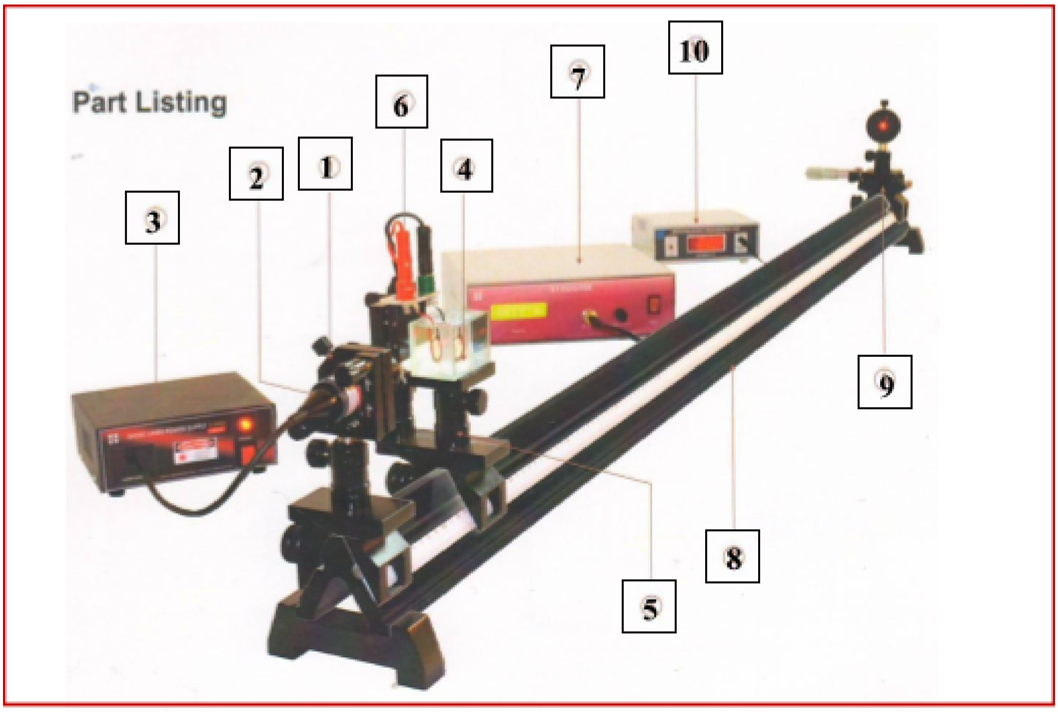
Experiment No. 7

ULTRASONIC DIFFRACTION EXPERIMENT

I. OBJECTIVE

- Determination of the velocity of ultrasonic wave in liquid using the ultrasonic diffraction apparatus.
- Measurement of the bulk modulus of the given liquid.
- Estimation of the compressibility of the liquid.

II. APPARATUS



1. Kinematic Laser Mount
2. Diode Laser
3. Power Supply for Laser
4. Glass Tank with Liquid
5. Glass Tank Holder

6. Crystal with Mount
7. RF Oscillator
8. Optical Rail (1500 mm)
9. Cell mount with linear translation stage and Pinhole detector
10. Output measurement unit

III. THEORY

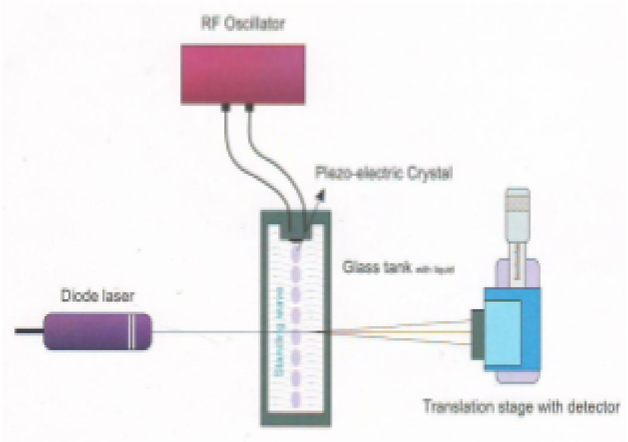


Fig. Optical system for observation of diffraction by ultrasonic waves

The ultrasonic waves generated by the transducer travels down the medium (liquid), gets reflected at the bottom (flat glass plate) of the cell. The incident and reflected waves interfere and stationary/standing waves pattern is formed. The velocity of the ultrasonic waves in a liquid is calculated using the formula

$$V = \nu\Lambda$$

where $\boldsymbol{\nu}$ is the frequency of the crystal oscillator and $\boldsymbol{\Lambda}$ is the wavelength of sound.

We have

$$\Lambda = \frac{n\lambda}{\mathrm{sin}sin\,\theta}$$

Where $\boldsymbol{n}$ is the order of diffraction, $\boldsymbol{\lambda}$ is the wavelength of the laser used and $\boldsymbol{\theta}$ is the angle of diffraction.

We can find the angle of diffraction by the equation

$$\theta = (D/L)$$

D is the order length and ***L*** is the distance measured from the crystal oscillator to the detector.

The bulk modulus of the liquid

$$\beta = \rho V^2$$

Where $\boldsymbol{\rho}$ is the density of the liquid and ***V*** is the velocity of the ultrasonic wave.

The adiabatic compressibility of a liquid can also be calculated using the relation

$$k = 4\rho v^2$$

IV. **<u>EXPERIMENTAL SETUP AND PROCEDURE</u>**

- Fix the laser mount on the optical rail.
- Place laser on the mount properly
- Place the glass tank holder on rail. Fill the glass tank with liquid and keep it on the tank holder.
- Fix the crystal on the mount and keep it immersed fully in the liquid. Connect it to the RF oscillator.
- Fix cell mount with linear translation stage on the rail. Insert the pinhole detector into the cell mount and connect the output probe to the measurement unit.

- Switch on the laser and output measurement unit. Align the crystal and laser so that laser beam is parallel to the face of the crystal. Adjust the kinematic setup provided on the laser mount to get the beam in the field of standing wave generated.

- Keep the laser spot falling on the detector stage and adjust the frequency of the oscillator until you get a very good fringe pattern on both sides of the central bright spot. Using the micrometer driven stage move the detector to extreme end of the diffraction pattern.

- Scan the pattern at close intervals. Each time note the micrometer reading and corresponding output of the detector.

- Plot a graph (Distance Vs detector current). From the graph we can note down the D, the distance from the central bright spot to the n^{th} order spot.

V. RESULTS AND CALCULATIONS

Wave length of the laser $\lambda = 650$ nm

Least count of the micrometer $=$ 0.01 mm

Distance between the crystal and the detector, $L =$ -------m

Frequency of the crystal $\nu =$ ______________ MHz

Observations:

Micrometer reading (mm)	Detector Output (μA)

From Graph

Order n	**Distance from the central spot to n^{th} order spot D (m)**	**Angle of ultrasonic $\theta = tan^{-1}(D/L)$ diffraction**	$\Lambda = n\lambda / Sin\ \theta$ **(m)**	$V = \nu\Lambda$ **(m/s)**

Mean velocity = _______m/s

The Bulk modulus of the liquid $\beta = \rho V^2$ = _______Pa

The compressibility $K = 1/\rho V^2$ = _______Pa^{-1}

VI. PRECAUTIONS

- Laser radiation predominantly causes injury via thermal effects. So one should avoid looking directly into the laser beam.

- Care should be taken while handling the crystal oscillator and other components.

- Remove the crystal from the liquid as soon as the experiment is completed.

Otherwise the crystal may get damaged.