Ultracold Fermi atom condensates: effects of disorder and imbalance in 1D

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Control of dimensionality of quantum degenerate matter has been made possible by the progress of cold atom experiments. The spatial disorder and the interactions can also be controlled with unprecedented precision. This is an ideal setting for the study of novel phases of quantum matter and quantum phase transitions. Introduction of a multichromatic potential [1] to a system of 2D array of 1D Fermi gases [2] would allow the study of the effect of disorder on fermionic superfluidity. While quantum fluctuations suppress the true long-range pairing order in 1D, superfluidity in a finite-size system is possible.

The density-matrix renormalization group (DMRG) method allows us to obtain the ground state of the disordered 1D Fermi gas with short-ranged interactions with high precision. We have studied a 1D Fermi gas with attractive short-ranged interactions in a multichromatic potential [3]. We have identified a region of parameters where the disorder enhances pairing. When the disorder is further increased, global superfluidity eventually breaks down. The separation between the disorder strengths at superfluidity breakdown and the insulating transition suggests that the intermediate phase is characterized by strong pairing without quasi long-range order.

An FFLO-type phase has been predicted to be realized in harmonically trapped 1D system of population-imbalanced Fermi gases without disorder [4]. We also present our results on the effects of disorder and harmonic trap in the population-imbalanced case.

References

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