INVESTIGATION OF QUANTUM WELL STRUCTURES USING LONGITUDINAL AND TRANSVERSE ELECTRIC FIELD COMPONENTS

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Laser beams with axial symmetric polarization have many unusual properties making them an excellent instrument for research work. When a radially polarized beam is focused with high numerical aperture, a strong longitudinal electric field component is observed. In contrast the azimuthally polarized beam generates a strong magnetic field on the optical axis, while the electric field is purely transverse and zero at the centre.

Both fields are used to experimentally investigate heavy holes (hh) and light holes (lh) absorption lines of a Quantum well heterostructure. The absorption by heavy and light holes is polarization dependent and occurs at different wavelengths. The quantum well is 80 nm deep from the sample surface and the sample is illuminated from the growth direction. In this geometry the focused azimuthally polarized beam has the same polarization state as that of a TE polarized beam if illuminating the sample from the in-plane direction while the radially polarized field has a TM component when viewed from the in-plane direction.

The radially and azimuthally polarized donut modes are generated by using a tuneable external cavity diode laser as a light source and a liquid crystal device as a polarization converter. We use an annular aperture to enhance the longitudinal field with respect to the transverse field at the focus of a high NA microscope objective. In air, the longitudinal component has approximately 70% of the total intensity, but this is reduced to almost 10% by the refraction of the high refractive index (n=3.5) material of the quantum well structure. Nevertheless it is evident that the amount of transverse component in the focused radially polarized donut mode is significantly smaller compared to that in azimuthal polarization and fits well to calculated profiles (fig 1). The longitudinal field component inside the medium can be enhanced by using a solid immersion lens.

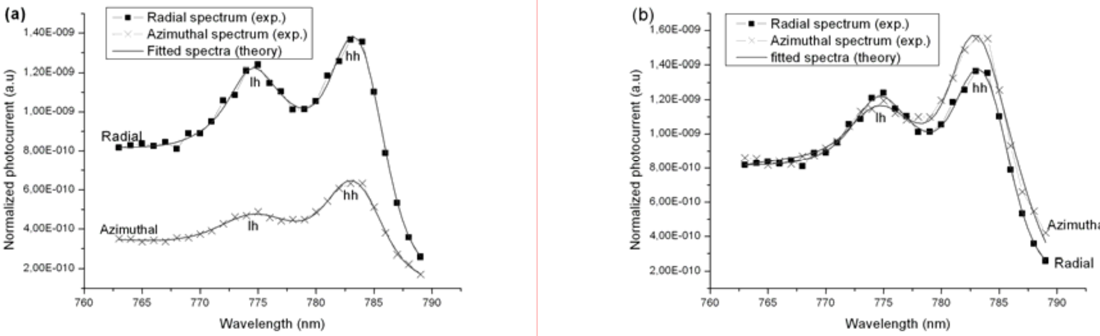

Fig.1:(a) Photocurrent spectra for azimuthally and radially polarized beams. Fresnel coefficients for azimuthal and radial polarization are different hence the spectrum for azimuthal is lower on the graph than that for radial polarization.(b) Shows a comparison between the azimuthal and radial spectra at the light hole (lh) peak. Difference between the radial and azimuthal spectra at the heavy hole (hh) peak is approx. 10%.

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