Elasticity of $Fe_{64}Ni_{36}$ Invar alloy to 13 GPa

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Abstract

The properties of iron-nickel alloy are of great importance in both Earth science and material science. One particular composition, with 36% nickel ($Fe_{64}Ni_{36}$), shows an anomalously low (almost zero) thermal expansion below Curie temperature (T_C), which is the so-called Invar effect. Although numerous studies have been performed since the discover of the Invar effect, its mechanism has not been completely understood. Currently, mainly two models are under debate: *i)* the 2-γ-state model proposed that the Invar effect can be explained by a magnetic state transition of iron form the high spin (with large volume) to the low spin (with small volume) state as temperature is raised [1]; ii*)* the noncollinear model proposed to interpret the Invar effect by a continuous variation of the iron spin directions from a parallel alignment to a disordered noncollinear state as the volume is decreased [2].

In this study, we measured both the compressional and shear wave velocities of $Fe_{64}Ni_{36}$ simultaneously from 1 GPa to 13 GPa at room temperature by using ultrasonic interferometry techniques. A disk-shaped sample (2 mm diameter, 0.665 mm thickness) was used in the current experiment which was cut from a cylindrical rod purchased from Princeton Scientific Corporation. The cylindrical surfaces of the sample were polished using 1-μm diamond lapping film. Travel time data were collected along both compression and decompression and the loading/unloading cycle was repeated three times in the course of the current experiment. A significant discontinuity/anomaly at around 4 GPa was persist in the Poisson's ratio in all loading/unloading cycles. Possible explanation of the behavior in relation to the mechanism of the Invar effect will be discussed.

Reference:

1. Weiss, R.J., *Origin of Invar Effect.* Proceedings of the Physical Society of London, 1963. **82**(526): p. 281-288.
2. van Schilfgaarde, M., I.A. Abrikosov, and B. Johansson, *Origin of the Invar effect in iron-nickel alloys.* Nature, 1999. **400**(6739): p. 46-49.