# Production and study of two-dimensional superfluid Fermi gases

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One of the most puzzling and still unsolved problems in condensed matter physics is, beyond any doubt, the existence of materials that exhibit a superconducting behavior at high temperature, namely, the high-Tc superconductors [1]. The physical gears behind this phenomenon are in fact still under debate. Three main ingredients are expected to play an important role in this physics: the dimensionality of the system, the many-body interaction between pair of electrons and the presence of disorder. In fact high-Tc superconductors are essentially two-dimensional structures in which fermions are coupled into tight pairs, whose extension is largely reduced with respect to the one of standard superconductors. Due to the anomalously high critical temperatures, the role of fluctuations is also relevant, meaning that the inter-fermion attraction is presumably stronger than in conventional systems [2]. The presence of disorder, unavoidable in real systems, adds another degree of freedom that must be taken into account. Disorder acts typically against superfluidity, trying to localize electrons via the Anderson localization phenomenon [3]. However, in particular regimes, superfluidity can survive the disorder. The SIT (Superfluid-to-Insulator Transition), superfluidity competing disorder, is a quantum phase transition at the basis of the behavior of “granular” superconductors: despite of the great interest is still under debate in the microscopic underlying mechanisms [4].

In this context, ultracold Fermi gases composed by atoms appear as an ideal test-bed to investigate this kind of phenomena thanks to its extraordinary versatility and control [5]. The basic idea is to mimic the physics of strongly correlated systems of fermions, leaving out most of the complications peculiar to the solid-state physics and studying this way the heart of the problem. In ultra-cold atoms experiment is in fact possible to finely tune the physical parameters, starting from the interaction strength between the atoms via Fano-Feshbach resonances, the dimensionality, and the presence of arbitrary optical potentials (such as disorder) realized by laser light.

We are proposing to use ultracold Fermi gases of fermionic Lithium-6 atoms to study superfluidity and strong correlation effects in two-dimensions. In particular, my project aims at studying fermionic superfluidity at different interactions strength also in the presence of random potentials, tackling the still open and fundamental question about the robustness of superfluidity in disordered systems.

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