Undergraduate Research Experience Opportunity

In nature, there are two kinds of elementary particles, bosons and fermions. Identical bosons can occupy the same quantum state, whereas fermions obey the Pauli exclusion principle and no two identical fermions can occupy the same quantum state.

As a result, in the ultracold temperature regime, bosons and fermions behave very differently. In 1D, remarkably, the distinction between bosons and fermions are not unbreakable but with some mystery to be unveiled. Now consider a system of strongly interacting bosons confined in a trap. If the trapping potential is suddenly switched off, the atomic cloud will expand. It was recently discovered theoretically that, in the long time limit, the momentum distribution of the expanded boson cloud will resemble that of the fermions in equilibrium. This is called the "dynamical fermionization". In the past couple of years, we have developed a rather general theoretical framework that allows us to investigate "dynamical fermionization" for strongly interacting atoms with spin degrees of freedom.

We plan to recruit a motivated undergraduate student to work on this project. The detailed project will be tailored to the capability of the student. This research involves both analytical and numerical calculations. The students should have some experiences with numerical simulation (with Matlab, Python, etc.). The analytical component requires a background in quantum mechanics.

From this project, the student will receive a **broad training in advanced analytic and numerical techniques**, which include:

- basic methods to solve quantum mechanical problems, such as Exact Diagonalization, Perturbation Theory, etc.
- advanced methods such as Generalized Gibbs Ensemble, Bose-Fermi Mapping
- advanced analytical and numerical techniques for 1D quantum many-body physics, such as Matrix Product State, Bosonization, Bethe Ansatz.

This project will be part of the SCI-STAR program (sci.rice.edu/sci-star) and a summer stipend will be provided.

If interested, please contact Li Yang (Physics & Astronomy) ly15@rice.edu.