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

Project name: How do the the coupling to continuum states affect the fusion cross section?

Researcher(s): Jeannie Rangel
Affiliation: Instituto de Fisica, Universidade Federal Fluminense, Rio de Janeiro, Br.
Supervisor(s):

Project outline and aims:

Sometimes it is assumed that the main contribution to fusion cross sections comes from the elastic channel. Therefore, one can solve the Shrodinger equation with and optical potential plus a polarization potential that accounts effectively for the coupling of the elastic channel with the other nonelastic channels and extract the full wave function of the entrance. The fusion cross section is obtained trough:

$$\sigma_{fus} = \frac{k}{E} < \psi^{+}_{elast}|W|\psi^{+}_{elast} > \tag{1}$$

However, for nuclei with internal degrees of freedom the coupling with several states to the bound state that might feed the fusion makes this approximation not valid anymore. The possibilities of inelastic excitations of the one, or both, nuclei may affect the absorption of the incident flux into to fusion channel. For weakly bound nuclei, where the the states feed the continuum, the couplings of these continuum states with the ground state are the uppermost importance. The purpose of this project is to study how these continuum states may affect the fusion cross section.

Methodology:

Fresco code will be used to obtain the full wave functions of the interesting channels included in the coupled scheme of the CDCC calculation. A fortran code have to be written to calculate and separate the continuum states contribution to the absorption to the fusion cross section. This can be achieved by using the equation [1] :

$$\sigma_{fusion} = \sum_{f}^{\alpha} \sigma_{\alpha} \quad com \quad \sigma_f^{\alpha} = |A|^2 \frac{\pi}{k_o^2} \sum_J (2J+1)\tau_{\alpha}^J \tag{2}$$

where the transmission coefficient for an unpolarised beam is given by:

$$\tau_{\alpha}^J = \frac{4k_o}{E_o(2I_o+1)(2J+1)} \sum_{ll_o l'_o \mu_o} \sqrt{(2l_o+1)(2l'+1)} < l_o 0 I_o \mu_o | J\mu_o > \int dr u^{*}_{\alpha l,0l_o}(r) W_{\alpha}(r) u_{\alpha l,0l_o}(r) \tag{3}$$

In this equation E_o and k_o are the energy and the momentum from the entrance channel; l_o and I_o are the angular momentum from the projectile and the target, respectively; and J the total angular momentum.

Key references:

1. Luiz Felipe Cant and Mahir S Hussein, **Scattering Theory of Molecules, Atoms and Nuclei**, World Scientific, 2013