VESTIGIAL PHASES IN MULTICOMPONENT SUPERCONDUCTORS: FIRST EXPERIMENTAL SIGNATURES OF A FERMION QUADRUPLING CONDENSATE THAT BREAKS TIME-REVERSAL SYMMETRY

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Superconductivity arises as a consequence of the formation and condensation of electron pairs. However, multi-component systems may exhibit a different kind of order associated with the condensation of electron quadruplets even above the superconducting critical temperature.

In this talk, I will present the first experimental observation, in the iron arsenide Ba_{1−x}K_xFe2As2, of a fermion-quadrupling condensate that spontaneously breaks time-reversal symmetry [1]. From a theoretical standpoint, this is a beyond mean-field state whose onset is driven by the proliferation of topological phase excitations. Studying the interplay between the different topological defects at play is a highly nontrivial problem that can be addressed via Monte Carlo simulations. In the second part of my talk, I will discuss the emergence of this phase within a London model for s+ is superconductors as a function of different intercomponent couplings [2]. Finally, I will briefly discuss the case of magic-angle twisted bilayer graphene, whose low-energy effective model has revealed a beyond-mean field phase diagram with a substantial fermion-quadrupling state for all the values of the parameters considered [3].

[1] V. Grinenko et al., ”State with spontaneously broken time-reversal symmetry above the superconducting phase transition”, Nature Physics 17, 1254–1259 (2021).

[2] I. Shipulin et al., “Calorimetric evidence for two phase transitions in Ba_{1-x}K_xFe_2As_2 with fermion pairing and quadrupling states” arXiv preprint arXiv: 2212.13515 (2023).

[3] I. Maccari, E. Babaev, ”Effects of intercomponent couplings on the appearance of time-reversal symmetry breaking fermion- quadrupling state in two-component London model ” Phys. Rev. B 105 (21), 214520 (2022).

[4] I. Maccari, J. Carlström, E. Babaev, ”Possible time-reversal symmetry breaking fermionic-quadrupling condensate in twisted bilayer graphene”, arXiv preprint arXiv:2206.02698 (to appear in PRB (2023)).