Discovery of New Vortex State in $TaSe_3$ Topological Ring Crystals

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Topology has many applications in modern condensed physics. Physical properties may be changed by topology. For example, at the mixed state of type II superconductor, Abrikosov lattice is the most stable configuration of vortices. However, when system size is small, shape of superconductors, such as boundary condition, affects penetration and arrangement of vortices [1]. Similarly, topology of systems has a potential of affecting the superconducting properties.

In this study, we have measured the magnetic torque of the $TaSe_3$ ring crystal by using piezoresistive cantilever in order to investigate the superconducting topological properties. This measurement is suitable for investigations of the effect of topology because we need no-electrode in this method. We measured two ring samples. The outer radius of sample A(Fig.1a) was 37.9 µm and that of sample B(Fig.1b) was 24.5 µm. From the measurement, we found that the magnetic torque oscillated periodically below the transition temperature in the ring crystal. The periodicity of sample A was 1.85 Gauss and that of sample B was 4.75 Gauss, respectively. And, we found that the period is proportional to the circumference of the ring crystal rather than the area enclosed by the outer circumference. In that case, it is natural that vortices in the ring crystal place along the circumference. From these results, we suggest that the vortex in ring crystal is the cylinder vortex. And these results may be experimental evidence of topological effect in superconductor.

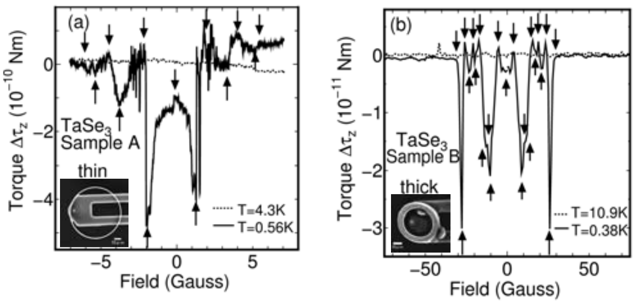

Fig.1: (a) Magnetic torque of Sample A as a function of the applied magnetic field and Scanning electron microscope (SEM) image of $TaSe_3$ ring crystal on the cantilever. Arrows show the peak positions. Solid lines represent the magnetic torque measured above T_c=2.0 K. Dotted lines represent the torque measured below T_c. (b) Magnetic torque of Sample B.

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[1] L. F. Chibotaru et al., Phys. Rev. Lett. 86 (2000) 7.