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Anisotropic Superconductivity and Ultrasound Attenuation in $U_{1-x}Th_xBe_{13}$

In a recent Letter¹ Joynt, Rice, and Ueda (JRU) proposed an explanation for the large sound-attenuation peak which we have observed at the "lower" phase transition T_{c2} in $U_{1-x}Th_xBe_{13}$ ($x=0.017$).² This phase transition, discovered in specific-heat measurements,³ occurs below the superconducting transition T_{c1} and the nature of the order parameter is not known so far. From the character of the ultrasound attenuation and the variation in sound velocity, we suggested the possibility of an antiferromagnetic transition. Estimates based on the specific-heat jump, change in sound velocity, and magnitude of the attenuation peak in comparison with U_2Zn_{17} suggested an ordered moment of $\sim 10^{-2}\mu_B/U$, which was consistent with NMR measurements. An alternative explanation was proposed by JRU, based on the possibility of a transition involving anisotropic superconducting states. As a clearcut and stringent test for their model, JRU suggested additional ultrasound experiments which we have performed in the meantime;

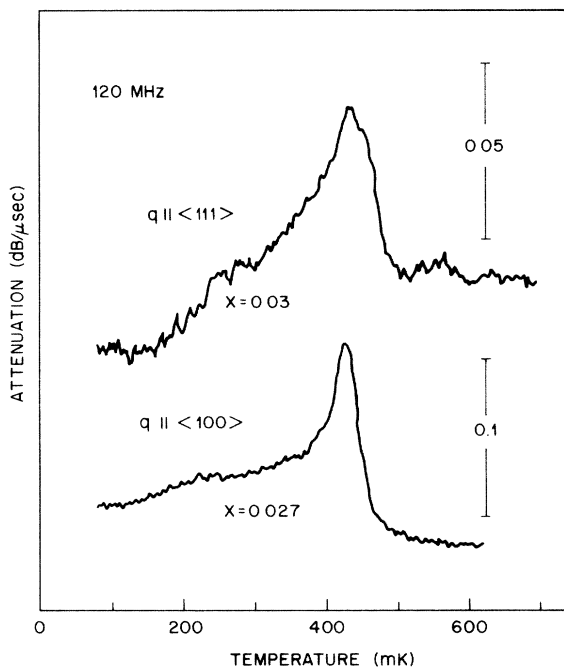


FIG. 1. Ultrasound absorption in superconducting $U_{1-x}Th_xBe_{13}$ ($x=0.03$) for (111) and (100) propagation. The two peaks associated with T_{c2} are of comparable magnitudes. Coupling of tetragonally strained domains, due to anisotropic superconductivity coupling to the lattice, would not give rise to absorption for (111) propagation.

here we report the results of this study.

The model of JRU starts from the idea that an anisotropic superconducting state in a cubic crystal drives a tetragonal or rhombohedral lattice distortion.^{1,4} Domain-wall motion then couples to sound waves and JRU studied in detail all cases involving tetragonal distortions. (Couplings to rhombohedral distortions were expected to be much smaller and were not analyzed quantitatively.) The magnitude of the attenuation due to this mechanism depends on the propagation direction and polarization of the sound wave. Specifically it was predicted to vanish for longitudinal sound in (111) directions. To test this prediction, we studied the ultrasound attenuation along the (111) direction of a $U_{1-x}Th_xBe_{13}$ ($x=0.03$) single crystal, employing the identical experimental setup as in Ref. 2. A typical temperature dependence at 120 MHz is shown in Fig. 1. Most dominant is the peak at T_{c2} (~ 430 mK). As was seen in (100) propagation, the peak height is, by two orders of magnitude, larger than the attenuation due to the electron-phonon interaction.^{5,6} Moreover, the (111) absorption peak is a large fraction (40%–50%) of the (100) value at the same frequency. Thus the present result does not support the JRU model of tetragonally strained domains below T_{c2} .

We conclude, therefore, that coupling of ultrasound to a tetragonally distorted superconducting phase cannot explain the observed absorption peak at T_{c2} .

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