Exploring Spin-Mixing Dynamics in Bosonic Systems Beyond the Mean-Field Approximation

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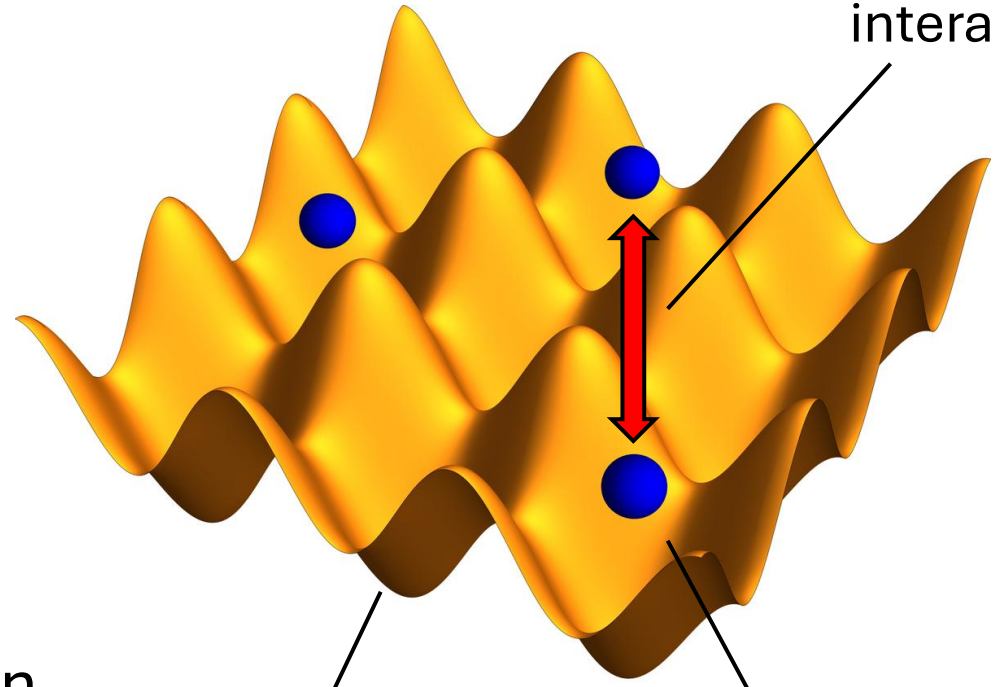
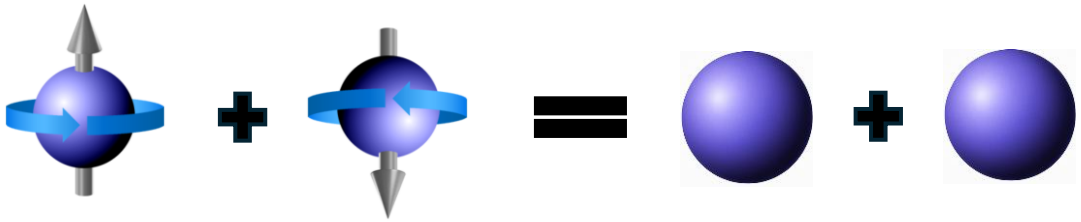
What Is the Blume Research Group?

- Our research is in the field of atomic, molecular, and optical (AMO) physics
- AMO is broadly the study of basic quantum properties of matter & light
- Much of our work focuses on transition from few- to many-body cold atom systems



My Project - Background

- Interested in spin-mixing dynamics of cold bosonic systems



Three possible spin-states, $m_F = -1,0,1$

- Has been investigated using mean-field theory (Guan et al. 2025), which uses optimal "average orbitals":

$$\Psi_{MF} = \Phi_{opt,-1}(z_{-1})\Phi_{opt,0}(z_0)\Phi_{opt,1}(z_1)$$

- Mean-field models don't capture important physics such as quantum correlations, fluctuations, or entanglement:

$$\Psi_{Exact} = \Psi(z_{-1,1}, \dots, z_{-1,N_{-1}}, z_{0,1}, \dots, z_{0,N_0}, z_{1,1}, \dots, z_{1,N_1})$$

