When every charge matters: doping of nanoscale semiconductors

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Doping of nanoscale semiconductors is critical for providing electronic and photonic device functionality. However, our understanding and control of the underlying charge transfer processes is often limited, impeding technological progress. Here we discuss recent insights into the doping of semiconducting carbon nanotubes (s-SWNTs) using a variety of optical spectroscopies and doping schemes, from femtosecond time-resolved pump-probe studies of redox doped s-SWNTs to photoluminescence microscopy of individual, electrochemically doped nanotubes. The experiments now allow a quantitative determination of doping levels in carbon nanotubes. We also discuss what such experiments reveal about the nature of exciton and trion photophysics in low-dimensional semiconductors. In addition, our findings highlight some fundamental challenges with controlling excess carriers in one- or two-dimensional atomically thin semiconductors due to notoriously weak screening and exacerbated sensitivity to external perturbations.