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Three-dimensional non-approximate Coulomb-like interaction between two trapped quantum particles

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Introducción

Two ultracold atoms interacting in a harmonic trap can be analytically solved in various ways by making different approximations: considering a punctual interaction given by a regularized δ-function [1] or a finite-range soft-core potential in one dimension [2]. In this work, this problem is generalized to 3-dimensions and the exact Coulomb potential is used. The system is solved by expanding the wavefunction into isotropic harmonic oscillator eigenfunctions and Hydrogen atom eigenfunctions independently, showing that each one result in a prime approximation for different domains of the normalized coupling constant γ of the relative interactions, suggesting that the combination of the basis is enough to build a well-suited base for the non-approximate problem. The results are compared to the work of Kościk and Sowiński [2] who used a finite-rage soft-core interaction model of the problem to give insights into the many-body states of strongly correlated ultracold bosons and fermions. We conclude that the 3-dimensional approach we propose facilitates the distinction between bosons and fermions while the solutions given by the expansions better define the behavior of the particles for repulsive potentials $0 \leq \gamma$. In addition, we discuss the substantial differences from our work and the previous approximate model.

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References

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