

RESEARCH INTERESTS

Summary of Research Accomplishments

My research in the past twenty years has focused on superfluidity and superconductivity, beginning with high temperature superconductors but with a current primary focus on ultracold Fermi gases.

In collaboration with my coworkers, I have previously developed a pairing fluctuation theory for the pseudogap physics in high T_c superconductors [Phys. Rev. Lett. 81, 4708 (1998), cited over 160 times]. This theory naturally interpolates between the BCS and BEC limits, and extends the mean-field BCS theory to short coherence length superconductors in a natural way so that finite-momentum pairing fluctuations play a progressively more important role as the pairing strength increases. It has been successful in addressing many high T_c experiments, including, among others, the cuprate phase diagram and the highly unusual quasi-universal behavior of the superfluid density as a function of temperature and hole doping concentration.

Since 2005, I have extended our pairing fluctuation theory and applied it to trapped atomic Fermi gases. I have made great progress in this area. We are the first that have introduced the concept of pseudogap into the field of atomic Fermi gases. We have successfully addressed the pairing gap in cold Fermi gas superfluids, the density profiles in a trap, the thermodynamic behavior in the strongly interacting regime, the phase diagrams with and without population imbalance, the collective mode behavior, theory on rf spectroscopy, Fermi-Fermi mixtures, Fulde-Ferrel-Larkin-Ovchinnikov physics, etc.

I have published more than 70 papers over my career, with a total SCI citation over 2200, and an H-index of 24. Since 2005, I have co-authored 6 review articles, written 1 Science paper, 9 Physical Review Letters, 14 Physical Review Rapid Communications, and 17 Physical Review regular articles. Among them, the Science paper in collaboration with the Thomas group has been cited as one of several ground-breaking works in the field of ultracold Fermi gases. The Physics Reports article has been the first review in the field of ultracold Fermi gases.

Current Research Interests

My primary focus is on the physics of superfluidity and related phenomena in ultracold atomic Fermi gases, while I am also interested in other areas outlined below.

1. Ultracold atomic Fermi gases, optical lattices and quantum simulation

Superfluidity in ultracold atomic Fermi gases is one of the most exciting research areas in condensed matter and atomic physics in recent years. Via Feshbach resonances, one can tune the attractive interaction between fermionic atoms from very weak to very strong. This makes it possible to observe Bose-Einstein condensation (BEC) in quantum degenerate Fermi gases directly over the entire range of the BCS-BEC crossover. Furthermore, this has created a strong hope that these systems may help us understand high T_c superconductivity. Besides interaction strength, there have now been a collection of many other tunable parameters, including population imbalance, geometric ratio or dimensionality, mass imbalance, pairing symmetry, optical lattices and lattice depth,

lattice geometry, synthetic gauge field, spin-orbit coupling, etc. This brings us an opportunity to simulate existing and engineer new and exotic quantum systems, with very rich physics to explore.

This is the main focus of my group.

2. Strongly correlated electrons

This involves mainly superconductivity in the cuprates, Fe-based superconductors, and heavy fermion systems. These systems call for new theories beyond the Landau Fermi liquid picture, which has been a foundation for modern solid state physics.

3. Topological insulators and topological superconductors

Topological insulators have become a very hot field over the past decade. Especially, topological superconductors have to do with Majorana fermion and quantum computing. One may use optical lattices to study topological insulators.