My Project - Goals

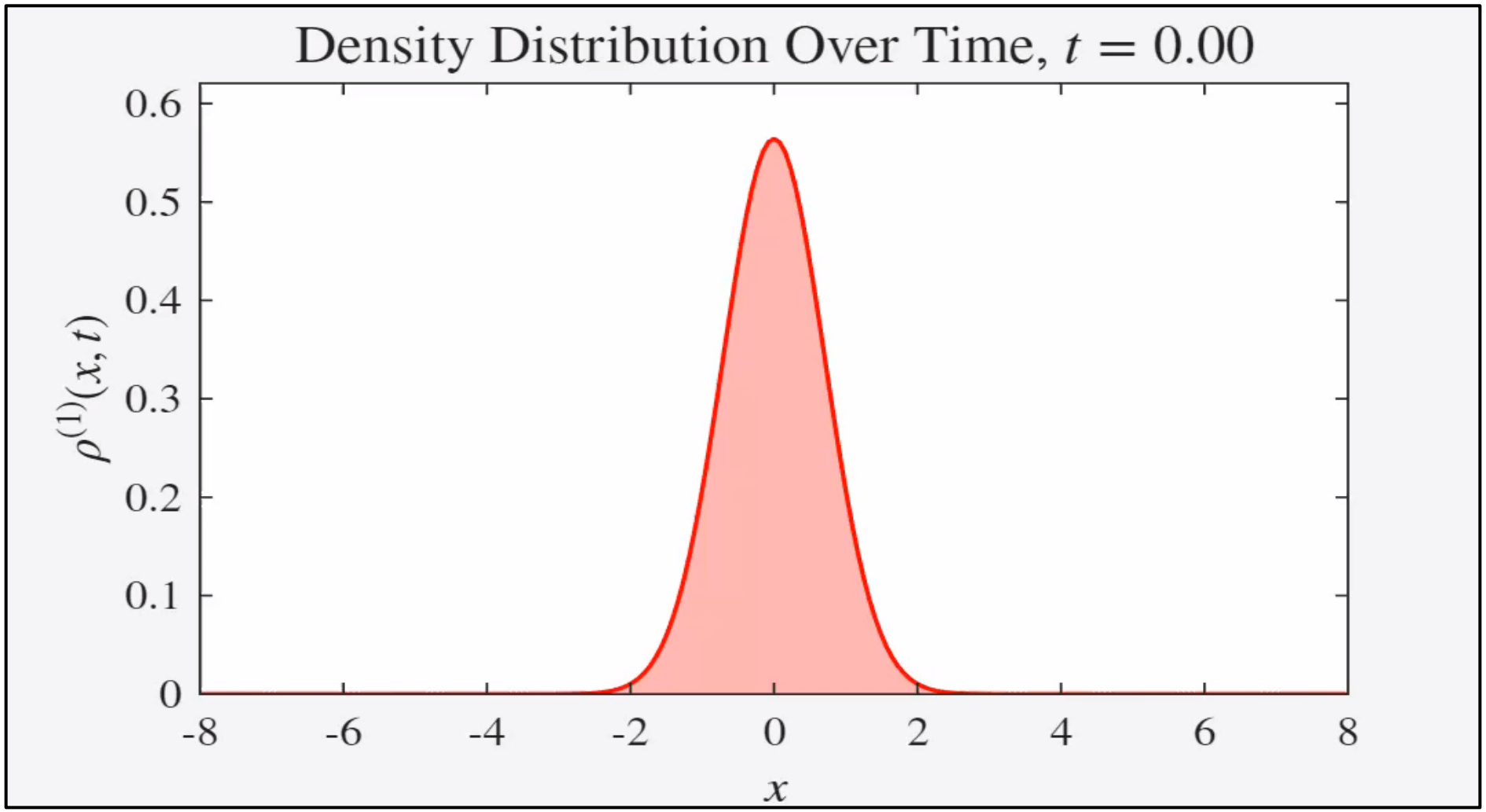
- Will investigate an analogous few-body system numerically using exact diagonalization

$$(N_{-1}, N_0, N_1) = (0,6,0)$$
$$= (1,4,1)$$
$$= (2,2,2)$$
$$= (3,0,3)$$

- Will extend a previously-written program to allow particles to change spin states

- Once completed, this code will allow the exploration of many interesting quantum phenomena!

My Project – Preliminary Results



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