

# THE EFFECT OF PRESSURE UP TO 100 kbar ON THE SPEEDS OF SOUND IN SILVER CHLORIDE

PHYSICS

1968

SovietRxiv

---

View the original and related papers at <https://sovietrxiv.org/items/ru-196801.80864>

Source: Math-Net.Ru and CyberLeninka. Machine translation. Verify with the original.

## Abstract

## Full Text

UDC 539.89

*PHYSICS*

F. F. VORONOV, S. B. GRIGOR' EV

# THE EFFECT OF PRESSURE UP TO 100 kbar ON THE SPEEDS OF SOUND IN SILVER CHLORIDE

*(Presented by Academician L. F. Vereshchagin on February 7, 1968)*

The study of the velocities of propagation of ultrasonic waves in solids at high pressures is of great interest, since it makes it possible to obtain important information on the phonon spectrum of a substance and to determine the pressure dependence of elastic characteristics, for example compressibility, the Debye temperature, etc.

Such investigations were carried out at the Institute of High Pressure Physics of the Academy of Sciences of the USSR at pressures up to 10–20 kbar<sup>(1–4)</sup>. A substantial expansion of the pressure range became possible owing to the creation of new apparatus and the further development of research methods<sup>(5)</sup>.

The experimental scheme is shown in Fig. 1. The ultrasonic transducers were located outside the high-pressure zone. The ultrasonic pulse passed through the high-pressure piston, was partly reflected from the piston-sample and sample-second-piston boundaries. The reflected signals were received by the same transducers during the periods when the generator was silent. A longitudinal-wave transducer was mounted on the upper piston, and a transverse (shear) wave transducer on the lower one.

The ultrasonic apparatus accordingly had two measuring channels, operating alternately 500 times per second. With this apparatus the change with pressure of the time interval between the I and II echo signals in both channels was determined with an accuracy of not less than  $\pm 0.1 \mu\text{s}$ .

A polycrystalline silver chloride specimen, prepared by pressing powder of "pure" grade, State Standard No. RU 419-57, had a height of 5–6 mm and a diameter of 14–15 mm. During the experiment its height was determined from the piston positions with an accuracy of  $\pm 0.015$  mm. Piston deformations were studied in separate experiments.

The pressure was determined from jumps in the electrical resistance of reference metals, whose wires were present in the chamber during the experiments. The following pressure values (in kilobars) were adopted for phase transitions<sup>(2,6)</sup>:

Fig. 1 and Fig. 2

Figure 1: Fig. 1 and Fig. 2

on increasing pressure, Ce 7.65; Bi 25.5; 27.2 and 89.3; Ta 36.8; Ba 58.5; on decreasing pressure, Ce 5.0; Bi 25.3; 26.8; Ta 36.6. In constructing calibration dependences, the pressure of the phase transition in silver chloride was also used, taken for the forward and reverse runs as equal to 73 kbar on the pressure scale used. This value was obtained by us in separate experiments on the forward run by the method of differential thermal analysis.

On increasing pressure, compression of the container and specimen first occurs, and measurements were usually begun at pressures of 5-10 kbar, using data from previous investigations <sup>(7)</sup> for the initial part and for reference. On decreasing pressure, measurements could be carried almost to complete unloading of the press. All experiments were carried out at a temperature of  $(25 \pm 1)^\circ$ .

The experimental dependences obtained for the specimen length, the transit time of elastic waves, and the pressure in the chamber on the force of the press had a large hysteresis between the forward and reverse runs, typical for

similar chambers. The velocities of propagation of elastic waves in silver chloride determined from these data showed an unambiguous dependence on pressure. The results of processing 5 independent experiments are given in Fig. 2; the data of previous investigations up to 20 kbar are also given there <sup>(7)</sup>. Noteworthy is the increase in the velocity of propagation of longitudinal waves, passage through a maximum at 50 kbar, and an abrupt 30% decrease at the phase transition, followed by an increase for the new phase.

The velocity of propagation of transverse waves decreases up to the transition point and increases with pressure for the new phase.

In the case of purely lattice transitions in ionic crystals (for example, of the NaCl–CsCl type) in rubidium halides <sup>(4)</sup>, an increase in the velocity of propagation of longitudinal waves up to the transition point was observed. In the electronic transition in cerium <sup>(2)</sup>, the longitudinal sound velocity decreased with increasing pressure for the first phase.

In our case, on the curve

**Fig. 1.** Experimental scheme. 1 –X-cut quartz transducer; 2, 5 –hard-alloy pistons; 3 –specimen; 4 –reference-metal wire; I –echo signal reflected from the piston–specimen boundary; II –echo signal reflected from the specimen–second piston boundary

**Fig. 2.** Velocity of longitudinal (a) and transverse (b) ultrasonic waves in silver chloride at pressures up to 100 kbar. The solid curve up to 20 kbar is from work <sup>(7)</sup>

$v_l = f(P)$  a maximum was observed. Taking into account that silver chloride is

not an ideal ionic crystal ( $C_{12}/C_{44} \simeq 6$ ), it may be assumed that at the phase transition at 73 kbar, in addition to rearrangement of the lattice, a substantial change in the electronic states in AgCl occurs, which affects the behavior of the sound velocities. Additional confirmation of this viewpoint is the shift of the absorption-band edge and the decrease in the width of the forbidden band at this transition, observed by Slikaus and Drickamer<sup>(8)</sup>.

It should also be noted that the obtained dependences of the sound velocities in silver chloride on pressure indicate the existence of a certain pre-transition region, in which the approach of the phase transition begins to be felt as the pressure increases. Thus, for example, one may note that near the transition the Debye temperature  $\theta_D \sim \bar{v} = (1/v_l^3 + 2/v_t^3)^{-1/3}$  decreases, i.e., the limiting frequency of lattice vibrations and the quasi-elastic force of interionic interaction decrease. The deep minimum in the dependence  $v_{l,t} = f(P)$  indicates a substantial weakening of the bonds in the lattice—at the point of the phase transition.

Further analysis of the data obtained and calculations of the elastic characteristics of AgCl under pressures up to 100 kbar will be published separately.

The authors express their sincere gratitude to Acad. L. F. Vereshchagin for his attention to and interest in this work, and also to A. A. Zmeyev, V. V. Zlobin, and V. K. Luikh, who took part in the measurements.

Institute of High Pressure Physics  
Academy of Sciences of the USSR

Received  
2 II 1968

## CITED LITERATURE

1. F. F. Voronov, L. F. Vereshchagin, *FMM*, **11**, 3, 443 (1961).
2. F. F. Voronov, L. F. Vereshchagin, V. A. Goncharova, *DAN*, **135**, 5, 1104 (1960).
3. F. F. Voronov, O. V. Stal' gorova, *ZhETF*, **49**, 3 (9), 755 (1965).
4. F. F. Voronov, V. A. Goncharova, *ZhETF*, **50**, 5, 1173 (1966).
5. F. F. Voronov, O. V. Stal' gorova, *Pribory i tekhn. eksp.*, **5**, 207 (1966).
6. L. F. Vereshchagin, E. V. Zubova et al., *DAN*, **169**, 1, 74 (1966).
7. F. F. Voronov, E. V. Chernysheva et al., *FTT*, **8**, 8, 2345 (1966).
8. T. E. Slykhouse, H. G. Drickamer, *J. Phys. Chem. Solids*, **7**, 207 (1958).

*Note: Figure translations are in progress. See original paper for figures.*

*Source: Math-Net.Ru and CyberLeninka. Machine translation. Verify with the original.*