Superfluid hydrodynamics in the inner crust of neutron stars

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The inner crust of neutron stars is supposed to be inhomogeneous and composed of dense structures (clusters) that are immersed in a dilute gas of unbound neutrons. Here we consider spherical clusters forming a BCC crystal and cylindrical rods arranged in a hexagonal lattice. We study the relative motion of these dense structures and the neutron gas using superfluid hydrodynamics. Within this approach, which relies on the assumption that Cooper pairs are small compared to the crystalline structures, we find that the entrainment of neutrons by the clusters is very weak since neutrons of the gas can flow through the clusters. Consequently, we obtain a low effective mass of the clusters and a superfluid density that is even higher than the density of unbound neutrons. Consequences for the constraints from glitch observations are discussed.

References

[1] N. Martin & M. Urban, Phys. Rev. C 94, 065801 (2016)

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