Ultrasound Studies of Low Temperature Electronic and Magnetic Properties of Bulk Multicomponent Metallic Glasses

Svitelskiy, O. and Lee, D. (Gordon College, Department of Physics); Suslov, A. (FSU, National High Magnetic Field Laboratory)

Introduction

The glassy state represents a universal property of supercooled liquids. Despite the long history of studies, many of the physical properties of glasses, including the very appearance of a metastable high entropy amorphous state, still represent a mystery. The slowness of the scientific progress stems from the randomness of the structural disorder, which makes systematic characterization of these materials very difficult. Metallic glasses, that have been discovered relatively recently, represent a new test platform for exploring the glassy state by giving access to probing their electronic and magnetic properties [1]. Acoustic methods, including the used in the current experiment, have been broadly utilized to characterize metallic glasses [1-5]. However, most of the acoustic studies in metallic glasses have been done at elevated temperatures where the liquid-glass, glass-crystal, and liquid-crystal transitions occur. At the same time, valuable information on the materials may be accessed through the low-temperature measurements, when the background of the thermal phonons does not disrupt the measured data. Thus, the low-temperature information not only may shed new light on the appearance of the glassy state, but also it can help in finding new alloys with interesting physical properties: superconductivity, magnetoresistance, magnetocaloric effect, etc. [6-8].

Experimental

We have fabricated several samples of a high-entropy metallic glass alloys $(ZrNb)_{23.7}(CaNiAl)_{76.6}$, and $Zr_{44}Ti_{11}Cu_{10}Ni_{10}Be_{25}$ and started investigating their acousto-magnetic properties using NHMFL DC Field facility (SCM-2) with the purpose to fulfill a comprehensive study of behavior of these metallic glasses in magnetic fields. We have completed a detailed characterization of low-temperature magnetic properties of these glasses by acoustic pulse-echo ultrasound velocity and attenuation in different configurations of the experiment with respect to the orientation of magnetic field, ultrasound polarization, and propagation direction. We also started investigating our materials by resonant ultrasound spectroscopy (RUS).

Results and Discussion

The RUS study detected an interesting and not previously reported effect of a significant resonant frequency dependence upon applied magnetic field (Fig. 1). We plan on conducting further detailed study of this phenomena.

Conclusions

We have observed a new effect of magnetic field dependences of the acoustic resonant frequencies of a metallic glass sample and we are planning to continue its exploration.

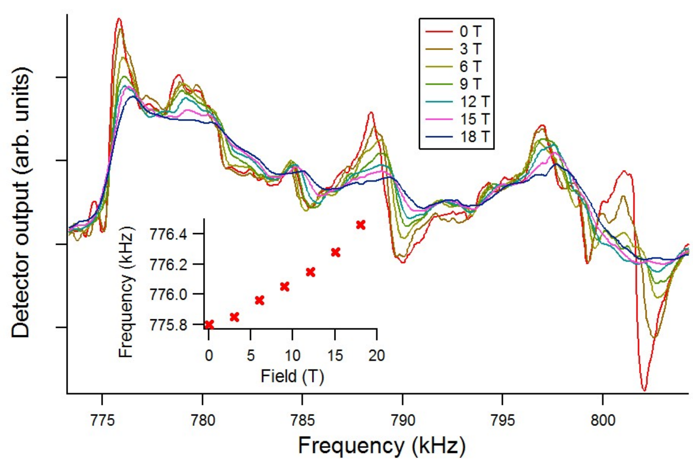

Fig. 1. Fragment of acoustic resonant spectra, recorded on $Zr_{44}Ti_{11}Cu_{10}Ni_{10}Be_{25}$ metallic glass sample at several values of magnetic field. T = 0.25 K. Inset shows frequency shift of the first peak.

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