EPSRC GRANT GR/L73159/01 **FINAL REPORT**

NOVEL PHOTONIC MICROSTRUCTURES IN SEMICONDUCTORS

Summary

This EPSRC research grant was awarded to Professor R A Abram and Dr S Brand of the Department of Physics, University of Durham and funded a postdoctoral research assistant for three years, the purchase of a Unix workstation and the associated costs, and travel to project meetings and conferences. The project was concerned with the theory of novel and unusual photonic microstructures, and involved collaboration with experimental colleagues at the University of Glasgow. The work in Durham concentrated on calculations of the properties of Penrose-tiled photonic quasicrystals and the light-matter interaction in photonic microstructures of cylindrical and spherical symmetry.

One problem with photonic crystals is the difficulty in producing a full photonic band gap for all directions of propagation and all polarizations of the light, and there have been suggestions that this could be achieved more easily in two-dimensional quasicrystals that have relatively high rotational quasisymmetry. We considered two-dimensional photonic quasicrystals with air cylinders at the vertices of a Penrose-tiling pattern. By considering the Fourier representation of the spatial distribution of the relative permittivity, we were able to predict the occurrence and the positions of the photonic band gaps and also show that their widths could be expected to be much smaller than in crystals. To study the light transmission properties, we used a modified version of the publicly available code of Ward and coworkers. The calculated spectra contain dips at frequencies which are the same for both polarizations and for all directions of propagation, indicating the presence of band gaps overlapping for all directions in reciprocal space.

Using non-local dielectric response theory, we have described exciton-light interactions in a system consisting of a cylindrical optical cavity with a quantum wire on the cylindrical axis. An interesting feature of the system is that a converging cylindrical electromagnetic wave can be fully absorbed by a quantum wire exciton when the radiative and non-radiative damping of the exciton are equal. The equation for the energies of the polariton states originating from the coupling of the optical modes of the microcavity and the exciton has been obtained, and the transition between the weak and strong coupling regimes has been shown to be similar to the case of a quantum well in a planar microcavity. A similar analysis has been carried out for a quantum dot at the centre of a spherical microcavity. A distinctive feature in this case is that there is only one electromagnetic mode (the TM mode with orbital angular momentum number equal to one) whose electric field is non-zero at the centre and hence able to interact with the quantum dot.

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