Observation of quantum and classical correlation regimes in cold dipolar exciton fluids

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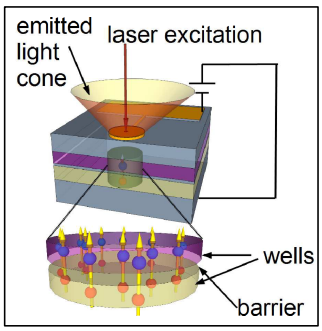
Cold two-dimensional dipolar fluids are predicted to display a very rich phase diagram and intricate interaction induced particle correlations in both the classical and quantum regimes, far beyond the well studied weakly interacting quantum gases [1,2]. Therefore they are currently a major thrust in modern cold atoms and molecules research [1,3].



A dipolar exciton fluid in a semiconductor bilayer is a good system to study such physics directly [4-6]. Furthermore, these fluids can be transported, controlled, and manipulated over macroscopic distances via their interactions with externally applied potentials, a property that can be utilized for new types of coherent exciton based circuitry [10].

We will present experimental evidence for several many-body correlation regimes of a cold dipolar exciton fluid, created optically in a gated semiconductor bilayer trap. As the fluid temperature is lowered, the average interaction energy between the particles shows first a strong, temperature dependent reduction, which is an evidence for the onset of correlations *beyond the mean field model*. At lower temperatures, there is a clear transition to a temperature independent regime. We interpret this behavior as a transition from a classical to a quantum correlated dipolar fluid. At an even lower temperature, there is a sharp increase in the interaction energy of optically active excitons, accompanied by a strong reduction in their apparent population. This could be an evidence for a sharp macroscopic redistribution with the dark spin states [7] as was suggested theoretically [8]. We will also show experiments where the long-range character of the collective dipole of the exciton fluid is manifested by engineering and observing *remote* dipolar interactions between spatially separated fluids [9].

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