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Fermionic versus bosonic behavior of confined Wigner molecules

We assess whether a confined Wigner molecule constituted by 2N fermions behaves as N bosons or 2N fermions. Following the work by Law [Phys. Rev. A 71, 034306 (2005)] and Chudzicki et al. [Phys. Rev. Lett. 104, 070402 (2010)] we discuss the physical meaning and the reason why a large amount of entanglement is needed in order to ensure a bosonic composite behavior. By applying a composite boson ansatz, we found that a Wigner molecule confined in a two-dimensional trap presents a bosonic behavior induced by symmetry. The two-particle Wigner molecule ground state required by the composite boson ansatz was obtained within the harmonic approximation in the strong interacting regime. Our approach allows us to address few-particle states (widely studied within a variety of theoretical and numerical techniques) as well as a large number of particles (difficult to address due to computational costs). For a large number of particles, we found strong fermionic correlations exposed by the suppression of particle fluctuations. For a small number of particles, we show that the wave function calculated within the composite boson ansatz captures the Friedel-Wigner transition. The latter is shown in a regime in which strong correlations due to the Pauli exclusion principle arise; therefore, we conclude that the coboson ansatz reproduces the many-particle physics of a confined Wigner molecule, even in the presence of strong deviations of the ideal bosonic behavior due to fermionic correlations.

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