The vortex depinning transition in untwinned YBaCuO using complex impedance measurements.

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Abstract

We present surface impedance measurement of the vortex linear response in a large untwinned YBCO crystal. The depinning spectra obtained over a broad frequency range (100 Hz- 30 MHz) are those of a surface pinned vortex lattice with a free flux flow resistivity (two modes response). The critical current in the "Campbell" like regime and the flux flow resistivity in the dissipative regime are extracted. Those two parameters are affected by the first order transition, showing that this transition may be related to the electronic state of vortices.

The linear ac response of a pinned vortex lattice has been observed in the 60's in conventional type II superconducting materials [1]. At low frequencies, say f $\lesssim$ 1 KHz, a small ac field has an apparent penetration characterized by a static regime without any loss (the Campbell regime). It has been recognized as a direct consequence of the vortex pinning, and disagrees with first interpretations based on thermally activated depinning [2]. Note that this linear regime is not the ohmic regime of a vortex lattice free from any pinning (the so called liquid phase). At the same time, the high frequency response (f $\gtrsim$ 1-10 MHz) is that of a medium with a free resistivity (skin effect). Those two regimes are separated by the depinning frequency, and the shape of the whole spectrum allows to discriminate between different types of pinned vortex states. One of the main interest of this method is that vortex states can be studied even in the presence of a large critical current. The principle of the experiment is to measure the ac penetration length, due to the vortex response, in a small coil directly glued around the sample. The detailed experimental procedure can be found in [3]. A typical depinning spectrum is shown in the figure 1. It follows closely, over the whole frequency range, the two modes model of

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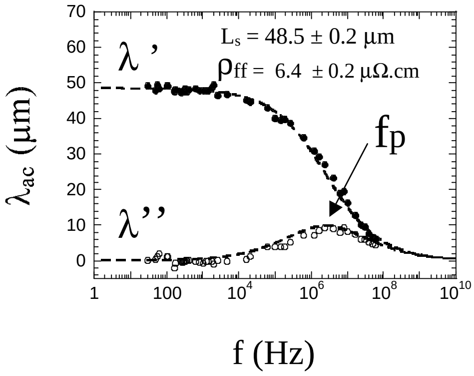

Fig. 1. Two modes response of the pinned vortex lattice in untwinned YBaCuO ($T = 88.6K < T_m$, B//a-axis=6 T).

surface vortex pinning developed in [4,5]. At the same time, it was impossible to perform acceptable fits using bulk pinning models. We conclude that the pinning in this YBaCuO sample is due to the surface roughness. We have also performed a precise study of the low frequency behavior close to the temperature of the first order transition. Within experimental accuracy, we do not find any evidence of a thermally assisted depinning regime. As the depinning frequency is directly measured by this method, we can identify the pure skin effect regime and measure the flux flow resistivity. A step in the flux flow resistivity is clearly identified at the temperature of the first order transition. At the same temperature, the low frequency penetration length diverges up to reach the full penetration (no pinning anymore). The first order transition affects both the critical current and the flux flow resistivity. It could suggest that this transition is linked to the pairing symmetry [6].

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