

Advancing low-energy nuclear reaction theory and indirect methods in nuclear astrophysics

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Indirect radiative capture reactions

Advancing the theory of the indirect methods, like ANC and Trojan Horse in the era of higher intensity radioactive beams.

The main stress is on the indirect radiative capture reactions with stable and exotic beams. Among the most important application of the developed theory is the famous $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ reaction. For more than 30 years there were numerous unsuccessful attempts to come close to the energy of 1 MeV while we need to reach the most effective astrophysical energy of 300 keV. New facilities, like underground labs in South Dakota, USA, and at IMP, China, new gamma-ray facilities in USA and Romania, are aimed to come closer to 1 MeV energy, which is still far away from the desired 300 keV. Meantime I and Prof. G. Rogachev suggested a new method to reach 300 keV energy by using the indirect radiative capture reaction $^{12}\text{C}({}^6\text{Li},d,\gamma)^{16}\text{O}$ to get information about the $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ reaction.

Measurements of this reaction would constitute a main breakthrough in nuclear astrophysics, what is exactly in the FRIB agenda. The proposed experiment is very difficult but doable. I hope Prof. Rogachev's group will add devices they needs to do this experiment.

Generalization of the theory of the indirect Trojan Horse method for three charged particles in the final state

Higher intensity radioactive beams allow one to use FRIB to conduct measurements of many astrophysical reactions using the Trojan Horse method for resonant rearrangement reactions and indirect radiative capture processes. Until now low triple differential cross sections of the Trojan Horse reactions forced experimentalists to measure only energy dependence of the Trojan Horse cross sections. Their absolute values were determined by normalization of the Trojan Horse cross sections to the available direct measurements at higher energies. When higher intensity stable and unstable beams are available the indirect Trojan Horse experiments would allow one to measure both energy dependence and absolute values of the experimental cross sections. Until now, because the absolute cross sections were not measured, I developed the theory of the indirect Trojan Horse method for resonant rearrangement and radiative capture reactions using only the plane wave approximation.

Now, taking into account a possibility to conduct absolute measurements of the indirect cross sections, I am planning to develop a theory, which includes the distorted waves, especially the final-state three-body Coulomb interactions to analyze the Trojan Horse reactions with three charged particles.

Generalization of the Faddeev equations for peripheral reactions

I will be working on the generalization of the three-body Faddeev integral equations in the two-particle Alt-Grassberger-Sandhas (AGS) form to analyze both sub-Coulomb and above the Coulomb barrier reactions. The AGS equations will be modified by rewriting the effective potentials in the form of the distorted-wave-Born-approximation.