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Open issues on scattering kernels of compound nuclear reactions

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Scattering kernels are more complicated to evaluate than absorption processes due to the fact that scattering procedures involve not only the internal structure of the target nuclei but also the free "classical"particle interacting and emitted from the target. Strictly speaking, the interaction within the nucleus is based on quantum mechanical considerations whereas the emitted particle (neutron) is being treated in a classical manner obeying the classical momentum and energy conservation laws.
The scattering kernel procedure that was recently adopted by a lot of Monte Carlo codes, uses the DBRC method which was validated experimentally by dedicated measurements done in RPI.
The theory behind the numerical treatment of DBRC method is based on Doppler broadening of the resonances for scattering kernels which is an extension of the Broadening of the cross section themselves. However, the DBRC approach includes a double differential treatment of the angular and energy distribution as independent variables. The azimuth angle is a dependent variable of the polar angle. This model, which was validated for S-wave resonances is not consistent the Optical Model (OM) and the Blatt Biedenharn (BB) scattering kernels, both based upon the angular momentum numbers and spin. In those latter treatments the scattered energy is a function of the angular polar angle, taken mostly at 0° K, while the azimuth angle is being a free parameter taken to be isotropic. Main cause for those differences is the explicit appearance of the temperature and hence a Doppler Broadening approach, which does not exist in the OM nor in the BB formalism.
In the higher resonance range above 9 KeV and in particular for p wave resonances the BB approach adopts the spin obtained by measurement of integral scattering cross sections. Further, at energies where a resonance structure is not clearly resolved one usually uses optical model potential theory. However, based of development in one can extract from the OM (via S- Matrix) the needed parameters for the BB angular distribution treatment.
Further, in the low thermal energy range the impact of the chemical binding replaces usually replaces the free gas model, albeit neglecting the fact that the integral temperature dependent cross section is mostly being broadened with a free gas approach. Consequently, in several codes like MCNP the scattering cross section itself depends on which model is used in the input, new scattering table -(S(a,b))- or free gas model.
This work deals with comparison of different approaches of scattering kernels experimentally and numerically. In particular the validity range of different scattering models are discussed, as well as the planned measurements in RPI for the angular distribution in the resolved energy range and above. In parallel, the impact of the temperature and the doppler effect, discussed above, is being investigated in dedicated experiments in the GALINA facility in Geel.

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