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Optical properties, light-harvesting, and energy transfer in hybrid nanomaterials

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Modern nanotechnology involves both nanocrystals (metal and semiconductor) and biomaterials. Using biomolecules as linkers, solid-state nanocrystals with modified surfaces can be assembled into hybrid (i.e. assembled from different materials) superstructures with unique optical properties. In a superstructure, individual building blocks (nanocrystals and biomolecules) strongly interact and these interactions bring new properties. In particular, Coulomb and electromagnetic interactions in a hybrid nanostructure cause several interesting effects: Energy transfer between nanoparticles (NPs), plasmon enhancement, modified exciton diffusion in nanowires, Fano interference effect, non-linear phenomena, etc. In our studies, we also look at the properties of artificial light- harvesting complexes composed of chlorophylls, photosynthetic bacterial reaction centers, and NPs. Using superior optical properties of metal and semiconductor NPs, it is possible to strongly enhance an efficiency of light harvesting in such complexes. In conclusion, our theory explains current experimental results and also provides rationale for future experiments and applications. Potential applications of dynamic hybrid nanostructures include sensors, nonlinear optical media, and light-harvesting systems.