Kinematic and Structural Studies of Metastable Vortex Lattice Phases in MgB_2

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When a type-II superconductor is subjected to a magnetic field it is threaded by vortices, each carrying one quantum of magnetic flux. In materials with low vortex pinning to defects, the vortices will arrange themselves into a regular array known as the vortex lattice (VL) due to their mutual repulsion. The VL depends sensitively on the anisotropy of the screening current plane, and in many cases undergoes a structural phase transition as the magnetic field and/or temperature is varied.

I will discuss our recent studies of the VL in MgB_2, where one observes an unprecedented degree of metastability in connection with a second order (continuous) VL rotation transition. This phenomenon represents a novel kind of collective vortex behavior, and can not be understood from the single VL domain free energy or from vortex pinning. Rather, we speculate that it is due to VL domain jamming, reminiscent of behavior observed for colloids or granular materials.

To better understand the metastable VL phases in MgB_2 we have studied their kinematic as well as their structural properties using small-angle neutron scattering (SANS). Using a stop-motion technique we imaged the VL as it was driven from the metastable phase to the ground state by a controlled number of small-amplitude ac magnetic field cycles either parallel or perpendicular to the dc field. In both case the metastable VL volume fraction follows a stretched exponential, but with different parameter values. This difference is most like due to flux cutting in the perpendicular ac field case. Spatially resolved SANS measurements were able to resolve the VL domain distribution and provide an upper limit of both metastable and ground state domains.

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