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Vortex configurations in mesoscopic superconductors: direct observation using Bitter decoration

Vortices in superconductors are often regarded as a distinct state of matter, representing an ensemble of interacting 'particles' whose density can be varied simply by changing the externally applied magnetic field. Thanks to recent technological advances, it has now become possible to achieve considerable control over vortex behaviour by creating artificial pinning landscapes or confining vortices in a small (mesoscopic) superconductor. A number of new and exotic vortex states have been reported or predicted for such mesoscopic superconductors: paramagnetic Meissner effect, fractional and 'negative' vortices, giant vortices and distinct multi-vortex states. We study vortex configurations in confined geometries directly, by using the Bitter decoration technique, and the results will be reviewed in this talk. After a brief introduction to the strengths and weaknesses of the technique, I will present our recent observations on several different types of mesoscopic samples: thin-film- and single-crystal-based disks of a few-micron size and perforated thin films with periodic and quasi-periodic arrangements of holes. In all cases, confinement had a profound effect on vortex configurations, e.g., concentric shells of vortices were found for circular geometry, with well defined shell-filling rules and 'magic' numbers for vorticities corresponding to complete vortex shells. Furthermore, while investigating the effect of pinning, we found that strong pinning in combination with confinement leads to the formation of vortex clusters and, under certain conditions, even true giant vortices, while the effect of artificial pinning centres (holes in a thin film) strongly depends on the symmetry of the hole arrangement.

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