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### **Optically probing charge and spin states in quantum dots and molecules**

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In this talk I will discuss recent experiments in which we electrically manipulate coupled excitonic states (neutral and negatively charged single excitons) in individual QD-molecules using static electric fields. The samples investigated consist of a single pair of vertically stacked, self assembled InGaAs QD-molecules embedded in an n-type GaAs Schottky photodiode. This device geometry enables us to control the coherent coupling between excitonic states in the upper and lower dots by tuning the electric field oriented along the axis of the QD-molecule by applying a bias voltage between the n-contact and the Schottky-gate. New information is obtained on the spin structure of negatively charged trions in coupled quantum dot nanostructures. At low excitation power densities, field dependent luminescence reveals a clear anticrossing of spatially direct (e,h in the same dot) and indirect (e,h in different dots) neutral excitons, with coupling energies in the range  $2E_{ee}=1.2-3.2\text{meV}$ . Our experimental findings are shown to be in very good accord with realistic calculations of the single exciton spectrum, confirming that the tunnel coupling is mediated by hybridization of the electron component of the exciton wavefunction over the two dots. In contrast, the spectrum and controlled hybridization of *negatively* charged excitons is shown to be much richer due to the complex spectrum of three particle states ( $X^- = 2e+1h$ ) that can exist in a QD-molecule. For example, the spin structure of the spatially localized and dissociated  $X^-$  states is found to play a major role in the spectrum of controlled hybridization with distinct triplet and single states evolving very differently as the coupling is tuned. The demonstration of tunable coupling and manipulation of spin and exchange couplings in negatively charged systems may constitute an important step towards the development of optically gateable QD-molecules for applications in quantum information science.