Ultrafast Emission from Highly Excited Magneto-Plasmas: First Results on Dynamics of the Emission Process

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Introduction

A 2D high density electron-hole plasma in $In_xGa_{1-x}As$ multi-quantum wells can emit coherent bursts of radiation (superflourescence) from inter-Landau level (LL) recombination at sufficiently high densities ($n_{2D} > 10^{12}/cm^2$) due to the formation of a cooperative macroscopic dipole state [1-3]. Here, we investigate the transient behavior of the emission process as a function of magnetic field and e-h carrier density to understand the formation and emission dynamics of this system.

Experimental

Our experiments were performed in the new Fast Optics Facility using SCM3 (17.5 T) and a 150 fs, 800 nm Ti:Sapphire chirped pulse amplifier (CPA) to pump the sample coupled with a broadly tunable optical parametric amplifier (OPA) to probe the temporal dynamics as a function of laser fluence F_{laser} and magnetic field B. Excitation of the sample was accomplished via direct free space propagation into the bore of SCM3 and normal to the QW plane. In addition, time-resolved photoluminescence was performed using streak camera with 20 ps resolution.

Results and Discussion

For the transient absorption experiments, the OPA was tuned to specific LL resonances and interrogated the sample as a function of delay time after the CPA excitation pulse arrived. Figures 1 and 2 display the temporally-resolved normalized transmission signal at 0 T and 17.5 T probing at the 00 LL transition. In both cases, a fast rise time is observed, consistent with an overall change in transmission due to the presence of a dense plasma. At zero field, a long delay of 100 ps is seen before the maximum transmission is reached, followed by a ~ 200 ps relaxation. At 17.5 T, relaxation times are much longer, possibly due the cascaded relaxation through higher LLs to the lowest LL. A slight dependence on power is seen, with higher powers showing faster relaxation times. Streak camera data time-resolving the in-plane PL emission from the 00LL are shown in Figure 3, which displays emissions directed from the plane of the QW for 11 mW pumping, consistent with carrier densities in excess of $10^{12}/cm^2$. This edge collection geometry reveals some intriguing dynamics. Multiple peaks are observed, consistent with the emission of *multiple* pulses via a stimulated process as carriers in the 00LL relax and recombine, followed by subsequent relaxation from higher lying LLs. Further studies at higher fields are needed to *definitively* identify these bursts as superfluorescence.

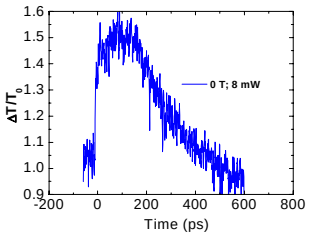

Figure 1 – Differential transmission vs time probing the e1h1 transition in $In_xGa_{1-x}As$ multi-quantum wells at 5K at zero magnetic field.

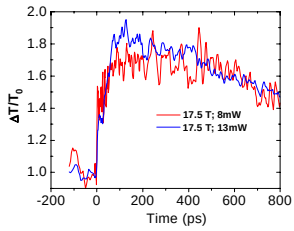

Figure 2 – Figure 1 – Power-dependent differential transmission probing the 00 LL resonance vs time for $In_xGa_{1-x}As$ multi-quantum wells at 5K and 17.5 T.

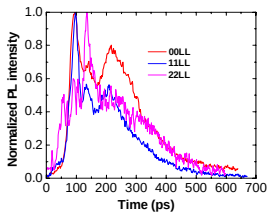

Figure 3 – Normalized photoluminescence from the 00, 11, and 22 LLs in $In_xGa_{1-x}As$ multi-quantum wells at 5K for 11 mW pump powers

Acknowledgements

This research was sponsored by the NHMFL IHRP and the NSF through grant DMR0325499.

References

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