Elastic Properties of the Pnictides Ba(Fe$_{1-x}$Co$_x$)Fe$_2$As$_2$


Introduction
We used resonant ultrasound spectroscopy (RUS) to study elastic signatures of the phase transition in novel FeAs compounds. For the electron-doped superconductor Ba(Fe$_{1-x}$Co$_x$)$_2$As$_2$, the single magnetic/structural phase transition that is observed for undoped BaFe$_2$As$_2$ at 134 K appears to split into two distinct phase transitions, both of which are rapidly suppressed with increasing Co concentration[1].

The layered nature of this compound prevents polishing a rectangular parallelepiped sample, something desirable if we want to calculate elastic constants from the spectra of resonance frequencies by RUS. However, from previous measurements of elastic moduli on the tetragonal-orthorombic phase transition of the high temperature superconductor La$_{2-0.16}$Sr$_{0.16}$CuO$_4$[2], we know that some shear modes are sensitive to structural phase transition. In our case, the temperature dependence of the measured resonance frequencies allows us to find a critical exponent for the phase transition.

Experimental
We measured the resonance frequencies by RUS at NHMFL-LANL on a single crystal of Ba(Fe$_{1-x}$Co$_x$)$_2$As$_2$ were grown by the self-flux method. The amplitude of the mechanical vibrations was recorded while sweeping the frequencies from 0.32 to 1.5 MHz at constant temperature. The RUS probe was mounted into a $^4$He-flow cryostat, and we performed frequency-scans from room temperature down to 48 K. The signal quality was acceptable down to 84 K.

![Figure 1: Temperature dependence of selected resonance frequencies. One of them shows a good agreement with a Curie-Weiss lineshape fit (blue line). The equation used and the values obtain for the parameters are shown.](image)

Results and Discussion
We attempted to fit the frequencies with “Curie-Weiss” lineshape (shown in Fig. 1). The mode with 0.66 MHz at 300K showed a good agreement with this fit, obtaining a value of 78.4 K for the transition temperature when the critical exponent $\beta$ had a value of 0.5 (For the fit to be robust we would need data through several decades of temperatures, in this case, the parameter $\beta$ was not free).

Conclusions
We only observe one transition, the structural phase transition, at (78.4 ± 0.4) K, twinning in the crystal produces loss of signal and we are not able to measure frequencies below 84 K, and the noise overhelms any signal at 48 K. We propose some shear mode may eventually be shown to be a good order parameter for the transition, with a critical exponent value very close to 0.5.

References