

Many-body effects on linear and nonlinear optical properties of low dimensional materials

Vasili Perebeinos

Electrical Engineering Department, University at Buffalo, Buffalo, New York, USA

E-mail: vasilipe@buffalo.edu

Atomically thin two-dimensional materials are direct bandgap semiconductors with a rich interplay of the valley and spin degrees of freedom, which offer the potential for electronics and optoelectronics. A strong Coulomb interaction leads to tightly bound electron-hole pairs or excitons and two-electron one-hole quasiparticles or trions. We solve the two-particle and three-particle problems for the wavefunctions for excitons and trions in the basis set of the model-Hamiltonian for single particles. The calculated linear and nonlinear absorptions, photoluminescence spectra, and polariton spectra as a function of doping and temperature explain the experimental data in 2D monolayers and predict novel spectroscopic features due to the many-body Coulomb interactions [1-5]. Exciton lifetime plays a crucial role in optoelectronic applications. I will also discuss the phonon-assisted Auger non-radiative decay mechanism of excitons in doped 2D materials. This material is based upon work supported by the Air Force Office of Scientific Research under award number FA9550-22-1-0312.

- [1] Y. V. Zhumagulov, A. Vagov, D. R. Gulevich, V. Perebeinos
Electrostatic and Environmental Control of the Trion Fine Structure in Transition Metal Dichalcogenide Monolayers
Nanomaterials 12, 3728 (2022)
- [2] V. D. Neverov, A. E. Lukyanov, Y. V. Zhumagulov, D. R. Gulevich, A. V. Krasavin, A. Vagov, V. Perebeinos
Non-linear spectroscopy of excitonic states in transition metal dichalcogenides
Phys. Rev. B 105, 239902 (2022)
- [3] Y. V. Zhumagulov, S. Chivazzo, D. R. Gulevich, V. Perebeinos, I. A. Shelykh, O. Kyriienko
Microscopic theory of exciton and trion polaritons in doped monolayers of transition metal dichalcogenides
npj Comput Mater 8, 92 (2022)
- [4] Y.V. Zhumagulov, A. Vagov, N.Y. Senkevich, D.R. Gulevich, V. Perebeinos
Three-particle states and brightening of intervalley excitons in a doped MoS2 monolayer
Phys. Rev. B 101, 245433 (2020)
- [5] Y.V. Zhumagulov, A. Vagov, P.F. Junior, D.R. Gulevich, V. Perebeinos
Trion induced photoluminescence of a doped MoS2 monolayer
J. Phys. Chem. 153, 044132 (2020)