Finite Bose-Fermi droplets – hydrodynamical versus atomic-orbitals analysis

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In this comment we show the results of an atomic-orbital (Hartree-Fock) method used to obtain the densities of a Bose-Fermi droplet consisting of a small number of fermions, see Fig. 1. These new results are compared to the results we already demonstrated in the main text, which were achieved within the hydrodynamic description of the Bose-Fermi mixture. The atomic-orbital approach has been used by us previously to study dynamics of Bose-Fermi solitons in quasi-one-dimensional mixtures [1, 2] (observation of trains of Bose-Fermi solitons were reported recently in [3]) as well as fermionic mixtures, in particular in the context of a formation of Cooper pairs [4].

Densities plotted in Fig. 1 were obtained by using a time-dependent version of the Hartree-Fock method. We start with a noninteracting system consisting of N_F fermions and N_B bosons confined in a harmonic trap, i.e. $a_{BF} = 0$. Then we adiabatically turn on the boson-fermion interaction and we propagate in time the set of coupled N_F Schrödinger-like equations for fermionic orbitals and bosonic wavefunction. In duration of $3 \times 10^5\ m_B a_B^2/\hbar$ the interaction strength is changed from zero to $a_{BF} = -3a_B$. After that the harmonic trap is slowly removed within time interval equal to $5 \times 10^5\ m_B a_B^2/\hbar$. Finally, we observe the droplet for the further period of $5 \times 10^5\ m_B a_B^2/\hbar$. The densities are stable and shown in Fig. 1. Already for as small as tens of fermions atomic-orbital and hydrodynamic descriptions give very similar results.

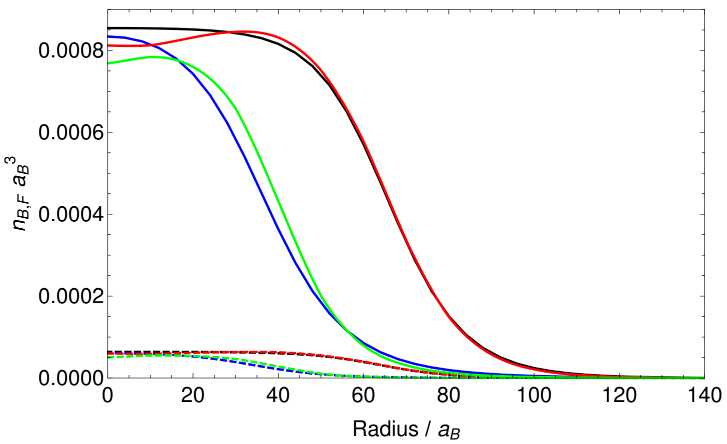

FIG. 1: Radial densities of bosonic (solid lines) and fermionic (dashed lines) components for two Bose-Fermi droplets. Blue (hydrodynamical approach) and green (atomic-orbital method) colors correspond to the droplet consisting of 35 fermions and 350 bosons whereas colors black and red describe the case for 120 fermions and 1250 bosons. In both cases $a_{BF} = -3a_B$.

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[2] T. Karpiuk, M. Brewczyk, and K. Rzążewski, Bright solitons in Bose-Fermi mixtures, Phys. Rev. A **73**, 053602 (2006), doi:10.1103/PhysRevA.73.053602.

[3] B. J. DeSalvo, K. Patel, G. Cai, and C. Chin, Fermion-Mediated Interactions Between Bosonic Atoms, arXiv:1808.07856.

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