Referee report on the opening of new theme and project "Ultrasensitive SECARS microspectroscopy and luminescence biolabeling with core-shell nanostructures"

The project under review is aimed at solving modern fundamental and practical problems in the field of photo and upconversion luminescence within the new JINR theme put forward for consideration.

As we know from the published works, the multimodal optical platform based on the CARS microscope was successfully used in the past years not only for investigations in Raman and nonlinear spectroscopy and microscopy but also, in view of unique specific features of this device, for luminescence investigations of various optical matrices doped with rare-earth elements. Uniqueness of the approach is that in addition to measurement of photoluminescence at high-energy optical excitation, the optical platform allows excitation of a sample by near-IR radiation (multiphoton absorption) and detection of luminescent signals in the anti-Stokes spectral region, as in CARS spectroscopy. This phenomenon, known as upconversion luminescence (UCL), has a few interesting applications. In particular, UCL-featuring nanoparticles are more and more often viewed as an effective alternative to traditional fluorescent markers for visualization of biological objects because they are free of some limitations that are typical, for example, of dyes, such as optical instability, photo fading, etc.

Recently many world's leading research centers active in this field have been using promising nanostructures known as core-shell nanoparticles. They are attractive by the diversity of their chemical composition and structure, which makes them multifunctional and ensures their high-intensity luminescence. Luminescent characteristics are most brightly manifested in synthesis of composite shells, including those consisting of silver or gold nanoparticles. It is investigations of these nanostructures that are to be carried out in the scope of the project under review. Scientifically and practically, the project under review is undoubtedly a promising direction in physics similar to the observed SERS phenomenon.

As an applied research after achieving high-intensity luminescence of the core-shell nanoparticles, the authors of the project intend to test them in photodynamic cancer treatment investigations using $NaYF_4$: Yb,Tm nanoparticles as cores and porphyrins as shells. This demonstrates not only the importance of the work but also some novelty of the research within the given area.

In conclusion, a few important points must be noted:

1. Investigations with two complementary methods, Raman scattering and luminescence, are a productive approach. Implementation of the project under review within the framework of international collaboration, including Belarussian scientists, can complement the Raman scattering project in terms of applications, e.g., high-contrast optical visualization of biological objects, diagnostics of oncological diseases and diseases of a bacterial nature, etc.

2. The choice of the core-shell structures with cores of $NaYF_4$: Yb,Tm nanoparticles and shells of silver or gold nanoparticles for enhancement of luminescence signals via plasmon interaction is important for creation of competitive phosphors, being in line, in terms of the underlying scientific ideology, with current research, development, and applications in this field.

Based on the aforesaid, we recommend with confidence the implementation of this project on the multimodal optical platform at the Frank Laboratory of Neutron Physics within the proposed new theme in 2018–2020.

V. M. Fedosyuk,
Corresponding-member of NAS of Belarus
Director General
State Scientific Production Association
"Scientific and Practical Center for Material Science,
National Academy of Sciences of Belarus"

A. V. Mudryi
Chief Researcher