Vortex dynamics as a function of field orientation in $BaFe_{1.9}Ni_{0.1}As_2$

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This work presents a vortex dynamics study performed on an optimally doped cristal of $BaFe_{1.9}Ni_{0.1}As_2$ with a sharp $T_c = 20$ K. We obtained several isothermic $M-H$ (loop) curves for three different geometries, $H\|c$-axis, $H\|ab$-planes and H-forming a 45 degrees with ab-planes, where $M-H$ curves show the second magnetization peak for all geometries. We obtained many magnetic relaxation, ($M(t)$ curves, for fields along the second magnetization peak at several temperatures for all geometries. The resulting analyses of these data did not show any evidence for a pinning-crossover related to the peak effect phenomena, this from the behavior of the rate of relaxation (defined as $R{=}dM/dlnt$) as function of field for fixed temperatures, as a function of temperature for fixed fields, from the behavior of isofield activation energy curves as a function of T, and from the functional form of the $H_p(T)$ line in the phase diagram. The double plot of a $M(H)$ and the correspondent $-R(H)$ curves shown in Fig. 1a exemplify the general trend observed in the relaxation rate relativelly to the second magnetization peak, where the fields H_1 and H_2 appearing in the R vs. H plot are clearly not related to the peak field H_p. Fig. 1b shows the critical current obtained by using the Bean Model applied to the $M-H$ curves where $J_c(H\|c){>}J_c(H\|ab)$. This is an unexpected result, since results found in the literature show $J_c(H\|ab){>}J_c(H\|c)$, as for instance in an overdoped pnictide of the same systems (2011 Phys. Rev. B 84, 052510). This unexpected result was recently predicted to occur in systems with a moderate anistropy with point like-strong pinning for $H\|c$ (2012 Supercond. Sci. Technol. 25 084010). We also observed that the shape of the critical current curves in Fig. 1b, are well explained (solid lines) in terms of a softening ot the vortex-lattice (2005 Phys. Rev.B 72 144512).

We observed that the physical quantities H_p (the peak field position), H_{on} (the onset of the second magnetization peak) and H_{irr} (the irreversible field) extracted from $M(H)$ curves obtained for the three different geometries can be plotted together in a unique phase diagram shown in Fig. 2, after proper scaled by a factor proportional to the anisotropy of the system, $\sqrt{(sin(\theta))^2 + (1/3)(cos(\theta))^2}$, where θ is the angle between

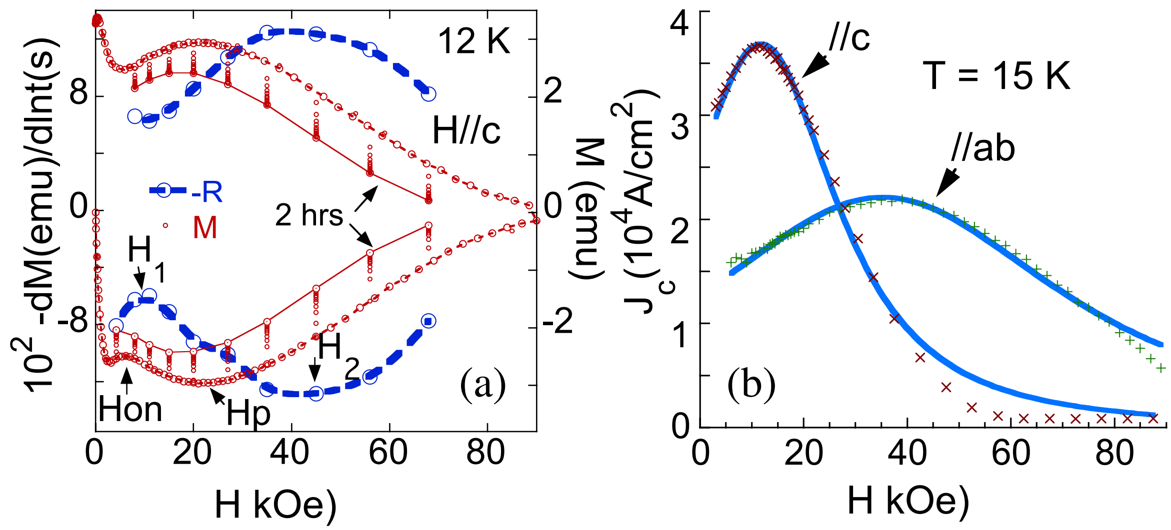

Figure 1. a) Double plots of $-R$ *vs.* H and $M(t)$ *vs.* H at $T = 12$ K for $H\|c$; b) $J_c(H)$ at 15 K for $H\|c$ and $H\|ab$. Solid lines represent a fitting to the data.

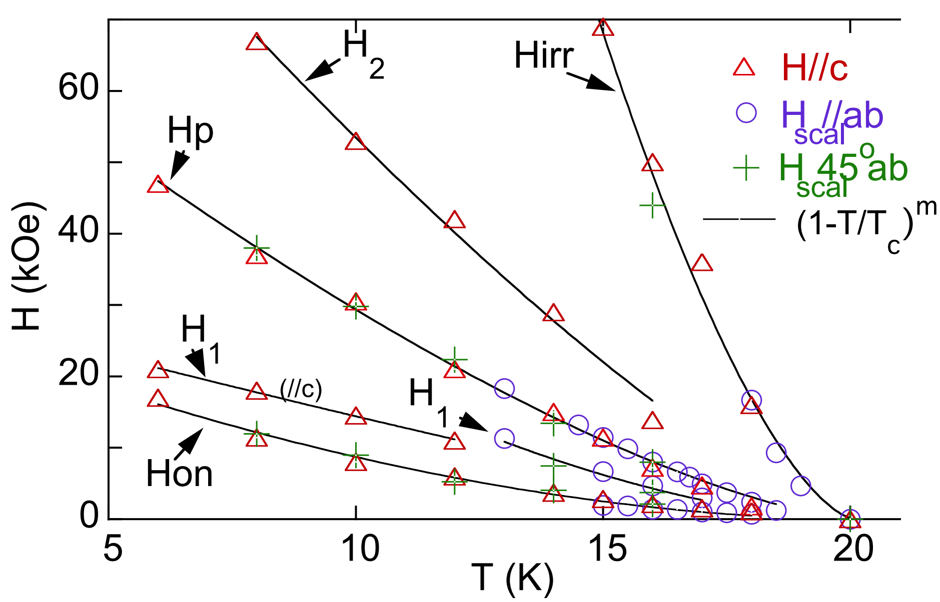

Figure 2. Hvs.T diagram for the three geometries after scale the Y-axis for $H\|ab$ and $H45^o ab$. Solid lines represents a fitting of the data.

H and the ab-plane, and the factor $3\approx H_p(H\|ab)/H_p(H\|c)\approx H_{irr}(H\|ab)/H_{irr}(H\|c)$ is of the order of the system (upper critical field) anisotropy. It is also plotted in Fig. 2 the fields H_1 and H_2 extracted from $R(H)$ curves, evidencing the anisotropy on H_1 as the magnetic field rotates away from the c-axis direction. The collapse of the H_{on}, H_{irr} and Hp lines is evident and suggests that the same underlying physics is occurring independent of the orientation of field. Each solid line in Fig. 2 follows a $(1 - T/T_c)^m$ dependence. The H_p line does not fit the predicted elastic to plastic crossover expression (1996 Phys. Rev. Lett. 77, 1596)