ULTRASONIC DIFFRACTION (HOLMARC)

INSTRUCTION MANUAL

PRODUCT FEATURES

Ultrasonic diffraction apparatus is used to study the diffraction of light by ultrasonic waves. The apparatus consists of a graduated long rail and rail carriages appropriately fitted with laser head and detector with translation stage. The ultrasonic diffraction setup uses laser as light source. We can perform the following experiments using this apparatus.

1. Determination of velocity of ultrasonic wave in liquid.
2. To find bulk modulus of the given liquid.
3. To find compressibility of the liquid.

SAFETY INSTRUCTIONS

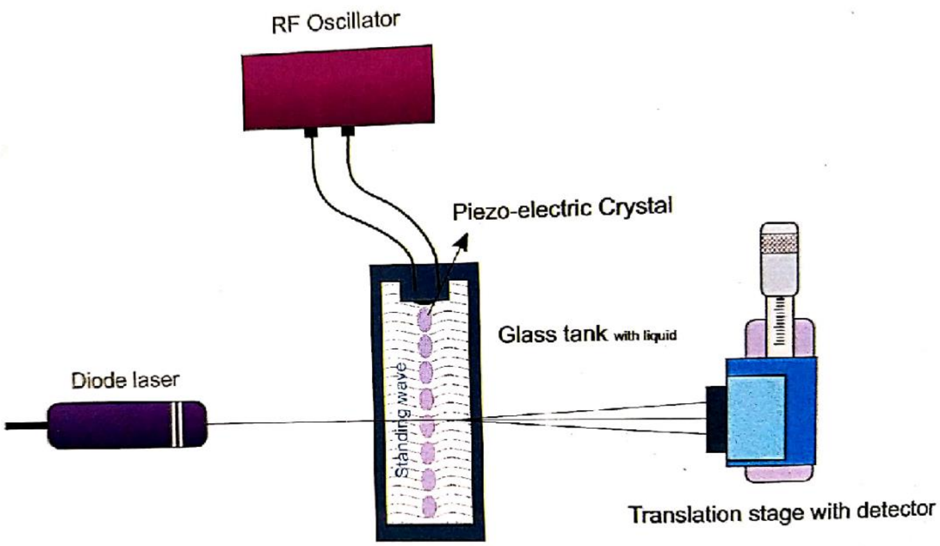
1. Laser radiation predominantly causes injury via thermal effects; avoid looking directly into the laser beam.
2. Care should be taken while handling by crystal oscillator and other component.
3. Remove the crystal from the liquid as soon as the experiment is completed. Otherwise the crystal may get damaged.

FUNDAMENTALS

AIM:

1. To find the velocity of ultrasonic wave in a liquid.
2. To find the bulk modulus of the given liquid.
3. To find the compressibility of the liquid.

THEORY



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 stationery/ standing waves pattern is formed. The velocity of ultrasonic waves in a liquid is calculated using the formula:

$$V = \upsilon\Lambda$$

Where υ is the frequency of the crystal oscillator and Λ is the wavelength of sound.

We have $$\Lambda = n\lambda / \text{Sin}\ \theta$$

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

We can find angle of diffraction by the equation

$$\theta = \tan^{-1} (D/L)$$

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

The bulk modulus of the liquid

$$B = \rho V^2$$

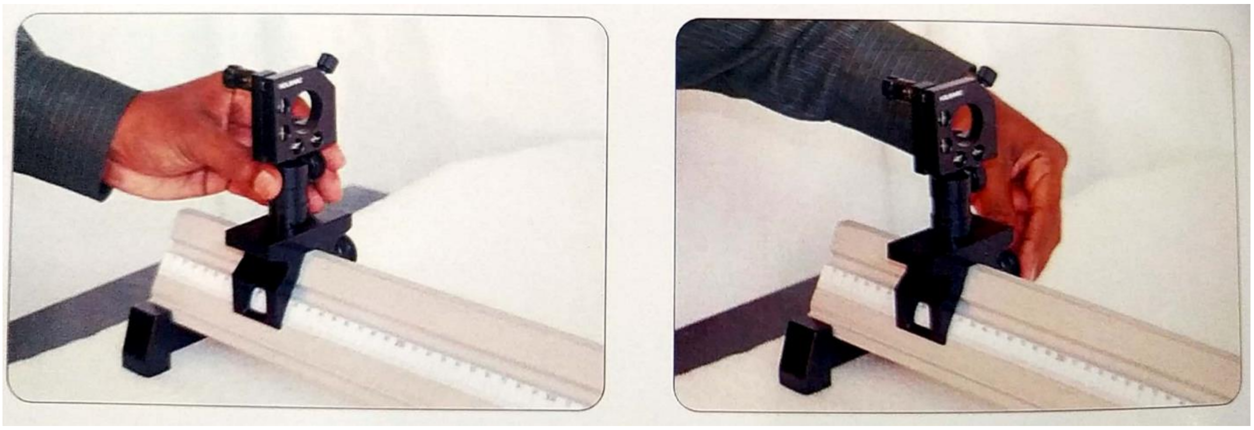
Where $\boldsymbol{\rho}$ is the density of the liquid and **V** is the velocity of the ultrasonic wave.

