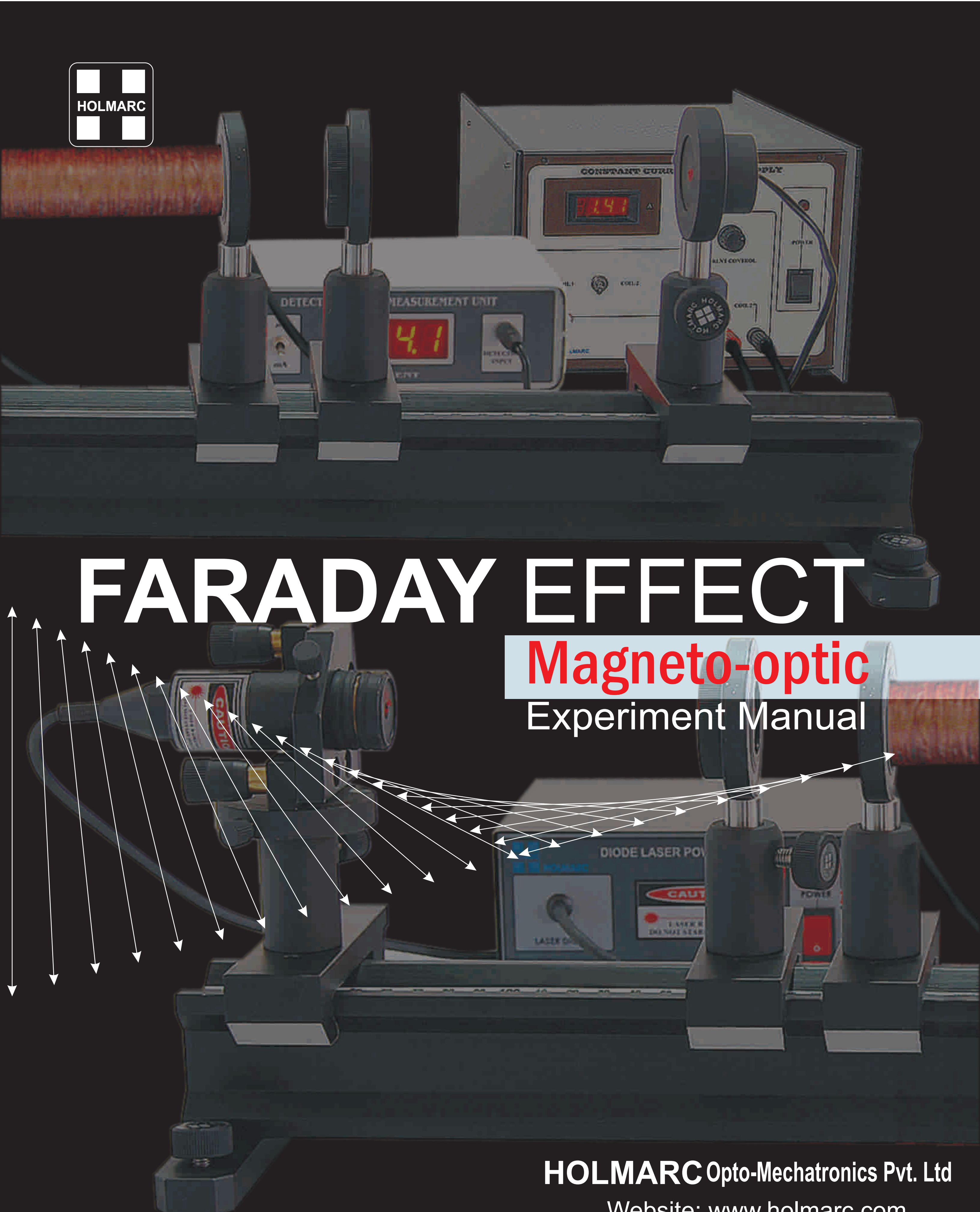

HOLMARC

FARADAY EFFECT

Magneto-optic

Experiment Manual

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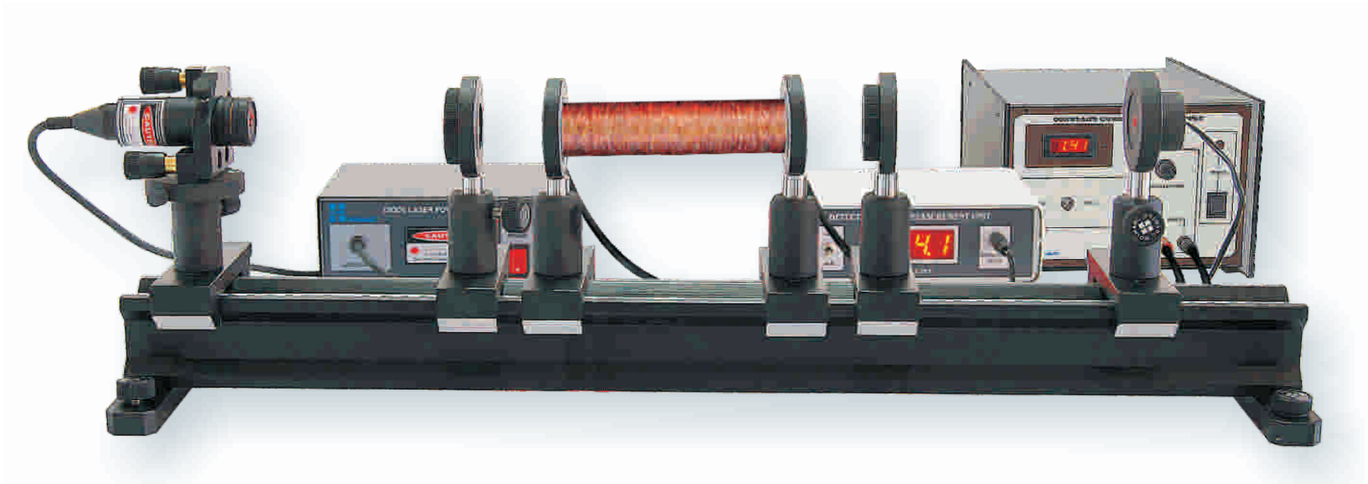
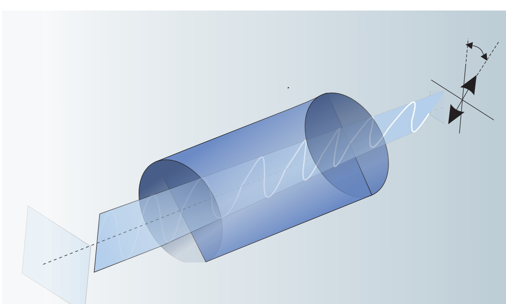
Faraday Effect Apparatus

Model No: HO-ED-P-04



Experiments



Magneto-optics: It is the optical activity in a homogeneous medium in the presence of a magnetic field. In physics, the Faraday effect or Faraday rotation is an interaction between light and a magnetic field. The rotation of the plane of polarization is proportional to the intensity of the component of the magnetic field in the direction of the beam of light. The angle of rotation of the polarization-plane of plane polarized light through a transparent material is found to be a linear function of the product of the mean flux-density and the length of the optical medium. The factor of proportionality is known as Verdet's constant.

Required Components

Introduction

In 1854 M. Faraday found that isotropic media become optically active when a magnetic field is applied in the propagation direction of the light. This was one of the earliest indications that light and electro-magnetism are related. The angle φ by which the plane of polarization of a linearly polarized beam is rotated is given by

$$\varphi = V H l \qquad (1)$$

where "V" is the so-called Verdet constant, and "H" is the magnetic field (in Oersted) in the direction of the light, and the "l" is the length of the medium.

