Josephson oscillations between exciton condensates in electrostatic traps

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The Josephson effect is a remarkable phenomenon that has been observed in systems as diverse as superconductors, superfluid Helium, trapped ultra-cold atomic gases. Since Josephson oscillations appear naturally as the state oscillation between the macroscopic wave functions of two weakly linked condensates, they have been predicted for bosonic excitations in solids as well, like polaritons and excitons [1]. However, unlike the polaritons, which have a photonic component allowing for easy detection, excitons stay dark unless they recombine radiatively. So far, it is unclear how the exciton Josephson effect could be observed. Here, we propose a possible experiment [2].

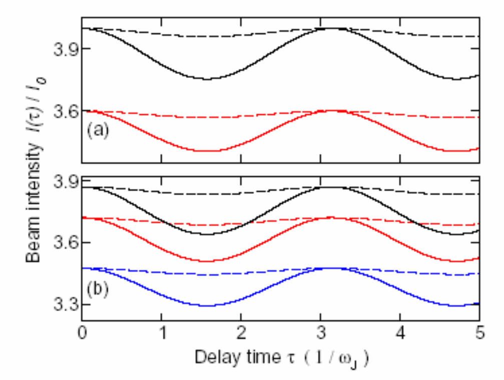

Figure 1. Predicted beam intensity vs delay time for the proposed correlated photon counting setup. Dashed and solid lines refer to increasing values of the inter-trap dipole energy difference. (a) Red and black curves indicate increasing values of fringe visibility. (b) Black, red, and blue lines indicate increasing values of temperature.

Condensed excitons are predicted to emit coherent light. If Josephson oscillations occur between two exciton traps, in principle they can be probed by measuring the interference of the beams separately emitted from the traps. However, in the time interval before recombination, the photons emitted are too few to allow to resolve the signal of their time correlation and one has to average it over many replicas of the same experiment [3]. We show that this ensemble average blurs the signature of the Josephson effect but in the relevant case of exciton "plasma" oscillations. For the latter the tunable dipole energy difference between electrostatically defined exciton traps [4] controls fringe visibility, providing a means for detection.

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[2] M. Rontani and L. J. Sham, Phys. Rev. B **80,** 075309 (2009)

[3] S. Yang *et al.*, Phys. Rev. Lett. **97,** 187402 (2006)

[4] A. A. High *et al.*, Science **321,** 229 (2008)