tumour selectivity was best 3 to 4 h after administration of the drug. The drug also showed rapid clearance and the drug induced fluorescence from tumour, surrounding tissue, and normal mucosa was not detectable beyond 72 h of its administration. For photodynamic therapy the tumour was irradiated with light at 660 nm (± 25 nm), 4 h after drug administration. The irradiation dose used for the experiments was 100 J/cm^2. Small tumours subjected to PDT became edematous at 24 h and a reduction in tumour size was observed in next 48 h. A week after the PDT the tumour was seen to regress completely and only scar tissue was observed. In contrast, for larger tumours necrosis was confined to the superficial region (300-800 μm) of the tumour. About 20% reduction in the tumour size was observed 72 h after PDT. For one of the animals having large tumour, PDT was repeated at 72 h interval.

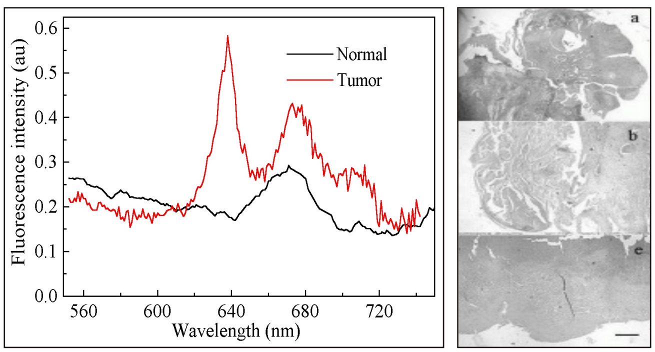

Fig. L.2.1 *Left panel: Fluorescence spectra collected from tumour (red) and normal mucosa (black) at 4h after intraperitoneal administration of Cp6. Fluorescence band with peak at 672 nm corresponds to Cp6 and that with peak at 635 nm arises due to endogenous porphyrin. Right panel: (a) Photomicrographs showing histology of tumour tissue from control animals that received drug but not light irradiation and (b) tumour subjected to PDT 4h after intraperitoneal administration of Cp6. Hematoxylin stain can be seen in dark control tumours due to the presence of intact nucleus. In contrast, photodynamically treated tumours showed little staining because of cellular necrosis and loss of nuclear material. Magnification used is 5X.*

Complete tumour regression was observed after three PDT treatments. For histological examination a few of the photo dynamically treated and dark control animals (animals that received drug but not light) were sacrificed 48 h after PDT. The photomicrographs (fig. L.2.1, right panel) suggest that photodynamic treatment leads to cellular necrosis and loss of nuclear material. [*Alok Dube, Sulbha Sharma and P K Gupta, to appear in Oral Oncology*].

(Contributed by: P.K. Gupta; pkgupta@cat.ernet.in)

L.3 Observation of spin-independent transverse shift of the center of gravity of a reflected Laguerre-Gaussian optical beam

Some time ago Fedoseyev predicted (Opt. Comm. 193, 9, 2001) that when a linearly polarized Laguerre-Gaussian (LG) beam undergoes reflection from a refractive index interface, a transverse displacement of the center of gravities of the refracted and the reflected beams should occur with respect to the positions predicted by the geometrical optics. This kind of shift is different from the longitudinal shift observed earlier in total reflection regime (Goos-Hänchen effect) as well as from the spin dependent transverse shift (Imbert-Fedorov effect). We have carried out the first experimental measurement of the predicted shift using linearly polarized 632.8 nm He:Ne laser beam that was transformed into a LG beam by use of computer generated holograms. A glass prism (refractive index 1.5) that was mounted on a rotational stage was used to reflect the LG beam. By rotating the prism, the angle of incidence of the beam on the reflecting surface of the prism could be varied from 0° to 90°. The reflected LG beam was imaged using a CCD camera. Since in our experiment the plane of incidence was parallel to the horizontal plane, the predicted linear transverse shift (LTS) should result in a vertical shift of the reflected beam with respect to the plane of incidence. The predicted LTS is small, at best ~ a few l , with LTS for p- polarized beam being significantly larger than that for s- polarized beam. Therefore, to avoid interference with any vertical shift of the beam that may occur due to insertion of hologram used for generation of LG beams, we measured the difference in LTS for s- and p-polarized beams, keeping the hologram fixed. For the measurement of these small shifts we used the cross-correlation method [*J. Gelles, B. J. Schnupp, M. P. Sheetz, Nature 331*, *450*, *1988*] to determine the centroid of CCD images and thus locate the center of gravities of the incident and reflected beams. The estimated resolution of our position measurements was 162 nm and 138 nm in x and y directions respectively.

