Optical reaction cross-sections for light projectiles

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Abstract. The optical reaction cross-sections for n, p, 3H, 3He and 4He for several global optical potentials available in the literature have been parametrized in terms of simple empirical expressions which are smooth functions of the target mass number and the projectile energy. The empirical forms are 5-10% accurate over the periodic table and energy-range up to 50 MeV. They can be conveniently used in calculations where the optical reaction cross-sections are required as input. The calculation of proton spectra in the (n, p) reaction at 14 MeV is discussed.

Keywords. Optical reaction cross-sections; empirical parametrization; evaporation; preequilibrium models; light projectiles; parametric forms; neutrons; charged particles.

1. Introduction

The non-elastic part of the interaction between the incident particle and the target nucleus manifests itself as the reaction cross-section. As a first approximation this interaction is described by a complex (optical) potential, the imaginary part of which leads to a finite reaction cross-section. In the literature the projectile-target interaction for target nuclei over the periodic chart has been given in terms of global optical parameter-sets. The reaction cross-sections generated using these global parameters are employed in several further calculations. In the statistical evaporation theory and the preequilibrium model the break-up of the total reaction cross-section into partial modes involving the emission of one or more particles is described by emission rate expressions which contain the cross-sections for the inverse processes involving the emitted particle as a function of energy. The cross-section for the inverse process is the optical reaction cross-section of the excited residual nucleus with the emitted particle as the projectile. This is approximated as the optical reaction cross-section between the residual nucleus in its ground state and the (emitted) particle. Thus optical reaction cross-sections are required for the incident channel at the projectile energy and for the exit channels over the energy range of the emitted particles. The statistical evaporation theory is a widely-used description for reactions at low energies. At energies in the range of several tens of MeV the preequilibrium models have been successful. Reaction cross-sections are also used in intra-nuclear-cascade calculations (Kikuchi and Kawai 1968) and in the calculation of the nuclear-reaction efficiency correction for detectors (Makino et al 1968).

Usually the optical reaction cross-sections at all the required energies and particle-target combinations are obtained by a numerical solution of the Schrödinger