EMISSION FROM HIGHLY EXCITED MAGNETO-PLASMAS IN THE SUPERFLUORESCENCE REGIME: DEPENDENCE ON TEMPERATURE AND PUMP GEOMETRY

Y. D. Jho (NHMFL and UF), X. Wang (UF, Physics), D.H. Reitze (UF, Physics), J. Kono (Rice, ECE), C. J. Stanton (UF, Physics), A. A. Belyanin (Texas A&M, Physics), and X. Wei (NHMFL)

Introduction

Ultrafast optical excitation of a dense electron-hole plasma in $In_xGa_{1-x}As$ multiple quantum wells in high magnetic fields (> 20 T) results in cooperative radiative recombination (superfluorescence or SF) between conduction and valence band Landau levels (LLs). Above a critical field and density threshold, the emission is characterized by very narrow LL line widths, superlinear increase with increasing field and laser excitation fluence, and stochastic directionality from shot-to-shot [1]. Here, we investigate how the collective emission process is influenced by temperature and the excitation focal geometry [2].

Experimental

Experiments were performed in the new Fast Optics Facility on two $In_{0.2}Ga_{0.8}As/GaAs$ quantum well samples grown by molecular beam epitaxy at 430 C (S1) and 390 C (S2). A 775nm, 150 femtosecond Ti:sapphire laser excited the samples in magnetic fields up to 30 T. Samples were oriented with the plane of the quantum well perpendicular to the magnetic field. Photoluminescence (PL) was collected using optical fibers and analyzed as function of sample, temperature, and excitation geometry

Results and Discussion

The formation of SF inherently relies on the establishment of a macroscopic coherence among photoexcited e-h pairs, thus the emission threshold and strength should depend sensitively on temperature. An increasing temperature should increases the intercarrier dephasing rate and thus increase the critical magnetic field B_C for SF formation. Fig. 1 compares the observed B_C with a model based on optical and acoustic phonon dephasing. Since the LO phonon energy E_{LO} is much larger than the thermal energy (k_BT) in our temperature range up to 120 K, we tentatively identify the acoustic phonon contribution as a dominant temperature mechanism for increasing B_c. Fig. 2 shows how the emission direction can be controlled via tailoring of the excitation geometry. Using a cylindrical lens to generate a rod-like 3mm x 0.5mm excitation region, Fig. 2 shows the emitted output as a function of angle θ from 0° to 180° at 25T. The output intensity follows the orientation of the long axis of the gain region, with the relative emission strength from two edges reversed as the angle is rotated by 90°. Tracing the output intensity for edges 1 (black) and 2 (red), the emission is highly directional. Moreover, the ratios of the integrated signals indicated that the gain is exponential as expected for SF emission.

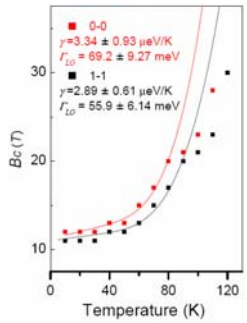

Fig. 1 - Threshold field B_c for the 0-0 LL (red scattered line) and for the 1-1 LL (black scattered line) sharp emission. The solid lines are fittings based on a phonon model.

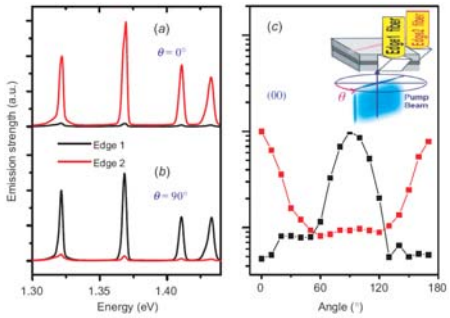

Fig 2 - Edge emission spectra measured at (a) 0° and (b) 90° (see inset for geometry) In (c), the emission strength of 0-0 LL is plotted for edge 1 (black) and edge 2 (red) as a function of angle.

Acknowledgements

This research was sponsored by the NHMFL IHRP and NSF (DMR0325499).

References

[1] Jho, Y. D., *et al*., Phys. Rev. Lett., **96**, 237401 (2006).
[2] Jho, Y. D., *et al*., J. Mod. Optics **53**, 2325-2335 (2006).