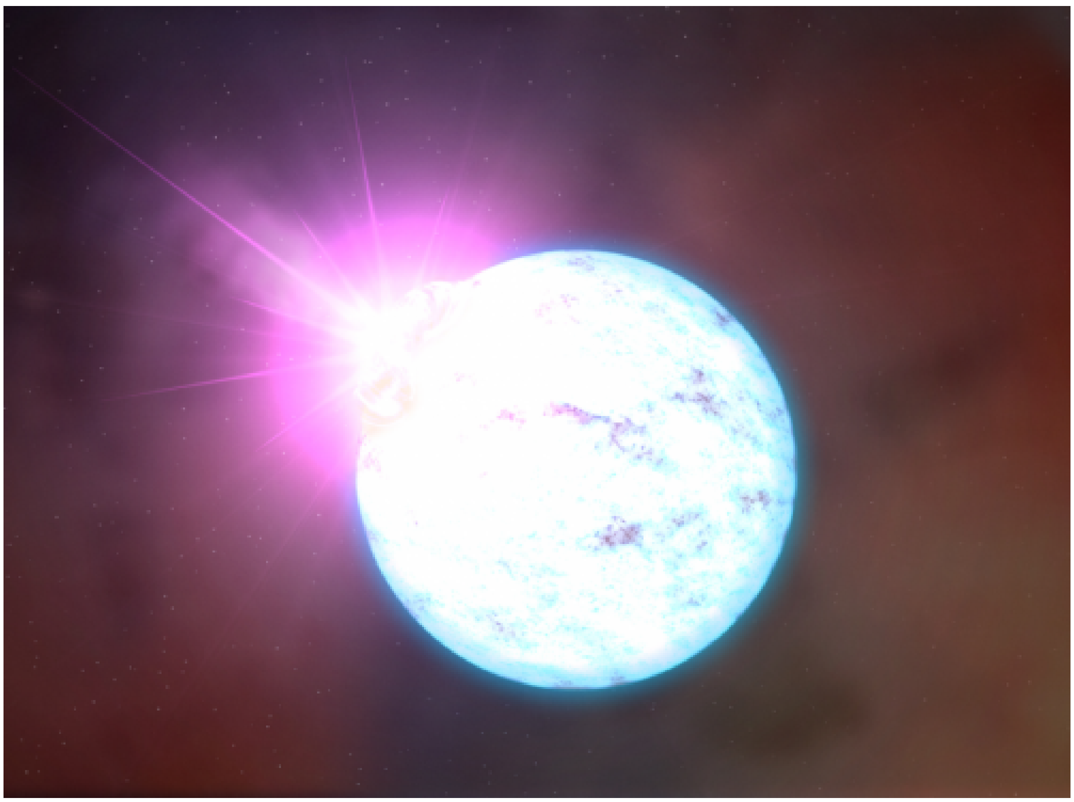

Neutron star. Credit: NASA

(Phys.org) —A pair of researchers affiliated with universities in Sweden and Denmark has published a paper in the journal *Physical Review Letters*, suggesting that current theories that describe the makeup of the crust of neutron stars need to be rethought. In their study Dmitry Kobyakov and Chris Pethick have found that if the crusts of neutron stars conformed to current thinking, they would be unstable.

Neutron stars are the remnants of supernova after collapse—though small in size, on average just 20 kilometers in diameter—they are exceedingly dense with most having a mass greater than our own sun. Researchers are interested in neutron stars because it is believed they may be the source of some gamma ray bursts and that they could also be releasing gravitational waves. To better understand such phenomena, scientists have been studying the crusts of neutron stars, which are believed to be just one to two kilometers thick, but which might hold the key to their behavior.

A neutron star's crust is believed to be made up of clumps of neutrons and protons that have been forged together by gravity, with nuclei that is believed to be neutron rich. Those neutrons in the crust that are not clumped together with protons, theorists have suggested, move freely about the crust but don't have much of an impact on the properties of the crust as a whole. In this new effort, the researchers suggest that if that were the case, the crust would be unstable, which means, they claim, that the free flowing neutrons exert far more influence than has been previously thought.

Kobyakov and Pethick propose that the free flowing neutrons and clumps can be thought of analogously to earthbound metal alloys—with neutrons and nuclei standing in for different atomic metal species. This would imply, the two suggest, that like metal alloys, the crust of a neutron star could have a number of different structural phases, each of which could have different properties.

Different properties in the crust of neutron stars could possibly help explain behavior that has been observed, such as gamma ray bursts—they could be the result of part of the crust shattering, much like some metal alloys when reaching a certain stress point. Such properties might also help explain what are known as "glitches"—where neutron stars suddenly, inexplicably begin to spin around faster. There is also the possibility that different parts of the crust with different structures could give rise to mountainous type terrain on the surface, which some have suggested might be related to the emission of gravitational waves.

More information: Towards a Metallurgy of Neutron Star Crusts, Phys. Rev. Lett. 112, 112504. journals.aps.org/prl/abstract/ … ysRevLett.112.112504

ABSTRACT
In the standard picture of the crust of a neutron star, matter there is simple: a body-centered-cubic lattice of nuclei immersed in an essentially uniform electron gas. We show that, at densities above that for neutron drip (~4×1011 g cm−3 or roughly one-thousandth of nuclear matter density), the interstitial neutrons give rise to an attractive interaction between nuclei that renders the lattice unstable. We argue that the likely equilibrium structure is similar to that in displacive ferroelectric materials such as BaTiO3. As a consequence, the properties of matter in the inner crust are expected to be much richer than previously appreciated, and we mention possible consequences for observable neutron star properties.