Observation of the "freezing" of an ultrasonic wave

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A method is proposed for producing, in a medium, a constant three-dimensional periodic structure by exciting in it a standing ultrasound wave during the time of the transition from the liquid to the solid phase. The effect of "freezing" the ultrasonic wave is recorded.

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Theoretical and experimental investigation of static and particularly dynamic properties near phase transitions are being intensively developed of late. The development of the theory and the elucidation of the importance of individual mechanisms

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can be helped by an experimental investigation of the process of fixing the periodic distribution of the density (periodic structure) in the transition from the liquid to the solid phase.

A periodic structure is produced by exciting a standing ultrasound (US) wave in a medium that is in the liquid phase or in the form of a solution, with simultaneous lowering of the temperature until the medium is solidified (crystallized). After this process is completed, a periodic distribution of the density is fixed, with a spatial period determined by the frequency of the ultrasonic oscillations and by the sound velocity in the medium; this distribution remains fixed even after the US source is turned off.

The periodic structure was realized in our case in water, although the method can be used also for other materials.

To transform the electromagnetic oscillations into acoustic oscillations we used lithium niobate plates loaded on one side to ensure directional emission of the US wave. The frequency of the excited oscillations, depending on the thickness of the employed plates, ranged from 30 to 36 MHz.

The periodic variation of the density of the medium and hence of the refractive index, due to the presence of the standing US wave, produces a phase grating that causes diffraction of the transmitted radiation.[7] This makes it possible to monitor the presence of a periodic structure by observing the optical diffraction.

In our experiment the US propagation direction and the freezing direction were

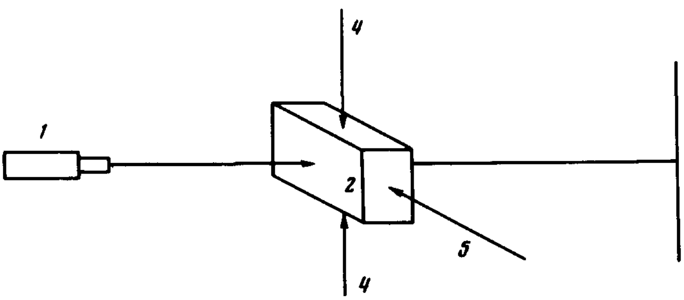

FIG. 1. 1—He-Ne laser, 2—US cell, 3—screen, 4—US-wave propagation direction, 5—freezing direction.

mutually perpendicular (Fig. 1). The monitoring was both in the Raman-Nath[2] and in the Bragg[3] region of optical diffraction (Fig. 2). The measurements have shown that in the case of Bragg diffraction by the periodic structure, approximately 40% of the energy of the incident radiation is diffracted (at a voltage of 8 V on the transducer and a frequency 34.5 MHz).

Periodic structure of this kind, realized in a number of substances, can find extensive application in various branches of physics, particular in semiconductor physics, in high-energy-particle physics, in quantum electronics, in solid-state physics, and in systems of coding and optical reduction of information.

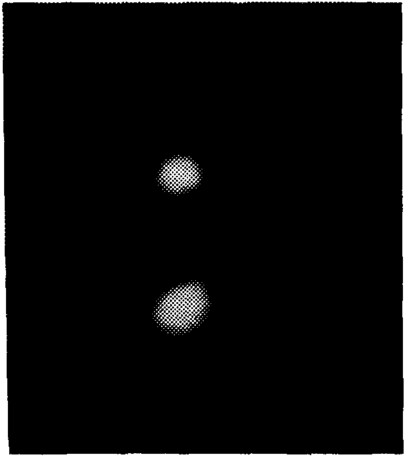

FIG. 2. Optical Bragg diffraction by the periodic structure. The US source is turned off.

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