Local electronic states around a vortex near the surface in inclined magnetic fields

Masanori ICHIOKA [1,2]

[1] *Department of Physics, Okayama University, Okayama 700-8530, Japan*
[2] *Research Institute for Interdisciplinary Science, Okayama University, Okayama 700-8530, Japan*

Vortex structures and the local density of states are theoretically studied near the surface plane (z=0) in type-II superconductors when the magnetic field orientation is inclined θ away from the z-axis. In the inclined magnetic field orientation, the observation of STM experiment suggested a vortex line bending near the surface [1] . In 2H-$NbSe_2$, STM experiment by Hess *et al.* reported the distortion of the star-shaped vortex core image to a “spiky comet shape” when the magnetic field orientation is tilted into the surface plane [2].

In this study, the calculation method of self consistent Eilenberger theory is developed for the studies of vortex states near the surface under the inclined fields, assuming specular reflection of quasiparticles at the surface. The calculation is performed for six-fold symmetric anisotropic s-wave pairing as a model of 2H-$NbSe_2$, which reproduces a star-shaped vortex core image in the local density of states [3]. After the self consistent calculation of the pair potential and the quasiparticle states, in the spatial structure of the pair potential $\Delta(\boldsymbol{r})$, a vortex line bending occurs near the surface under the inclined magnetic fields as shown in Fig. 1. There, the tilt angle of the vortex line becomes smaller with approaching the surface. In the calculation of the local density of states $N(E,\boldsymbol{r})$ at the surface, we will discuss how the star-shaped vortex core image [3] is changed by inclining the magnetic field orientation.

References

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E-mail: ichioka@okayama-u.ac.jp

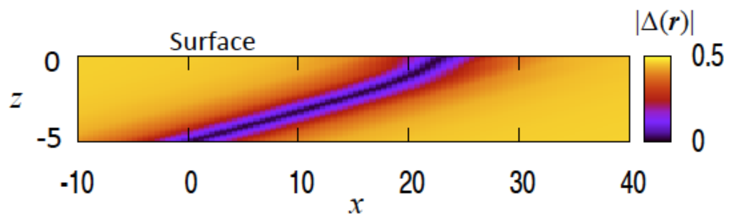

FIG. 1. Density plot of the pair potential’s amplitude $|\Delta(\boldsymbol{r})|$ in the x-z plane. The surface is located at the plane z=0. The magnetic field is inclined θ =80° away from the z axis. Dark region of the vortex core shows a vortex line bending near the surface.