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SEMINAR

Bridging Few- And Many-Body Physics in Fermi Gases

by

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Time: 10:00 - 11:00 a.m.
Join ZOOM Meeting: https://qrgo.page.link/je2YZ

ALL INTERESTED ARE WELCOME
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Abstract

The strongly interacting Fermi gas with large scattering lengths constitutes a paradigmatic model system that is relevant to atomic, condensed matter, nuclear and particle physics. Such a model applies to the core of nuclei, the crust of a neutron star, and the highly controllable ultracold atoms with tunable scattering lengths. Whereas it is challenging to theoretically tackle strongly interacting Fermi gases, the virial expansion serves as a powerful tool to bridge few- and many-body physics. With the help of Richard Feynman's path integral, we used classical computers to quantum simulate few-body systems and obtained the viral coefficients for many-body systems. In particular, I will discuss how to extract the so-called contact, the central quantity controlling dilute quantum systems, using the virial expansion. I will also discuss how to use contact to explore polaron physics in the highly spin-imbalanced unitary Fermi gas. The contact for polarons is verified experimentally by MIT using radiofrequency spectroscopy.

Including multiple flavors in interacting Fermi gases provides physicists with an even richer playground. Using exact solutions in 1D systems, Prof. C.N. Yang predicted that a SU(N) Fermi gas, which has isotropic interactions between different flavors, will bosonize as N increases at zero temperature. That is, thermodynamic observables of the SU(N) Fermi gas will approach that of a spinless Bose gas. However, due to the lack of exact solutions, bosonization of SU(N) Fermi gases in higher dimensions had not been studied in theory or experiments. In a recent collaboration with Prof. Gyu-Boong Jo's group at HKUST, we have theoretically predicted and experimentally verified that the contact of a 3D SU(N) Fermi gas approaches spinless bosons via a particular scaling law at finite temperatures. This provides the community a rigorous proof of the bosonization of 3D SU(N) fermions for the first time and also opens the door to a new framework of manipulating quantum statistics in many-body systems.

[1] Phys. Rev. A 88, 023616 (2013)
[2] Phys. Rev. Lett. 116, 230401 (2016)
[3] Phys. Rev. X 10, 041053 (2020)

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