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PHASEAUTOMODULATION IN MAGNESIUM

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Large amplitude internal friction experiments performed on nonlinear anelastic samples possessing a metastable state at a finite strain are interesting in various respects. If the amplitude of oscillation is sufficiently large so that the metastable state can be entered and exited in the course of one cycle, the phenomenon of automodulation can occur. This phenomenon has been observed repeatedly [1-7] and discussed in various publications [8-10]. So far, however, the automodulation of the amplitude has been emphasized. In principle, automodulations of the phase exist as well. They have been recorded during large amplitude internal friction experiments in magnesium and will be reported in this letter.

It has been shown previously [8,9] that the motion of a nonlinear anelastic reed is approximately given by

$$x(t) = a(t) \cos[2\pi\nu t + \phi(t)] \tag{1}$$

where the quantity ν represents the frequency of the force setting the reed in motion. The amplitude $a(t)$ and phase $\phi(t)$ are slowly varying functions of the time. Each function is given by a first order nonlinear differential equation. These can be found in reference 8 for the non-resonance case where the amplitude and phase are not coupled. Near resonance, the amplitude and phase are coupled, as must be the differential equations for $a(t)$ and $\phi(t)$. This has been shown in reference 9.

Experimentally, internal friction experiments are often done at or near resonance. In this case, the automodulation of the amplitude and phase should co-exist, provided the conditions for their existence are fulfilled. It is known that magnesium deforms by twinning, which in turn can be formally described in terms of the concept of nonlinear anelasticity [10,11]. It must therefore be suspected that automodulations can be observed in the course of large amplitude internal friction experiments on magnesium. Such an experiment has been performed using the apparatus shown schematically in Fig. 1. The results are presented in Figs. 2 and 3.

The recording of the simultaneous presence of the phase and amplitude automodulation in a magnesium sample vibrating at large amplitudes of oscillation completes the qualitative dynamical measurements on nonlinear anelastic solids. All the dynamical characteristics of a nonlinear anelastic solid, nonlinear resonances, phase and amplitude-automodulations have now been observed and described for magnesium. The latter two are uniquely characteristic of the dynamics of the formation of a metastable state, be it twinned, martensitic or ordered, and can be utilized to study it.

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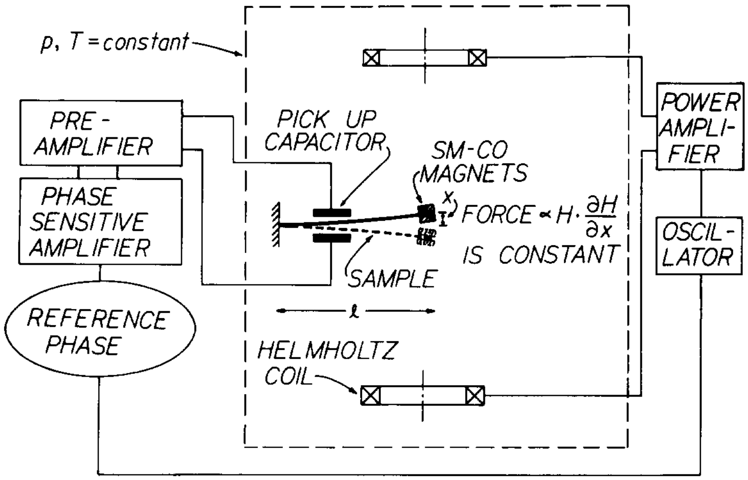

FIG. 1
Schematic internal friction apparatus used to demonstrate the simultaneous automodulation of the phase and the amplitude. The excitation of the vibration of the reed through the force exerted by a constant gradient magnetic field onto the permanent Sm-Co magnet assures a constant excitation at finite amplitudes.

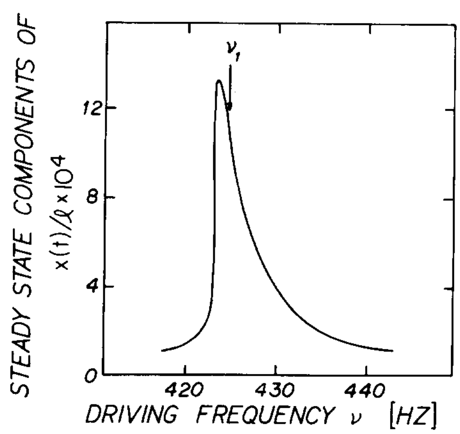

FIG. 2
Resonance curve of a 99.99% magnesium reed taken at 22°C. The reed was cut parallel to a [21$\bar{3}$4] direction and vibrated in a [$\overline{79161}$] direction. The amplitude is measured in terms of the displacement, x, and length of the reed, ℓ, as shown in Fig. 1.

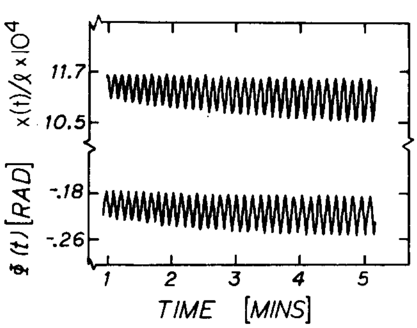

FIG. 3
Simultaneous automodulations of the phase $\phi(t)$ and the amplitude $a(t) = x(t)/\ell$ observed at the driving frequency ν_1 shown in Fig. 2.