Diffraction of light due to ultrasonic wave propagation in liquids

Aritra Mukhopadhyay

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1 Objectives

1. To study the diffraction of light due to propagation of ultrasonic wave in a liquids

2. To determine the speed of sound in various liquids at room temperature

3. To determine the compressibility of the given liquids

2 Apparatus

- Radio frequency oscillator fitted with a frequency meter

- Quartz crystal slab fitted with two leads

- Spectrometer

- Glass cell with Turpentine oil

- Sodium lamp

- Spirit level

3   Theory

Acoustic waves in **closed** liquids cause periodic high and low density regions in them. The spacing between high-density and low-density regions of ultrasonic waves in the MHz range is similar to the spacing in diffraction gratings. Since these density changes in liquids will cause changes in the index of refraction of the liquid, it can be shown that parallel light passed through the exciting liquid will be diffracted much as if it had passed through a grating. The experiment can be used as an indirect method to measure the velocity of sound in various liquids. The phenomenon of interaction between light and sound waves in a liquid is called the **DebyeSears effect**.

The successive separations between two compressions or rarefactions are equal to the wavelength of the ultrasonic wave, λ_u in the liquid. Due to reflections at the sides of the tank or the container, a stationary wave pattern is obtained with nodes and antinodes at regular intervals. In these periodic high and low density regions, the liquid acts as a diffraction grating.

If λ_u denotes the wavelength of sound in the liquid, λ the wavelength of incident light in air and θ_n is the angle of diffraction of nth order, then we have:

$$d \sin \theta_n = n\lambda$$

Here, the liquid acts as the diffraction grating. So, here, the $d(= (e+b) = \frac{1}{N})$ becomes equal to λ_u. Thus:

$$\lambda_u \sin \theta_n = n\lambda$$

Now, if ν is the frequency of the crystal, the velocity V_u of the ultrasonic wave in the liquid will be:

$$V_u = \nu \lambda_u$$

References

[SPS, 2022] SPS (2022). Lab manual. *Website.* https://www.niser.ac.in/sps/sites/default/files/basic_page/Diffraction%20of%20light%20by%20ultrasonic%20waves.pdf.