X. INFRARED NONLINEAR OPTICS

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1. INFRARED NONLINEAR PROCESSES IN SEMICONDUCTORS

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Studies of resonant, spin-induced, four-photon mixing in (Cd, Hg)Te are continuing. Some time ago, we reported the observation of several distinct spin resonances in our (Cd, Hg)Te sample – a result which indicated that the crystal is inhomogeneous. This experiment is now being used by the Honeywell group as an analytic technique to determine g-value and alloy composition as a function of position in (Cd, Hg)Te. In our work, we have concentrated on homogeneous portions of the (Cd, Hg)Te crystals, which show exceedingly sharp spin resonances. At higher laser powers (in the 500 W/cm^2 range) the four-photon resonances broaden and saturate in a manner similar to that observed in n-InSb. The values of the spin-relaxation times, T_1 and T_2, that we infer are comparable to those measured in InSb. Finally, at the highest laser powers the spin line splits in a quite unexpected way. We suspect that the sideband is a Rabi frequency, induced by coherent oscillation of carriers between the conduction and valence bands. Calculations to test this hypothesis are in progress.

We have made extensive studies of carrier excitation[1] – from donor levels to the conduction band – as n-Ge is irradiated by intense (10.6-μ) laser beams. In cold n-Ge crystals, the optical absorption decreases markedly (by more than a factor of 10) in the power range 100 kW-10 MW/cm^2. A kinetic model, which balances the photoionization rate from 1s levels against the rate of carrier recombination with donors, gives an excellent fit to the data. This experiment determines photoionization cross sections, the donor recombination cross section as a function of carrier temperature, and the thermalization rate of hot carriers in n-Ge.

Studies of resonant, impurity-induced, four-photon mixing in n-Ge and n-Si are continuing. During the past year, we have observed[2,3] resonances in the third-order nonlinear coefficient caused by impurity levels in Si – the resonance being at the valley-orbit splitting energy of the donor levels. To date, the impurity resonances in these four-photon mixing experiments have been studied by step-tuning the CO_2 lasers. More precise data can be obtained by sweeping the impurity levels with magnetic field. These experiments, which are now under way, will determine:

i. magnetic structure of donor levels in n-Ge and n-Si;

ii. precise linewidths of valley-orbit transitions;

iii. excitation transfer rates between donor levels.

References

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3. M.A. Khan, "Four-Photon Mixing in Semiconductors," Ph.D. Thesis, Department of Physics, M.I.T., May 1979.