THE BRAGG DIFFRACTION MODELING USING ULTRASOUNDS★

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Usually, the Bragg diffraction is associated with the X ray diffraction in a crystal, but in this paper we will use ultrasounds for modeling and experimental verification of the Bragg equation. The lattice is modeled with a plastic spheres disposed in a cubical volume placed on a goniometer. The reception and emission directions of the ultrasounds can be individual modified independently from the diffraction lattice in different angles.

The diffraction signals are plotted using an X-Y recorder.

Key words: Bragg diffraction, ultrasound, laboratory work.

1. INTRODUCTION

The Bragg Diffraction is used for the study of the crystal’s structure using X rays, which are diffracted by the layers corresponding to the crystalline lattice and which produced figures of interference. The study of the Bragg Diffraction using X rays is difficult to made without some special conditions. There were developed during the time three methods and devices to investigate the structure of the solid body: modifying the incidence angle or rotating method, and Debye – Scherrer used for powder and modifying the wave length – Laue Method. The presented paper use the diffraction of the ultraacustical waves on a crystalline lattice made using plastic spheres disposed in a cube. The paper allows the understanding of the diffraction phenomena of the crystalline structure and the determination of the lattice constant using the Bragg equation.

2. THEORY

It is considered a crystalline lattice made from atoms disposed at equal distances one from another – Fig. 1.

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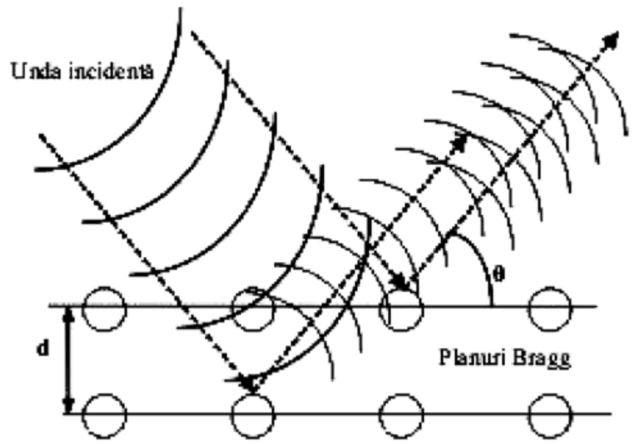

Fig. 1 – Ultrasonic waves diffraction.

If, to the realized structure is sent an ultraacoustical field under an incidence angle θ from one of the planes, outside the structure there will propagate reflected waves with a reflection angle equal with the incidence angle. Each sphere from the lattice will became a secondary source of spherical coherent waves and will propagate outside the lattice.

The wave field is reflected by all the planes resulting, the appearance of some fringes or interference patterns determined by the difference in pathlength distance between the planes and the incidence angle.

Outside the crystalline lattice there will be detected maximums and minims, caused by the interference of the different fields, the directions in which the interference appears is determined by the θ incidence angle. The diffraction image is similar with the one obtained using optical radiation on a lattice. Using Fig. 1 we can deduce the Bragg equation:

$$n\lambda = 2d\sin\theta,$$

(Where $n = 1, 2, 3, \ldots$) allowing the determination of the constant of crystalline lattice knowing the wavelength λ of the wave and the angle θ corresponding to the maximums and minims of interference. The detection of the interference image is made using an ultraacoustical receptor placed under a θ angle corresponding to the incidence angle of the crystal plane.

3. EXPERIMENTAL INSTALLATION

The crystalline lattice is moderated using spheres having 1 cm diameter, placed at a distance of 2 cm between on XX plane named Bragg plane, the Bragg planes are settled at 1.5 cm distance one from another on Z direction; the all ensemble having the side of 12 cm. The ultraacoustical source uses a generator working on 40 kHz frequents (λ = 0,85 cm). The cube which simulates the lattice is placed on a goniometer which can be rotate with 360 grades. The block scheme of the experimental installation is presented in Fig. 2:

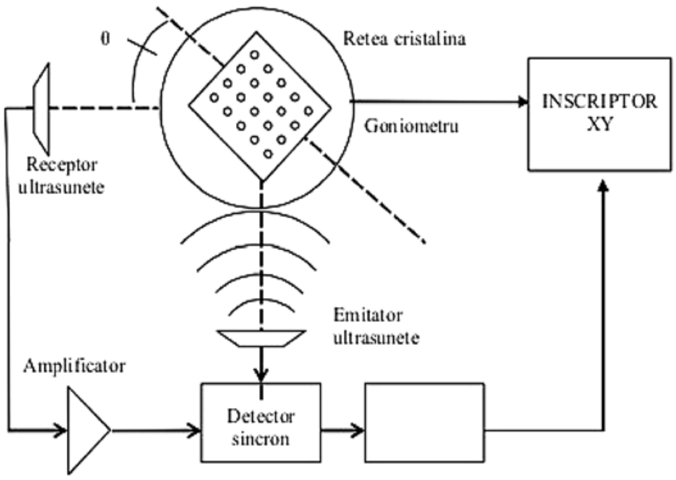

Fig. 2 – The experimental setup for rotating method.

The receptor is a condensator microphone type. Fixed on an arm of the goniometer; the incidence angle of the ultraacoustical waves can be independent modified from the angle made by the microphone's axes with the reflection planes.

