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Proximity effect of pair correlation in the inner crust of neutron stars

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We study proximity effect of neutron superfluid in the inner crust of neutron stars by solving the Hartree-Fock-Bogoliubov equation in a spherical Wigner-Seitz (WS) cell. Numerical analysis shows that the presence of nuclei affects the pair correlation of neutron superfluid in proximity region, which is characterized by the coherence length measured from the edge of the nuclei. We use the functional SLy4 and density-depend delta interaction as the pairing force, which is designed to reproduce a realistic pairing gap in low-density neutron matter, i.e. Gor'kov's gap at low density limit and Ab-initio gap at $\rho_n \sim 10^{-3}\,\mathrm{fm}^{-3}$, as well as the average neutron gap of $^{120}\mathrm{Sn}$. The length of proximity effect is smaller than the site of WS cell. It reflects short coherence length of dilute neutron superfluid, where the strong-coupling pairing close to the BCS-BEC crossover is realized. At the densities $\rho_{n,\mathrm{ext}} \approx 4 \times 10^{-5}\,\mathrm{fm}^{-3}$ and $\rho_{n,\mathrm{ext}} \approx 4.4 \times 10^{-2}\,\mathrm{fm}^{-3}$, the length of proximity effect is same or longer than the site of WS cell. In this case, external neutron pair density is different from uniform neutron matter.

Field of your work

Theoretical nuclear physics

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