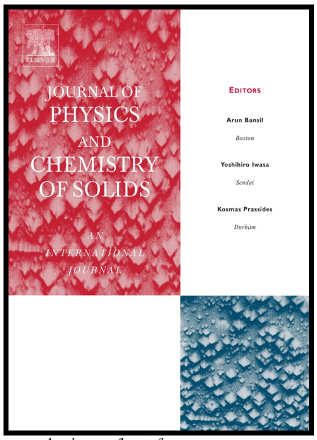

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A general theory for calculating magnetoacoustic effects in pure metals

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Abstract

A new experimental technique yields high-precision measurements of attenuation and dispersion of ultrasound in pure metals in the presence of a magnetic field, but existing theories have approximations which make it impossible to make accurate comparisons with the data. I have constructed a theory with few approximations to eliminate this problem. In addition, symmetry theorems are derived for the effects resulting from the reversal of the magnetic field direction. Calculations for very pure copper are in very good agreement with experimental data.

Keywords: Ultrasonic attenuation, velocity, magnetoacoustic effect, conduction electrons, long relaxation time, magnetic field

1. Introduction

The first evidence that conduction electrons in metals play an important role in the attenuation of ultrasonic waves came from experiments on superconductors. Bömmel[1] and Mackinnon[2] found that the attenuation of an ultrasonic wave propagating through a superconductor began to rise as the temperature was reduced and then dropped drastically when the specimen was cooled below the transition temperature T_c.

Clearly the conduction electrons in the normal metal were absorbing an increasing amount of energy from the ultrasonic wave as the temperature was lowered. Morse[3] constructed an electron relaxation model for a wave with frequency ω propagating through a metal with electron relaxation time τ. He found that the attenuation in the normal state for $\omega\tau \ll 1$ should be proportional to the electrical conductivity σ and thus to $\omega\tau$, in good agreement with later, more detailed experimental data. He attributed the rapid decrease in attenuation below T_c to the diminishing number of "normal" electrons, using the two-fluid model of superconductivity. However, the observed temperature dependence did not agree with the power-law behavior expected from a simple two-fluid model.

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