TALENT Course 6: Theory for exploring nuclear reaction experiments
Outline project proposal

Project name: Sub-barrier fusion cross sections within the WKB approximation

Researcher(s): Vladimir Rachkov
Affiliation: Joint institute for nuclear research, Dubna, Russia
Supervisor(s): Filomena Nunes

Project outline and aims:
Quantum tunneling is on of the fundamental problems in nuclear physics. Fusion enhancement below the Coulomb barrier is one of the intensive studies problem. It is by now well established that to describe the sub-barrier fusion cross sections one needs to include coupling of relative motion to other degrees of freedom such as rotation of deformed nuclei and/or their surface vibrations. The sub-barrier fusion enhancement with account of the excitation of collective states (rotational and/or vibrational) is well understood and properly describe within coupled-channels formalism.

In this work will be show that the large enhancement of sub-barrier fusion cross sections for heavy-ion collision processes can be partially accounted for by using the variation of the effective mass due to nonlocal effects in WKB theory.

Methodology:
The WKB approximation will be used to calculate the barrier penetration for heavy-ion systems at sub and near Coulomb barrier energies. The calculations wiil be include the nonlocal effects in a semiclassical WKB approach. In this approach, the nonlocality which simulates the many-body quantum effects manifests only in the sub-barrier region where the reduced mass of the fusing nuclei is not a constant but varies with the so-called nonlocal parameter.

Key references:
1. R. Dutt, T. Sil, and Y. P. Varshni, Phys. Rev. C. **54**, 319 (1996).
2. Fröbrich P. Lipperheide R., Theory of Nuclear Reactions, Oxford University Press, USA, 1996.
3. Thompson Ian J. Nunes Filomena M., Nuclear Reactions for Astrophysics, Cambridge University Press, 2009.