

Vortex matter in the presence of magnetic pinning centra

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The vortex structure of a thin mesoscopic disk is investigated within the phenomenological Ginzburg–Landau theory in the presence of a ferromagnetic disk or circulating currents in a loop near the superconductor as well as different "model" magnetic field profiles with zero average. It will be shown how a magnetic field can drive the system through different stable and metastable vortex states and ultimately to the normal state. The regions of existence of the multi-vortex state, giant vortex state and ring-shaped vortices are found. Furthermore, the ring vortex actively participates in forming of new type of multi-vortices. We also found a vortex state consisting of a central giant vortex surrounded by a collection of anti-vortices. The examples of unconventional *re-entrant* behavior and transitions between different superconducting states will be given.