The Fermionic Tonks-Girardeau gas: composite boson formation and a novel formulation of the ground state wave function

Francesc Sabater
Abel Rojo-Francàs, Grigori E. Astrakharchik, Bruno Juliá-Díaz

Departament de Física Quàntica i Astrofísica, Facultat de Física, Universitat de Barcelona, E-08028 Barcelona, Spain

francescsabater11@gmail.com

Attractive p-wave one-dimensional fermions are studied in the fermionic Tonks-Girardeau regime in which the diagonal properties are shared with those of an ideal Bose gas. We study the off-diagonal properties and present analytical expressions for the eigenvalues of the one-body density matrix. One striking aspect is the universality of the occupation numbers which are independent of the specific shape of the external potential [1]. We show that the occupation of natural orbitals occurs in pairs, indicating the formation of composite bosons, each consisting of two attractive fermions. The formation of composite bosons sheds light on the pairing mechanism of the system orbitals, yielding a total density equal to that of a Bose-Einstein condensate [2]. Additionally, we propose an alternative form of the Fermionic Tonks-Girardeau ground state.

References

[1] P. Kóscik and T. Sowínski, Phys. Rev. Lett. 130, 253401 (2023)
[2] Sabater, F., Rojo-Francàs, A., Astrakharchik, G. E., & Juliá-Díaz, B. (2023) arXiv preprint arXiv:2309.03606 (Accepted in Phys. Rev. Lett)

Figures

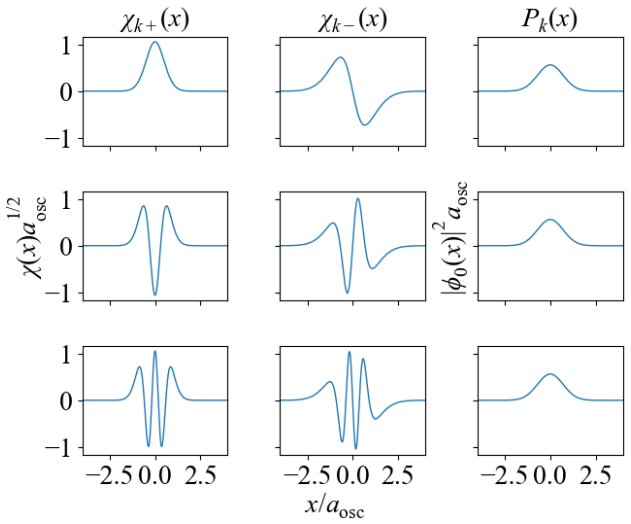

Figure 1: Fermionic natural orbitals and composite boson density profile in a harmonic trap potential for an even number of particles. First and second columns, the first six natural orbitals, $\chi_k+(x)$ and $\chi_k-(x)$, respectively, corresponding to the three largest doubly degenerate eigenvalues k =1,2,3 of the OBDM. Third column, the first three composite boson density profiles $P_k(x)$.