Fermions with long and finite-range interactions on a quantum ring

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Idealized systems are commonly used in nuclear physics and condensed matter. For instance, the construction of nuclear energy density functionals involves properties of infinite matter, whereas neutron drops are used to test nuclear interactions and approximations to the nuclear many-body problem. In condensed matter, quantum rings are also used to study properties of electron systems. We recently investigated the possibility to use quantum rings with systems of nucleons including many-body correlations [1]. A quantum ring model of a finite number of same spin fermions is developed. Several attractive and repulsive interactions with finite and infinite ranges are considered. Quantum Monte Carlo calculations are used to provide exact ground-state energies. Comparisons with analytical Hartree-Fock solutions are used to get an insight into the role of correlations. Hartree-Fock results with no breaking of space translational symmetry are able to describe many systems. However, additional spatial correlations are required in the case of dense systems with a strong short-range repulsion or with attractive interactions in large rings. We conclude that self-bound systems of fermions with spatial correlations produced by basic features of the nuclear interactions can be described on a quantum ring, encouraging applications with realistic interactions, as well as investigations with higher-dimensional geometries, such as spherium.

[1] A. Bray, C. Simenel, Phys. Rev. C **103**, 014302 (2021).