Inter-Component Correlations in One-Dimensional Mass-Imbalanced Ultra-Cold Few-Fermion Mixtures

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With recent experiments on several particles confined in one-dimensional optical traps (fermions as well as bosons), quantum engineering has entered a completely new, so far unexplored, area of strongly correlated quantum systems. In these extremely sophisticated experiments, it is possible to control the total number of particles, their mutual interactions, and the shape of external potential with very high accuracies. Apart from a few exceptions, it has commonly been assumed that particles of different kinds have the same mass and the main impact on properties of the system comes from an imbalance of the number of particles.

In my talk, I will discuss the ground-state properties of two-component mixtures of a few fermions of different masses. I will show that in the regime of strong repulsions, independently on the number of particles, a mass difference between fermionic species induces a specific spatial separation in one of the component. Depending on the shape of the external confinement, spatial separation is present in heavier or in the lighter component. Consequently, the ground-state of the system undergoes a specific transition between different orderings when the confinement is changed adiabatically.

In the case of attractive interactions, the mass imbalance also strongly influences the properties of the system. Namely, when the mass ratio is large enough, the many-body ground state of the system changes its structure and it can be viewed as an almost perfect product of the non-interacting ground state of the heavier component and some well-defined state of the lighter particles. In a consequence, inter-component correlations are strongly suppressed and they are almost insensitive to the strength of attractive mutual interactions.

References