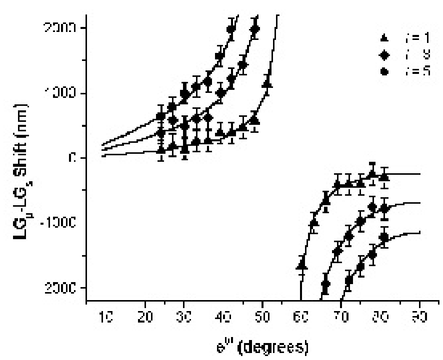

Fig. L.3.1 *The observed transverse shifts of reflected LG beams on partial reflection from air-glass interface*

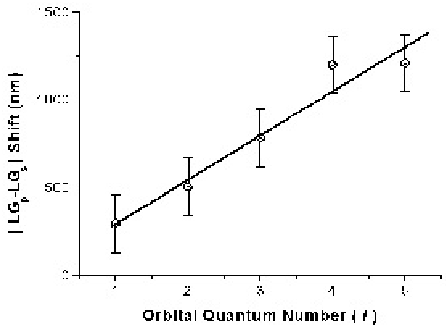

Fig. L.3.2 *The variation of absolute value of relative transverse shift with changing orbital quantum number.*

In fig. L.3.1 we show the measured differential transverse shift of the reflected LG beams for a range of angle of incidence (~ 20° to 80°). Measurements could not be carried out in the vicinity of Brewster angle (~ 56°) because of the low reflection coefficient. The measured differential LTS is in good agreement with the theoretical predictions (shown by solid line in fig. L.3.1). The dependence of the measured LTS on azimuthal index of LG beam for a fixed angle of incidence (81°) is shown in fig. L.3.2. The linear dependence of the shift on orbital quantum number of the beam can provide an attractive non-interferrometric method for measurement of OAM [*R Dasgupta and P K Gupta, to appear in Optics Communications*].

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L.4 Design and fabrication of electro-optic modulator based on $LiNbO_3$

Light waves can be made to carry information, by modulating their intensity, phase, frequency or polarization. Among these, the intensity modulation is the most popular for optical fibre communication systems, primarily due to the simplicity of envelope photo detection. The intensity modulation can be implemented simply by direct modulation of the laser sources. Due to the requirements of bandwidth and efficiency, only semiconductor lasers are of practical interest for direct modulation. Several types of modulators have been developed over the past several decades for optical fibre communication applications. These include lithium niobate ($LiNbO_3$) modulator, semiconductor electro absorption modulators (EAMs), semiconductor Mach-Zehnder modulator and polymer modulators.

Electro-optic modulators use an electric field to alter the characteristics (band gap, index of refraction) of a material through which light is travelling, thus changing the characteristics of the light itself. The $LiNbO_3$ has always been preferred over other comparative materials due to its high electro-optic (EO) coefficient, non-hygroscopic nature, hardness and mechanical strength. Moreover as the optical communication wavelengths fall in the ranges 1.3 μm and 1.55 μm and optical distortion for $LiNbO_3$ is negligible for wavelength λ >1μm, its figure of merit is highest for these applications. The change in index of refraction of the material can be used to modify light passing through the material. Modulators are key components for high-speed optical transport systems. They modulate laser output into high-speed light pulses that transmit voice, data and video signals over fibre-optic cables. The electro-optic modulator based on lithium niobate presently operate at 40 gigabits per second (Gbps) which is the highest speed commercially available in optoelectronic devices. This is four times faster than current-generation based modulator products.

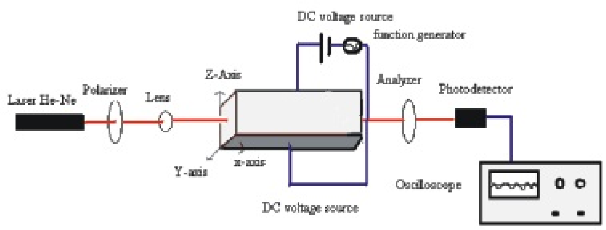

Fig. L.4.1 *Schematic of experimental set up used for modulation*

Fig. L.4.2 *$LiNbO_3$ Modulator module*

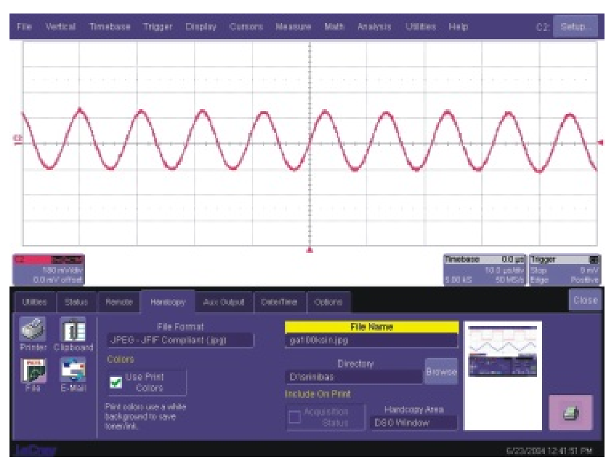

Fig. L.4.3 *Modulated out put signal at 100 kHz*