ULTRASONIC STUDIES OF THE FERMI SURFACE IN AuZn SINGLE CRYSTAL

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The practical importance of the shape memory effect that often accompanies a martensitic phase transition has kept attention focused on the alloys that possess it for many years. However, the mechanism of the shape memory remains unclear. Among various compounds, AuZn is the least investigated due to its low transition temperature and, consequently, little commercial value. On the other hand, this very feature makes AuZn especially interesting for a fundamental insight into the martensite behavior. Since the role of the electron gas in the metallic bond formation is widely known, it is also expected to be important in structural transformations of the metal. Yet, the low phonon background associated with low temperature helps in exploration of the electronic properties of this material.

In this work we, for the first time, applied the ultrasonic pulse-echo technique to explore the Fermi surface of single crystals of AuZn alloy [1]. The measurements were performed in magnetic fields up to 45 T, using the hybrid and superconducting magnets. Longitudinal sound wave propagating in the (110) direction was investigated. In the martensite phase (T < 64 K), the oscillations of the sound speed (Fig.1a) indicated presence of the acoustic de Haas-van Alphen phenomenon. The strength of the effect depends on the orientation of the sample with respect to the magnetic field. It has the highest value when the magnetic field is directed along (110) direction of the crystal. Fourier analysis of the signal indicates that in addition to the earlier described oscillations with frequencies of 1140 and 4720 teslas, we also discovered new oscillations with frequency of 120 teslas, which were predicted theoretically, but not observed by other experimental methods [2].

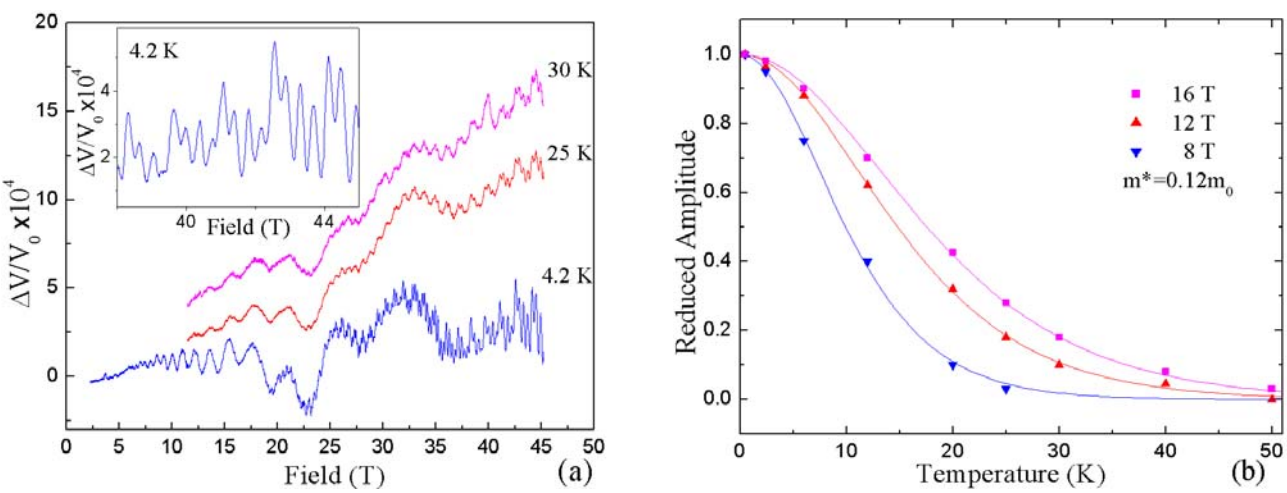

Figure 1. (a) Oscillations of the sound speed measured at several temperatures. The inset shows the high field part of these oscillations. The 60.3 MHz longitudinal sound wave and the field are both directed along (110) crystallographic direction. (b) Amplitude of the 120 tesla oscillations as a function of temperature. Solid lines represent a fit of the experimental data with Lifshitz-Kosevich expression.

Analysis of the oscillation amplitudes at various temperatures and magnetic fields allowed us to determine the values of effective electron masses and estimate Dingle temperatures for three corresponding electron orbits. Fitting the data with the Lifshitz-Kosevich expression (Fig.1 (b)), gives the values of the effective masses as $m^*_{120}=0.12\pm0.01\ (m_e)$, $m^*_{1140}=0.21\pm0.01\ (m_e)$, and $m^*_{4720}=0.32\pm0.01\ (m_e)$. The later two are in a good agreement with previous experimental results and theoretical predictions [2]. The Dingle temperatures for these oscillations we estimate as $T_D^{120}=19\pm1$ K; $T_D^{1140}=16\pm3$ and $T_D^{4720}=16\pm1$ K.

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References

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