The ultraacoustical signal is received by a microphone and is amplified with a synchronous detector which realizes a phase and amplitude detection. The command signal of the detector (reference) has the frequency equal with the frequency of the incident ultrasounds. The detected signal is integrated and then it is send to a XY plotter (on X axes). The value of the angle is transmitted from an angular movement transducer and applied on x axes of the XY plotter. The received signal can be visualized using an oscilloscope.

4. EXPERIMENTAL RESULTS

The lattice is placed in the center of the goniometer, and the ultraacoustical generator is placed under an angle θ to the plane 100 and 110 of the crystalline lattice, like in Fig. 3, after that the ultrasound receptor is rotating using the other arm of the goniometer.

The receptor is fixed on the arm of the goniometer and it is rotating until it is obtained some maximums indications. This operation is repeated for different angles, using the XY plotter the maximums and minims can be recorded

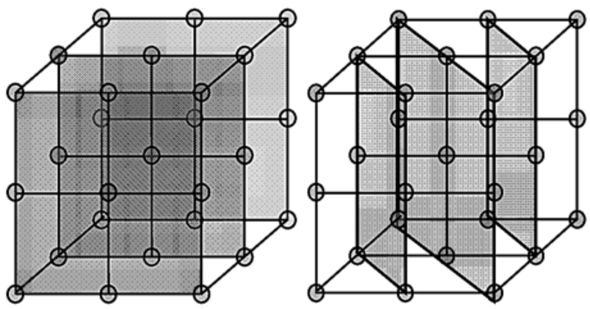

Fig. 3 – The crystalline lattice of NaCl – planes 100 and 110.

corresponding to the interference filed for variables angles. Knowing the wavelength equal with 0.85 cm and the value of θ angle there can be determined the lattice constant using the Bragg equation. In Fig. 4 it is presented the experimental installation.

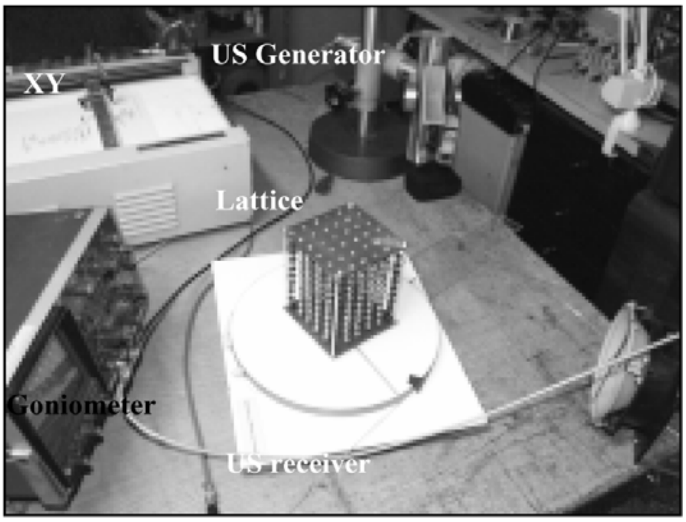

Fig. 4 – The experimental installation for the study of diffraction using the rotating method.

For reducing the perturbation effects of some secondary lobes of emission of the ultrasounds generator, this is placed at a distance of 50 cm from the goniometer, and the mobile arm with the receptor at a distance of 30–50 cm. The crystalline lattice is rotating – method Debye – Scherrer – using a goniometer and keeping the relative positions fixed for the source and the receptor.

In Fig. 5 is presented the diffraction signal obtained by rotating the lattice with a 180 grade angle. There we can observe the apparition of some maximums for the 100 and 110 planes.

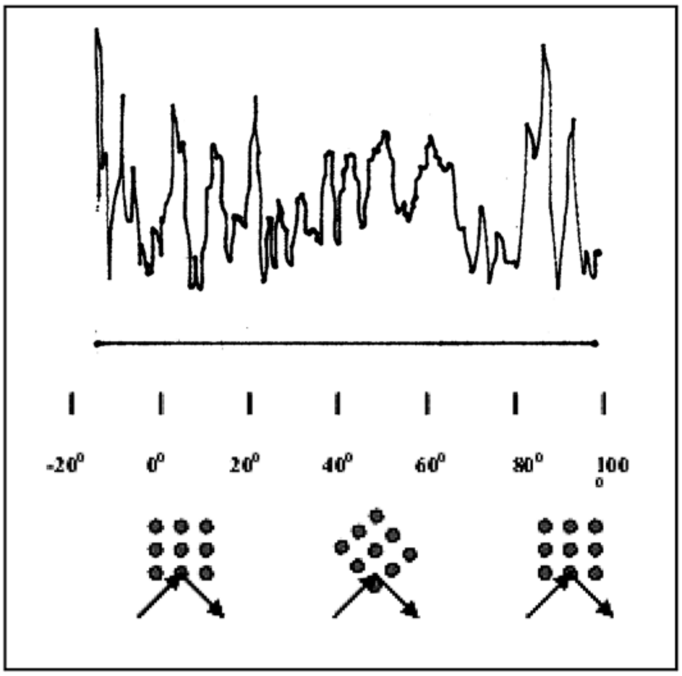

Fig. 5 – Experimental results.

5. CONCLUSIONS

The work paper allows the understanding of the diffraction phenomena of the waves, to deepen and fix the knowledge regarding the crystals structure.

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