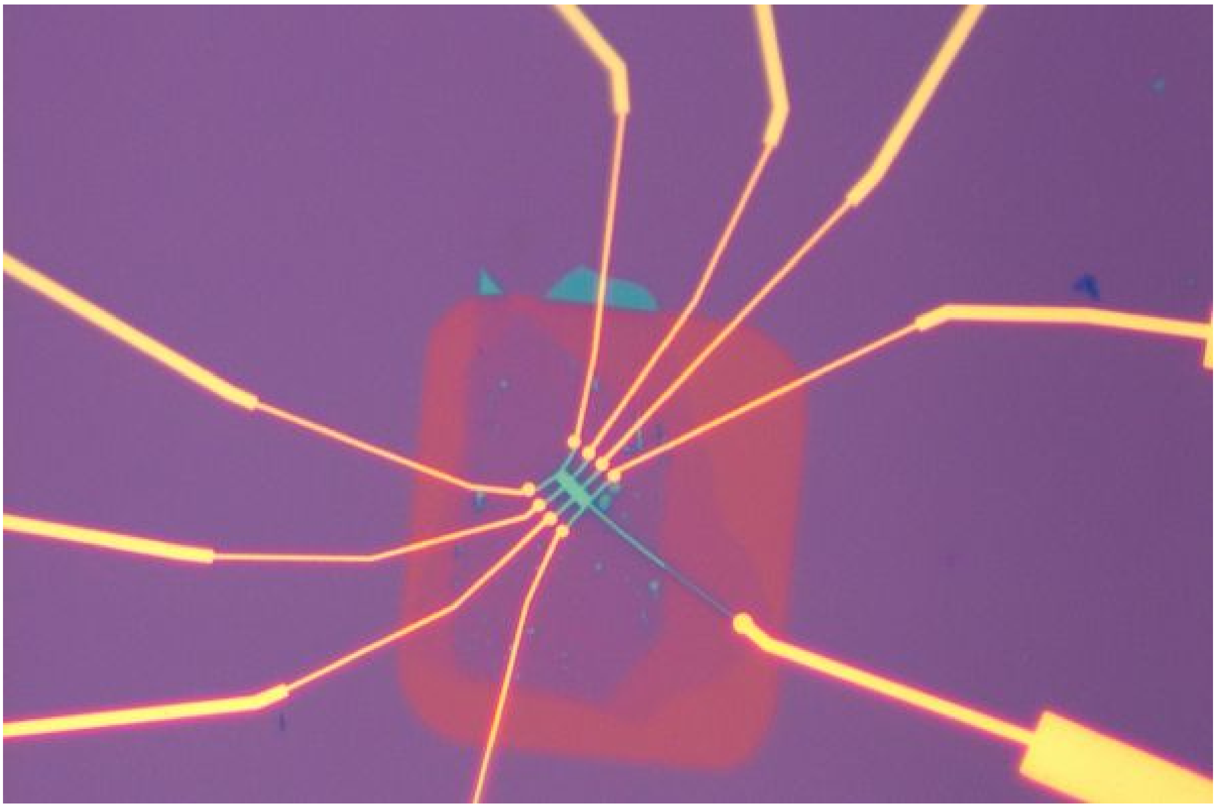

Revealing the strange metallic behaviour of twisted bilayer graphene

An international team of researchers from ICFO, MIT and NIMS report in Nature Physics that the metallic ground state of magic-angle twisted bilayer graphene can be electrostatically tuned from a conventional Fermi liquid behavior to a ?strange' metal in the vicinity of the superconducting dome down to the lowest temperatures.

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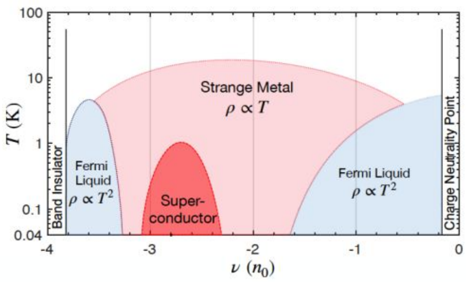
Magic-angle twisted bilayer graphene hosts a rich panel of correlated electronic states, among which superconductors, magnets and insulators have been observed. All these phases emerge within a metallic background, which was shown to display both an unusual ?strange'-metal behavior and an enhanced electron-phonon coupling. Nevertheless, the microscopic mechanism driving this metallic regime down to the lowest temperatures could not be unequivocally pinpointed as per the aforementioned abundance of low temperature phase transitions.

In a recent study, published in Nature Physics, ICFO researchers Alexandre Jaoui (former postdoc at ICFO), Ipsita Das, Giorgio Di Battista, Jaime Diez-Merida and Xiaobo Lu (former postdoc at ICFO), led by ICFO Prof. Dmitri K. Efetov and colleagues from MIT (Hiroaki Ishizuka & Leonid Levitov) and the National Institute for Material Sciences (Kenji Watanabe & Takashi Taniguchi) conducted transport measurements on a gate-screened magic-angle device designed to suppress the insulating states obscuring the metallic phase. They revealed that the metallic ground state of magic-angle twisted bilayer graphene can be electrostatically tuned from a conventional Fermi liquid behavior to a ?strange' metal in the vicinity of the superconducting dome down to the lowest temperatures. In the latter state, electrons are scattered at an ultra-fast rate which is observed across the various families of strongly correlated metals.

The existence of this ultra-fast scattering of electrons at an apparently universal rate, surviving down to the lowest temperatures in a finite Fermi temperature system, points to the existence of scattering centers of electrons distinct from phonons. Rather, this behavior is characteristic of an interplay with quantum fluctuations associated with a quantum-critical phase transition. Contrary to classical phase transitions, ruled by thermal disorder, such a zero-temperature phase transition systems directly from Heisenberg's uncertainty principle. The associated T=0 critical point is not a theoretical abstraction; it acts as a ?black hole' which distorts the finite temperatures phase diagram of the system and from which the ?strange-metal' phase emerges. Fascinatingly, these ?strange-metal' states are found across the di?erent families of unconventional superconductors and the intricate relationship between quantum fluctuations and unconventional superconductivity is a major conundrum of modern condensed matter physics. Finally, the ICFO researchers and coworkers showed that, in devices twisted away from the magic-angle which show no superconducting phase, the strange-metal regime is suppressed at low temperature and a Fermi liquid behavior is recovered across the electronic flat band.

The results presented in this study call for further experimental and theoretical investigations to unravel the microscopic nature of the fluctuations driving the metallic ground state of magic-angle graphene. In addition, this study establishes this system as an unprecedented playground to study the interplay between strange metallicity and unconventional superconductivity because of its manyfold tunability.



Schematic representation of the (?,T) phase diagram of hole-doped MATBG. The superconducting dome (SC) is enclosed in a strange metal region (SM), which is dominated by quantum fluctuations