MUSSIE BEIAN
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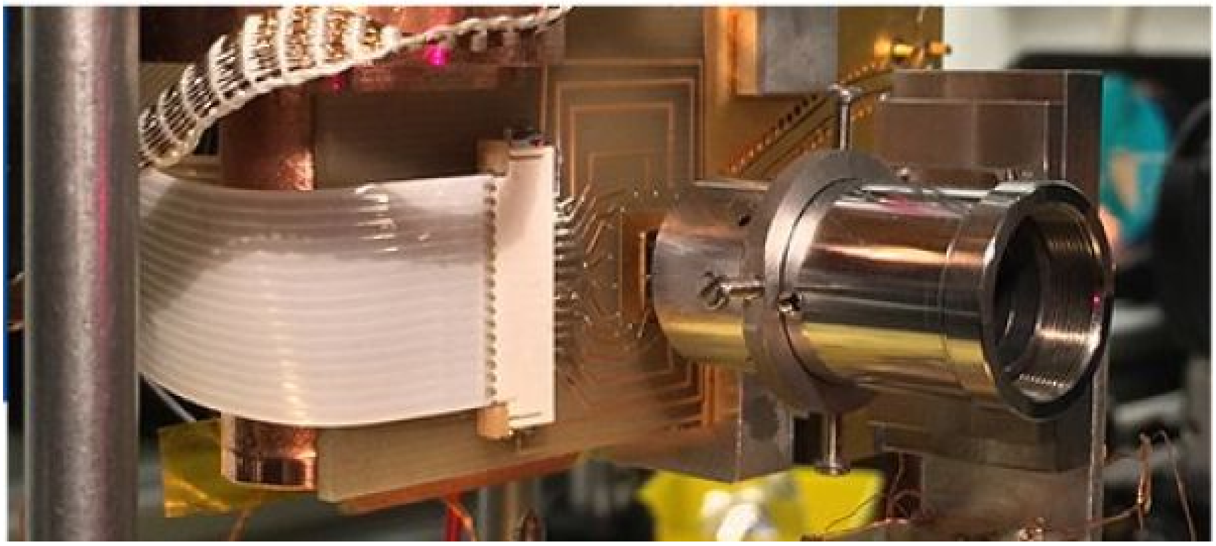

# PhD Thesis Defense MUSSIE BEIAN 'Spectral Evidence for a Condensate of Dark Excitons in a trap'

MUSSIE BEIAN

June 22, 2016

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Wednesday, June 22, 14:30. Universite Pierre et Marie Curie Paris IV

**MUSSIE BEIAN**

Quantum Optics Theory

ICFO-The Institute of Photonic Sciences

Spatially indirect excitons, being composite bosons, are attractive candidates to explore correlated many-body systems. They possess an inherent large electric dipole, a four-fold spin manifold, and can be studied via the emitted photoluminescence after electrons and holes have recombined. Due to their extremely low mass compared to atoms, a sufficiently dense gas of indirect excitons is expected to form a Bose-Einstein condensate below a critical temperature of a few Kelvins. Recent theoretical results show that this condensation must take place in optically dark states of the spin manifold. However, under a density increase the condensate is expected to coherently couple to a small population of bright excitons. It is then possible to study the condensate through its weak photoluminescence.

In this thesis we report on experiments with a cold gas of indirect excitons in coupled quantum wells embedded in a field effect device. Indirect excitons are photo-generated through pulsed laser excitation, in a fashion that minimizes photo-induced perturbations in the field-effect device. Confinement is provided by exploiting the high-field seeking dipolar nature of spatially indirect excitons through independently biased surface gate electrodes. Time and spectrally resolved analysis of the photoluminescence allow us to extract the decay time of the bright exciton population while at the same time monitoring the decay of the overall exciton population through the energy of the photoluminescence. Maintaining a fixed density while varying the bath temperature, we are able to observe a depletion of the bright state population, by even three-fold when the bath temperature is lowered from 3.5 K to 0.33 K. This stands in stark contrast to the expected classical behavior of a cold gas of excitons obeying Maxwell-Boltzmann statistics. The experimental results are confirmed by a phenomenological model which shows that Bose-stimulation from bright to dark excitons is compatible with the observed anomalous darkening. Lowering the exciton gas temperature should reinforce these signatures. However, in GaAs exciton-phonon interaction is the main mechanism to cooling an exciton gas to quantum degeneracy. The efficiency of this process is strongly reduced for temperatures below 330 mK. We have thus developed a technique to control the exciton confinement in-situ, on a time-scale of nanoseconds by pulsing the gate electrode. Our approach relies on a complete characterization of the transfer function linking the response of the indirect excitons to a voltage pulse, i.e. the strength of the confining potential. Our method shows no increase of the bath temperature thus paves the way towards exploration of evaporative cooling methods for a gas of cold indirect excitons.

**Wednesday June 22nd, 14:30 h Universite Pierre et Marie Curie Paris IV**

**Thesis Directors: Prof Dr Maciej**