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Is the Abrikosov's vortex-model still valid in nematic superconductors?

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Spontaneous rotational-symmetry breaking (RSB) in the amplitude of the superconducting gap is a necessary condition for "nematic" superconductivity. This was evidenced in the topological superconductor $Cu_xBi_2Se_3$ where, despite the threefold symmetry of its lattice, a twofold symmetry of electronic properties emerged from nuclear magnetic resonance[1], transport[2], and specific-heat[3] measurements, when the applied magnetic field is rotated in the Se planes. This is also the case of $CaSn_3$ semimetal with the cubic $AuCu_3$-type structure: we prove a spontaneous RSB below Tc[4] by magnetotransport- and muon-spectroscopy (μSR) measurements. Particularly meaningful are the transverse-field (TF)- μSR results in the mixed superconducting phase of $CaSn_3$, where the muon-depolarization rate depends on the magnetic field direction (here, applied along the [110] or [001] crystal directions). The absence of any additional muon depolarization along [110] suggests that an *unconventional vortex lattice* (VL) sets in. Conversely, in the [001] case, a VL encompassing at least 52% of the sample volume indicates the bulk nature of superconductivity.
Similarly, by scanning tunnelling spectroscopy in $Cu_xBi_2Se_3$, vortices exhibit an elliptical shape within stretched VLs for applied fields H orthogonal to the Se planes, whereas "no obvious in-plane vortices" could be observed for H parallel to the Se layers[5].
Such evidence and our current experimental results on $CaSn_3$ seriously question the pertinence of the conventional Abrikosov model to the superconducting mixed state of nematic superconductors since multi-component order parameter superconductors may exhibit unusual vortex structures (fractional and/or non-axial vortices)[6].
Finally, the superfluid density in the (001) planes, extracted from TF-μSR data, shows a fully gapped low-temperature behaviour, with $\Delta(0)=0.61(7)$ meV. Additional zero-field μSR results indicate that the superconducting state is time-reversal invariant. This fact and the RSB in a fully-gapped superconductor suggest $CaSn_3$ as *nematic superconductor with an unconventional pairing state in a multidimensional representation.*

[1]https://doi.org/10.1038/nphys3781
[2]https://doi.org/10.1038/s41467-019-14126-w
[3]https://doi.org/10.1038/nphys3907
[4]https://doi.org/10.1103/PhysRevB.105.094508
[5]https://doi.org/10.1103/PhysRevX.8.041024
[6]https://doi.org/10.1103/RevModPhys.63.239

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