Prof. Michael G. Moore
Physics and Astronomy Department
4230 Biomedical and Physical Sciences Building
Michigan State University

Trionic optical potentials for semiconductor charge carriers

Abstract:
Laser-induced 'optical potentials' for atoms have led to remarkable advances in precision measurement, quantum information, and show promise towards addressing fundamental questions in condensed matter physics. Despite advances in optical and electronic control in semiconductors, a similar use of light to trap and manipulate carriers in a semiconductor device has not been explored. Here, we propose generating such an 'optical potential' by driving the transition between a single charge carrier and the trion state (a three-body bound-state between the carrier and and an exciton). This adds a term to the vacuum Stark shift of the material that is proportional to the light intensity at the position of the carrier, and therefore acts as a potential source of mechanical energy. According to our theoretical calculations, this shift can be large relative to the thermal equilibrium temperture of the carrier, resulting in a relatively strong ‘optical potential’ that can then be used to trap, guide, and manipulate individual electrons and and holes within a semiconductor quantum well. These potentials can be thought of as artifical nano-structures on the scale of 100 nm, that can be strongly spin-dependent. Our results suggest the possibility of integrating ultrafast optics and gate voltages in new class of semiconductor opto-electronic devices, with potential applications in fields such as nano-electronics, spintronics, and quantum information processing.