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Metamagnetism and superconductivity in UTe2

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In 2019, unconventional superconductivity was observed in the heavy-fermion paramagnet UTe2 and a spin-triplet nature of the superconducting pairing has been proposed for this compound initially presented as a nearly-ferromagnet [1,2]. Soon after, multiple superconducting phases were found to develop near magnetic transitions in UTe2 under intense magnetic fields and high pressures [3-8].

Here, I will present a selection of results performed within a French-Japanese collaboration on UTe2. Experiments under combined extreme conditions showed that multiple superconducting phases can be induced by a magnetic field, sometimes coupled with pressure, in the vicinity of metamagnetic transitions [4,6,8] (see also [5,7]). From inelastic neutron scattering at zero magnetic field, we evidenced the presence of quasi-two-dimensional antiferromagnetic fluctuations in UTe2, which is also a two-legs magnetic ladder [9] (see also [10,11]). Their gapping in the zero-field superconducting phase indicates that these fluctuations may play a role in the superconducting mechanism [12-13].

Neutron scattering is a unique tool to microscopically unravel the role of magnetism, and particularly of the magnetic fluctuations, for the development of unconventional superconductivity in correlated-electrons materials. However, metamagnetism in UTe2 occurs at fields far beyond what is feasible today for inelastic neutron scattering (fields up to 36 T at ambient pressure, or up to 15-20 T under pressure may be needed). As perspectives, I will discuss how the extension of neutron techniques to higher magnetic fields, possibly coupled with very low temperatures and/or high pressures, will constitute a milestone to understand the interplay between magnetism and superconductivity in materials as UTe2.

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