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

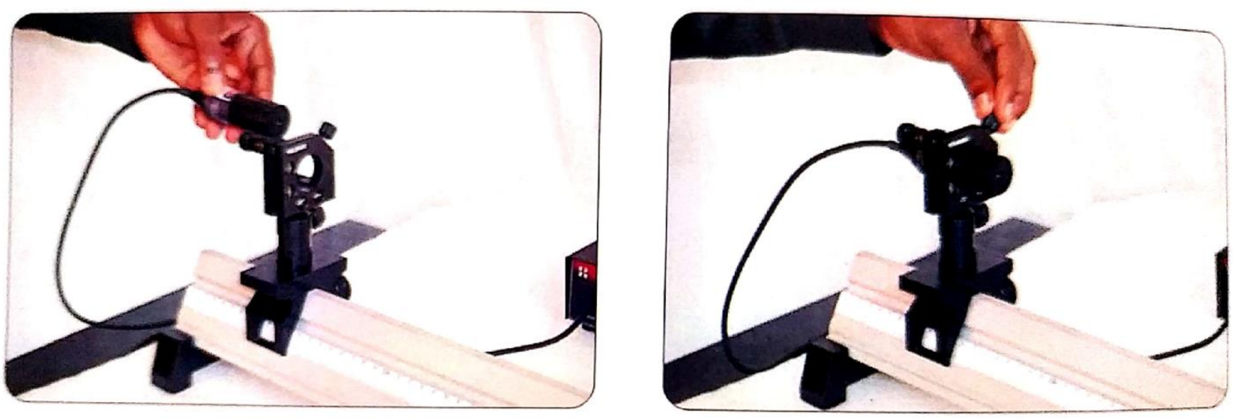
$$K = 1 / \rho V^2$$

EXPEERIMENTAL SET-UP

1. Fix the laser mount on optical rail.

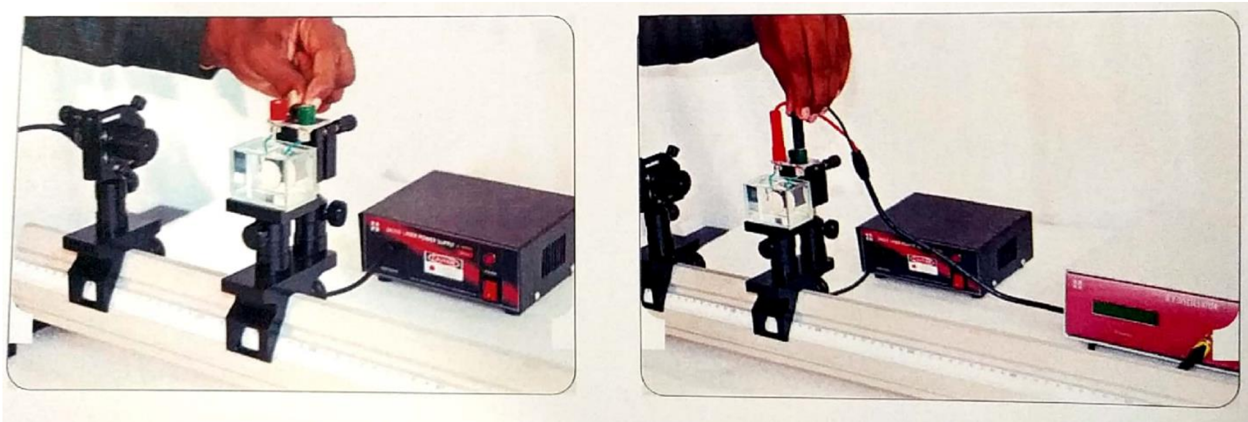


2. Place laser on the mount properly.

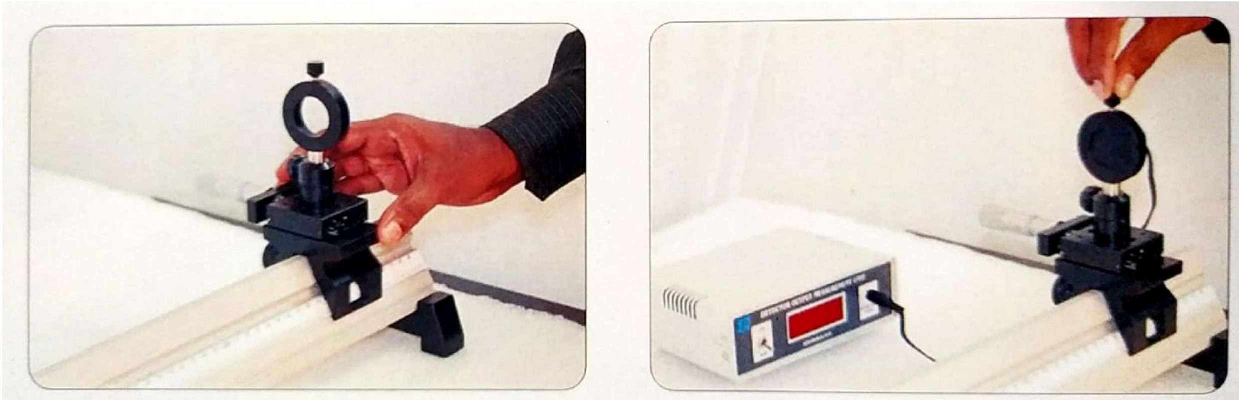


3. Place the glass tank holder on rail. Fill the glass tank with liquid and keep it on the tank holder.

4. Fix the crystal on the mount and keep it immersed fully in the liquid. Connect it to the RF oscillator.



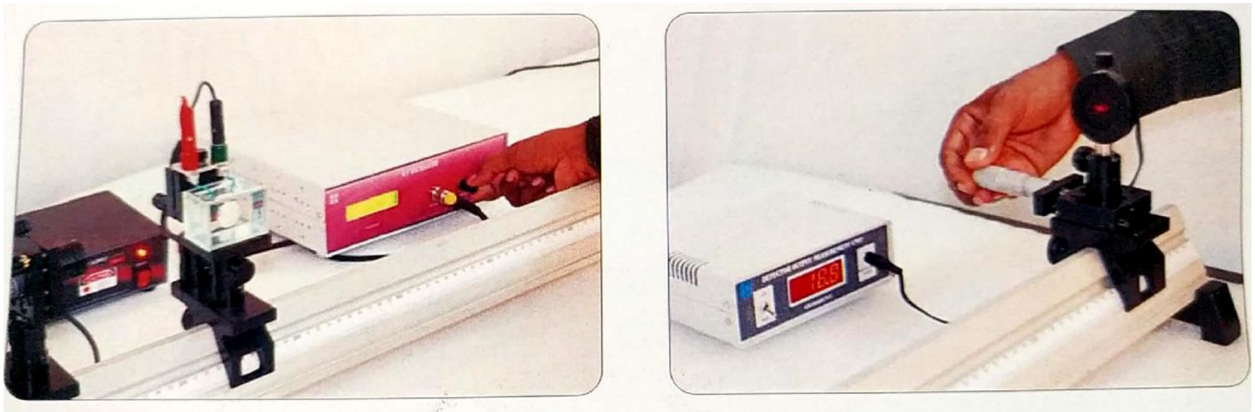
5. Fix cell mount with linear translation stage on the rail. Insert the pinhole detector into the cell mount and connect the output probe to measurement unit.



6. 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.

7. Keep the laser spot falling on 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.



8. Scan the pattern at close intervals. Each time note the micrometer reading and corresponding output of the detector.
9. 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.

MEASUREMENTS

Wave length of the laser λ = 650nm
Least count of the micrometer = 0.01mm
Distance between the crystal and the detector, L = ……………..m
