The attraction between antiferromagnetic quantum vortices as origin of superconductivity in hole-doped cuprates

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Abstract

Thirty years after the discovery of the first high-Tc superconducting cuprates, the microscopic mechanism behind superconductivity in this class of materials is still not fully understood, despite continuous experimental advances. It is commonly believed that antiferromagnetism (AF) is a key ingredient for the superconductivity in cuprates, then a natural pairing glue would be provided by the spin fluctuations, *i.e.*, AF spin-waves. Their action would be enhanced by nesting the Fermi surface (FS), but evidence for that is not so clear. We propose as the pairing glue another excitation still emerging from AF, but of purely quantum origin: AF spin vortices. In the AF phase the spin group SU(2) is broken to U(1), while the quotient SU(2)/U(1) is isomorphic to the 2D-sphere S^2 whose points label the directions of the magnetization. Their fluctuations are described by spin waves. The unbroken U(1) group describes unphysical gauge fluctuations. However, in two dimensions one can consider vortices of Aharonov-Bohm type in this U(1); due to AF these vortices have opposite chirality when centered on two different Néel sub-lattices, hence we dub them AF spin vortices. Lowering the temperature such gas of vortices in 2D undergoes a Kosterlitz-Thouless-like transition, with formation of a finite density of vortex-anti-vortex pairs. If the vortices are centered on charges, that induces a new form of charge-pairing, again due to AF, but different from the spin-fluctuation pairing. That charge pairing will eventually lead to superconductivity. To present how that is realized in the (hole-doped) cuprates is the fundamental aim of this talk. One finds that based on this key idea many structural features of the cuprate phase diagram could be understood and many physical properties are successfully computed.

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