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(G*) Superfluid neutrons: from particles to matter

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Superfluid neutron matter is a key ingredient in the composition of neutron stars. The physics of the inner crust is largely dependent on that of its S-wave neutron superfluid which has been connected to pulsar glitches and modifications on the neutron star cooling. An accurate description of these effects calls for a model-independent treatment of neutron superfluidity. Ab initio techniques developed for finite systems can be guided to extrapolate to the thermodynamic limit and attain this model-independent extraction of various quantities of infinite superfluid neutron matter. To develop a well-informed extrapolation prescription, we calculated the neutron $^1S_0$ pairing gap using the model-independent odd-even staggering in the context of the particle-conserving, projected Bardeen-Cooper-Schrieffer theory under twisted boundary conditions. While the practice of twisted boundary conditions is standard in solid state physics, and has been used repeatedly in the past to reduce finite-size effects, this is the first time it is employed in the context of pairing. We find that a twist-averaging substantially reduces the finite-size effects, bringing systems with $N > 50$ within a 2% error margin from the infinite system. This can significantly reduce extrapolation-related errors in the extraction of superfluid neutron matter quantities.

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