In order to understand the effect, it is useful to think of linearly polarized light as the superposition of left- and right-handed circularly polarized light of equal amplitude. If it happens that the index of refraction for left and right light are not the same (this is called circular bi-refringence), then the phase of one component will advance relative to the other by some angle. When recombining the two components, linear polarization results that is rotated by half that angle.

Quantum mechanics is needed to understand the reason for the different indices of refraction. Left and right light is really a beam of polarized photons with spin 1 and magnetic substate +1 or - 1, respectively. In a magnetic field, the energy levels that can be excited by such photons correspond to slightly different frequencies (discovered by Zeeman). The frequency shift is the Larmor frequency $\omega L = (e/2m)B$, where e and m are charge and mass of the electron. From this it is quite straightforward to derive the following expression for the Verdet constant

$$V = -\frac{e}{2mc}\lambda\frac{dn}{d\lambda} \qquad (2)$$

This equation, which was derived by H. Becquerel (1897) shows that the Verdet constant depends on the wavelength, the dispersion, and the charge to mass ratio of the electron.

Magnetic Field

The magnetic field is produced in a long solenoid. The solenoid has windings of #18 wire. The number of turns N = 2506 turns. The electrical resistance of the coil has been measured to be 5.2 Ohms at room temperature (note that this increases with increasing temperature).
The length of the coil (97 mm) is quite a bit shorter than the length of glass rod (120 mm). We may thus assume that the field B has fallen off to a negligible value before the end of the glass rod.
In this case, the integral in equation may as well be taken from $-\infty$ to $+\infty$. From E&M, we know that

$$\int_{-\infty}^{+\infty} B\,dl = \mu_0 N I \quad , \qquad (3)$$

where $\mu_0 = 4\pi\cdot 10$-7 mkg/C2, N is the number of windings, and I is the current through the coil.

Laser and light detection

A red and green diode laser (λ = 650, 531.9 nm, respectively) are available for this measurement. The laser output intensity exhibits slow variations in time. One has to keep this in mind for the following measurements. As the laser is warming up, these variations diminish. Measuring the light intensity as a function of time (with no other change) gives you a handle on this effect.

The laser beam should be aligned carefully, centering it on all optical components, the sample tube, and the photodiode. If the beam is not centered well on the photodiode, there may be an unwanted intensity change. This may deflect the light beam and cause unwanted changes in intensity. In addition, the signal from the photodiode may not be linear in intensity. In order to test the alignment and linearity, measure the intensity as a function of the analyzer angle φ for a full revolution, and compare with the expected sin2φ dependence.

The resistive heating of the magnet coil heats the sample and produce convection currents with varying index of refraction. Make sure the coil cooling is on.

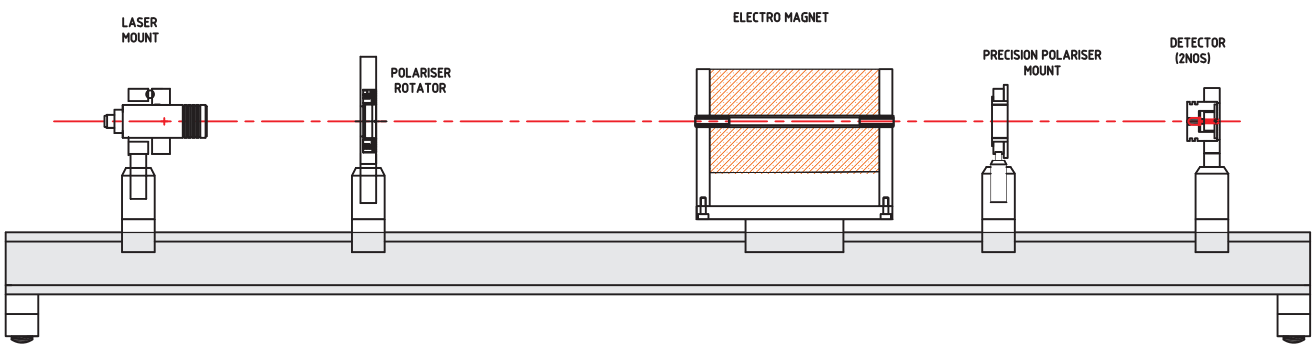


Fig. Experimental arrangement for Faraday effect

EXPERIMENTAL PROCEDURE:

1) Switch off the current and produce darkness by crossing the polarizing filters. Then switch on the current and observe the changes.

