Resonant Ultrasound Spectroscopy on Conductive Materials in High Magnetic Fields

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Introduction

Ultrasound velocities of longitudinal and transverse waves propagated in metals rise if a sample is placed in a magnetic field and the sound wave polarization is perpendicular to the field [1]. Therefore, a magnetic field should affect the resonances of conductive materials. Nevertheless, this phenomenon has not been studied either experimentally or theoretically. Absence of experimental studies and a theoretical model restricts applications of resonant ultrasound spectroscopy recently developed at Tallahassee site of the NHMFL.

Experimental

Resonances of amorphous BSCCO, monocrystal aluminum and monocrystal SiC were studied in magnetic fields of up to 31T in the temperature range from 4 to 300K. When a magnetic field was applied, the resonant frequencies of BSCCO and aluminum increased as expected (see Fig. 1.). No influence of a magnetic field on the resonances of SiC monocrystal was observed since this material is dielectric and nonmagnetic. The elastic stiffness tensors of aluminum and SiC were also measured at zero magnetic field and the values obtained are in perfect agreement with the data known.

![Figure 1. Resonance of an aluminum monocrystal at different magnetic fields T=300K](image)

Results and Discussion

The variations of the resonant frequencies in aluminum and BSCCO were associated with the changes of the conductivity of the samples studied under influence of the magnetic field. A proper mathematical model describing vibration of conductive solids in magnetic fields is now under development. Such a model is relatively simple for some specific experimental configurations. For example, when a magnetic field is applied along an axis of a high symmetry there are only four out of nine elements of the magnetoconductivity tensor which are nonzero: \( \sigma_{xx}=\sigma_{yy} \) and \( \sigma_{xy}=\sigma_{yx} \).

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References