INVESTIGATION OF PHOTOLUMINESCENT PROPERTIES OF M_OS_2 NANOTUBES

Smirnova O.O. (ITMO University, Ioffe Institute)
Academic Adviser – d.p-m.s, prof. Rodina A.V.
(Ioffe Institute)

Annotation
After the recent discovery of bright luminescence in single nanotubes based on MoS_2, we gained a new efficiently radiating object related to the whole family of nanotubes. The investigation of the observed phenomena deepen our understanding of the relaxation and recombination processes in such tubular multilayered systems and shed light on their application potential in optics and spin physics.

Introduction.
It occurs that nanotubes MoS2 have unique optical properties. The discovered ability to emit light dramatically expands the application area of these structures. Such nanotubes were synthesized by a chemical transport reaction. Currently, all the structures grown under existent chemical methods are multilayered in the wall thickness. Such structures are expected to demonstrate weak photoluminescence of indirect-bandgap excitonic states. Despite that, radiation around the energy of a direct-bandgap exciton was shown to dominate in the observed spectra. Besides, a complete suppression of the indirect-band excitons emission at low temperatures is observed. These particular qualities designate the existence of complex structure of the spin states of excitons and the strong influence of exciton-phonon interaction. Our research is aimed at the theoretical clarification of the experimentally observed photoluminescent features of nanotubes. Subjects of the research are the physical mechanisms and structural-morphological factors affecting the radiative ability, temporal, and polarization characteristics of radiation of the tubular van der Waals nanostructures based on transition metal dichalcogenides and determining the prerequisites for the creation of nanophotonic devices based on such structures.

Main part.
We propose theoretical studies of the energy and spin structure of states of direct and indirect excitons, including light and dark states of different nature, determination of their formation and recombination processes with and without participation of phonons in stressed and reflexed tubular structures characterized by surface curvature and chirality. Such an approach assumes consideration of the rate equations for the arrival and removal of carriers (electrons and holes) individually or excitons as a whole. The estimation of the necessary parameters is based on experimental data on the characteristic photoluminescent decay times obtained by micro-spectroscopy with temporal resolution. The results of the theoretical analysis of the fine structure of the energy spectrum are taken into account. We also compare the optical properties of nanotubes with those of planar nanostructures. Development and analysis of the system of rate equations are carried out to describe the kinetics of exciton recombination in multilayer nanostructures taking into account the light and dark states of both direct and indirect excitons and possible channels of their relaxation and recombination.
We determine the dominant radiation channels and mechanisms that govern the intensity and radiation energy of nanotubes, having different sizes by comparing the obtained optical dependencies with the results of theoretical and structural studies.

Conclusion.
First of all, this investigation expands our knowledge in the field of optics and spin physics of tubular structures in general. We describe the relaxation and recombination processes in complex multi-level systems, the relationship of nanotube architecture and their optical properties.

In practical terms, we are targeted at formulating recommendations for the creation of effective sources of coherent and quantum light based on micro- and nanotubes, combining the properties of an emitter and a resonator.

Smirnova O.O. (author)	Signature
Rodina A.V. (academic adviser)	Signature