2) Produce darkness with the current switch on. Then reverse the current. Find the angle of rotation necessary for such rotation.

3) Varying the current in the step of 0.4A and recording the angles of rotation. Plot rotation angles of light beam (vertical axis) vs. current intensity (horizontal axis).

The method used in this experiment is to observe the intensity change of the transmitted light due to a current change of ΔI. In a second measurement one then determines the angle change Δφ of the analyzing polarizer that causes the same intensity change. The measurement should be carried out for a range of magnetic fields in order to demonstrate that Δφ is proportional to ΔI. The measurement should be carried out at two different wavelengths.

DO NOT LEAVE THE MAGNET AT HIGH CURRENT SETTINGS FOR A LONG TIME, OR IT WILL OVERHEAT. BEFORE LEAVING THE LABORATORY, CHECK THAT THE LASER AND THE MAGNET POWER SUPPLY ARE TURNED OFF!

Calculation

Number of turns in the coil ‘n’ =

Number of turns per unit length ‘N’=

Wavelength of the laser =

Length of the glass rod ‘L’=

Refractive Index of the glass rod =

verdet constant of the glass rod =

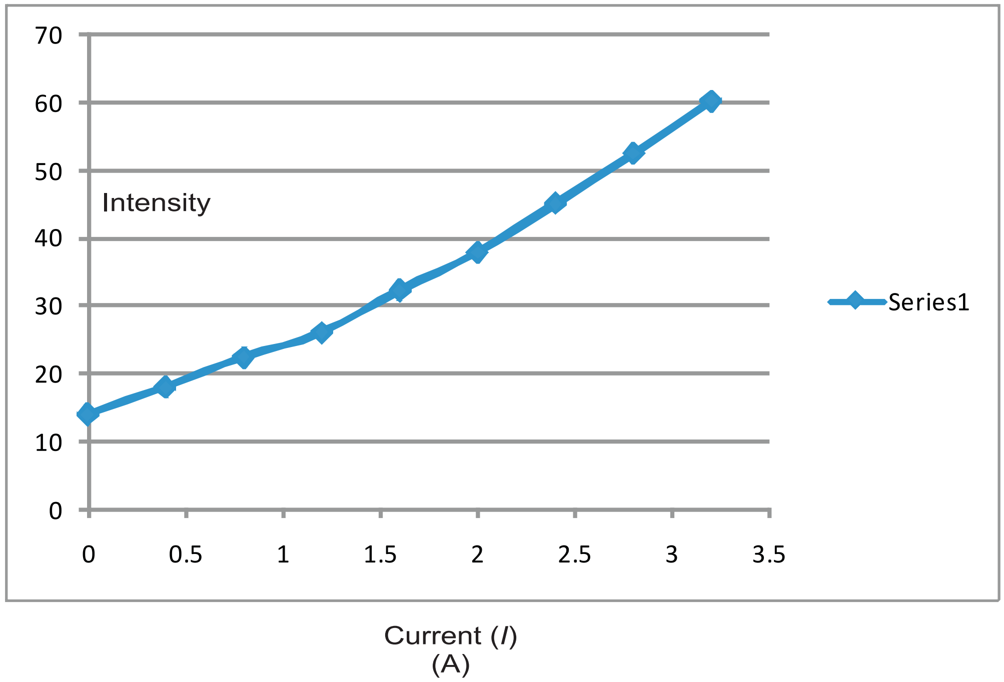
Laser Wavelength = ...   Material =.....Flint Glass.....