Frequency of the crystal υ = …………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 diffraction $\theta = \tan^{-1}(D/L)$	$\Lambda = n\lambda/\sin\theta$ (m)	$V = \upsilon\Lambda$ (m/s)

Mean velocity = ………..m/s

The Bulk modulus $\beta = \rho V^2$ = …………Pa

The Compressibility $K = 1/\rho V^2$ = …………Pa^{-1}

ITEMS AND SPECIFICATIONS

1. Diode laser with Power Supply
   Input ……………230V AC/50Hz
   Output power……………3Mw
   Wavelength …………………650nm

2. Output measurement unit
   Input …………….230V AC/50Hz
   Range…………….1 - 199µA, 0 – 199 Ma

3. Pinhole photo detector
   Detector Type ………….Photo transistor
   Pinhole Diamete…………0.7mm

4. Optical Rail
   Length …………..1500mm
   Material ………..Anodized Aluminum

5. Cell Mount with linear translation stage
   Total travel…………….25mm
   Least count…………….0.01mm

6. Glass tank
   Material : Float glass
   Dimension : 50mm x 35mm x35mm

7. Glass tank holder

8. Piezo Electric Ceramic Disc Transducer
   Dimension : 20mm diameter x 0.7mm thickness
   Resonant frequency fr : 3MHz ± 50KHz
   Resonant impedance Zm : ≤ 6 Ω
   Static capacitance Cs : 3800pF ± 20% @ 60Hz/1V

9. RF Oscillator
   Frequency Range ………..2MHz – 6MHz
   Input…………….230V/50Hz

MAINTENANCE NOTES

1. Always keep the equipment in a moisture and dust free atmosphere.
2. 'Switch on' all the electronic devices used in this experiment at least once a weak.