One Exciton Two Exciton Red Exciton Blue Exciton: Exciton-Exciton Interactions in Graphene Quantum Dots

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As an electron and a positron bind to form positronium, a conduction-band electron and valence-band hole in a crystal bind to form an exciton. As a pair of electrons and a pair of positrons bind to form a positronium molecule, a pair of electrons and a pair of holes can bind to form a biexciton. Exciton-exciton interactions are of fundamental importance in understanding many-body effects in non-metallic systems, but they are also important for potential applications ranging from optical gain to solar energy conversion. In nanoscale systems, the binding of biexcitons can be enhanced through confinement and reduced screening. At the same time, relaxation of momentum conservation and confinement of carriers allow for rapid, non-radiative recombination of biexcitons in nanoscale quantum dots. After an overview of the range of research being conducted in my lab, I will discuss our work to understand and engineer exciton-exciton interactions in colloidal quantum dots. I will focus on our recent work in graphene quantum dots in which the two-dimensional lattice of light atoms leads to weak screening of the Coulomb interaction and consequently yields strong interactions between excitons.