Sl. No.	Current (I) (A)	Magnetic Field H= NI	(Min)	Verdet Constant V = $\frac{}{HI}$

Mean Verdet Constant V= ....min/oersted/cm

Oersted (Oe) is the unit of magnetizing field (also known as magnetic field strength or intensity) in the CGS system of units. The unit was established by the IEC in 1930 in honour of Hans Christian Ørsted, who discovered electromagnetism in 1820. It is defined as 1000/4p (≈79.5774715) amperes per meter of flux path, in terms of SI units.

Current (I) (A)	Intensity
0	14
0.4	18
0.8	22.4
1.2	26
1.6	32.2
2	37.8
2.4	45
2.8	52.3
3.2	52.3



Number of turns in the coil 'n' = 2508

Number of turns per unit length 'N'= 2508/15cm = 167.2/cm

Wavelength of the laser = 650nm

Length of the glass rod 'L'= 10cm

Refractive Index of the glass rod = 1.717

verdet constant of the glass rod =

Magnetic Field Calculation

H= NI

N = 167.2

I = Current in Ampere

Sl. No.	Current (I) (A)	Magnetic Field H= NI	(Min)	Verdet Constant V = $\frac{}{\text{HI}}$
1	1.33	0.698×10^{3}	120	1.72×10^{-2}
2	2.78	1.459×10^{3}	240	1.65×10^{-2}
3	3.15	1.654×10^{3}	276	1.69×10^{-2}

Mean Verdet Constant V= 1.686×10^{-2} ....min/oersted/cm

EDUCATIONAL EXPERIMENTS

FIXED SETUPS

1] Diffraction Experiments Setup
2] Laser Diode Characteristic Study
4] Opto-electronics Experiment Setup
5] Polarization Experiments Setup.
6] Ultrasonic Grating Setup(Laser based)
7] Michelson Interferometer Setup

KITS

1] Standard Laser Kit
2] Opto-electronics Kit
3] Optical Fiber Characterization Kit
4] Optical Fiber Communication Kit
5] Michelson Interferometer
6] Sagnac Interferometer
7] Holographic Grating
8] Holographic Experiment Kit
9] Speckle Interferometry
10] CCD Based Zeeman Effect Apparatus
11] CCD Based Metal Arc Spectrometer
12] Interferometer Kit
13] Faraday Effect Apparatus
14] Fabry Perot Etalon
15] Fabry Perot Interferometer
16] Cornus - Experiment (Laser based)
17] Newton Interferometer (Laser based)
18] Spectrometer with hollow & solid prism, grating etc.
19] Ultrasonic grating with Video Spectrometer
etc.

RESEARCH AND PROJECT EQUIPMENTS

1] Z-scan system
2] Dip coating unit
3] Optical chopper
4] Thin film coating machine
5] Silar controller
Etc.

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HOLMARC

Established in 1993, Holmarc is a diversified manufacturing company catering to the needs of industry, research and education.

Our products for industry include linear motion slides, linear and rotary stages, motion control electronics and software.

For R&D market, we manufacture wide range of optics and opto- mechanics for laser based research in nuclear physics, space applications, biology, bio-technology, chemistry, semi-conductor physics etc.

Our educational products for optics, opto-electronics and optical fiber resulted from our years of manufacturing experience in research

PRODUCT PROFILE

Educational products include

OPTICS
OPTO- ELECTRONICS
OPTICAL FIBER
LASER

All our products are designed in such a way that students gain hands on experience and in depth knowledge. As far as possible we have followed open architecture in design and construction for students to understand the basics.
Another noticeable feature is modular nature of components. This feature allows users to setup innovative project and experiments.
We keep all standard items in ready stock for immediate delivery. All our components including diode lasers are warranted for one

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