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Hidden Magnetic Texture in the Pseudogap Phase of the High-Tc Superconducting $YBa_2Cu_3O_{6+x}$

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Despite decades of intense investigations, the origin of the enigmatic pseudogap phase of high-Tc superconducting cuprates remains an unsolved mystery. In the last 20 years, condensed matter physicists discovered that this mysterious phase hosts symmetry breaking states such as an intra-unit cell (or q=0) magnetism preserving the lattice translational (LT) symmetry and breaking the time-reversal and parity symmetries [1]. This q=0 magnetism gives rise to magnetic scattering on top of nuclear Bragg peaks and is interpreted in terms of loop current (LC) patterns accompanied by anapoles (or polar toroidal moments) [1]. It is followed, upon cooling, by an additional incipient charge density wave breaking the LT symmetry. However, none of these states can (alone) account for the partial gapping of the Fermi surface.

Our recent polarized neutron diffraction measurements in $YBa_2Cu_3O_{6+x}$ single crystals with different hole doping levels [2,3] reveal a novel hidden magnetism that breaks LT symmetry and that may be crucial to elucidate the pseudogap puzzle. This short-range magnetism (with typical correlations over 5-6 unit cells) is carried by the CuO2 layers and settles in at T*. Distinct from the q=0 magnetism, the related magnetic signal appears at the planar wavevectors of the form q=(0.5,0) and (0,0.5), yielding a (2x2) quadrupling of the magnetic unit cell within the [a,b] plane (q=½ magnetism). The associated magnetic moment is strongly anisotropic, predominantly pointing perpendicular to the CuO2 planes, which is consistent with the picture of a LC state as the microscopic origin of the q=½ magnetic correlations. Finally, the q=½ magnetism vanishes in the overdoped regime, following the doping dependence of the pseudogap [3].

We discovered that the q=0 and q=½ magnetisms could be embedded within a single complex and highly spread-out chiral magnetic texture of LCs consisting in an anapole vortex-like pattern accounting for the q=½ magnetism binding larger ferro-anapolar domains of the q=0 magnetism. Such a magnetic texture is consistent with the recent proposal of LC supercells, breaking the LT symmetry and able to account for the pseudogap opening [4]. The existence of such broad entities reveals an unexpected aspect of the pseudogap physics that may modify our understanding of this state of matter.

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[2] D. Bounoua et al., Comm. Phys, 5 (2022) 268.
[3] D. Bounoua et al, Phys. Rev. B, 108 (2023) 214408.
[4] C.M. Varma, Phys. Rev. B, 99 (2019) 224516.

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