(29b3)

Vortex states in superconducting $PrOs_4Sb_{12}$

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Novel vortex phase and nature of double transition field are investigated by two-component Ginzburg-Landau (GL) theory in a situation where fourfold-twofold symmetric superconducting double transition occurs[1]. We derive the two-component GL equation appropriate to study the double transition in $PrOs_4Sb_{12}$, and calculate the vortex structure by the simulation of time-dependent GL theory. Figure 1(a) shows field dependence of the order parameter, when gradient coupling terms vanish. The second order parameter η_2 appears below $H^*(T)$. The H-T phase diagram in our GL theory, presented in Fig. 1(b), qualitatively reproduces that obtained by the thermal conductivity experiment[1]. When gradient coupling terms exist (singlet pairing case), small η_2 survives up to $H_{c2}(T)$, as shown in Fig. 1(c). That is, H^* is changed to a crossover field. In this case, H_{c2} has $\cos 2\theta$ part in addition to $\cos 4\theta$, when H is rotated within ab-plane[2].

We expect that the vortex lattice deforms from 60° triangular lattice due to the effect of twofold symmetric second order parameter below H^*. In the two-component superconductor, there is a possibility to observe the domain structure of different combination of order parameters. At the domain wall, vortices have exotic structure of vortex sheets, where two order parameters have different vortex cores and these cores are alternatively located along domain wall. These characters of the vortex structure may be clear evidence of the fourfold-twofold symmetric double transition and unconventional multi-component superconductivity, if they are experimentally observed.

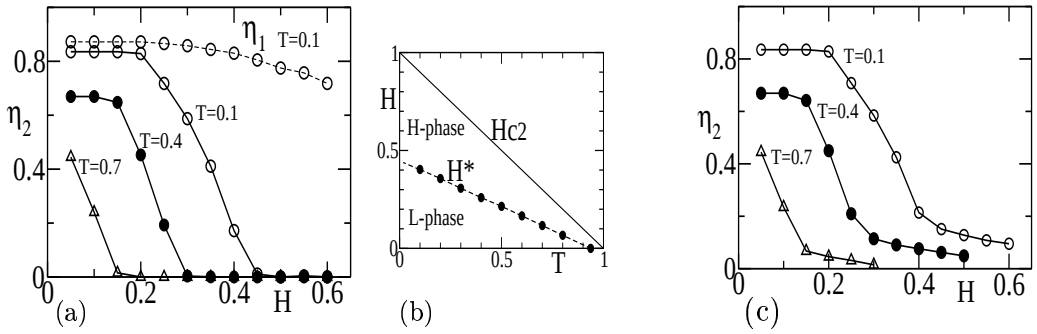

Figure 1: (a) Maximum of second order parameter amplitude $|\eta_2(\mathbf{r})|$ (solid lines) as a function of $H/H_{c2}(0)$, when gradient coupling terms vanish. $T/T_c = 0.1(\circ)$, $0.4(\bullet)$ and $0.7(\triangle)$. η_2 appears at $H < H^*(T)$. For $T/T_c = 0.1$, H-dependence of first order parameter amplitude $|\eta_1|$ is also presented (a dashed line). (b) H-T phase diagram in this GL theory. The transition field H^* and H_{c2} are presented. (c) Maximum of $|\eta_2(\mathbf{r})|$ as a function of $H/H_{c2}(0)$ in the presence of gradient coupling terms. $T/T_c = 0.1(\circ)$, $0.4(\bullet)$ and $0.7(\triangle)$. η_2 survives up to $H_{c2}(T)$.

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