GEOMETRY DEPENDENT HYBRID MODEL FOR NON-ELASTIC NEUTRON SCATTERING WITH INTRANUCLEAR TRANSITION RATES FROM THE OPTICAL MODEL[1]

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Pre-equilibrium spectra of the non-elastic scattering of 14 MeV neutrons have been investigated in the geometry dependent hybrid model with transition rates derived from the imaginary part of the optical potential.

In the geometry dependent hybrid model a local intranuclear transition rate $\lambda_{n\to n+2}(r, \varepsilon)$ can be calculated from the imaginary part $W(r, \varepsilon)$ of the phenomenological optical model according to [1, 2].

$$\lambda^{W}_{n\to n+2}(r, \varepsilon) = \frac{2}{\hbar} W(r, \varepsilon).$$

This approach has been used to investigate systematically absolute pre-equilibrium spectra in the non-elastic scattering of 14 MeV neutrons.

The method was tested for the reaction ^{93}Nb (n, n'), $\varepsilon_n = 14.6$ MeV with two optical potentials: the standard potential (A) of Becchetti/Greenlees [3] and a special potential (B) [4] fitting the neutron interaction with ^{93}Nb between 0 and 22 MeV incident energy. For energies around 14 MeV the transition rates λ^{W} from the optical model have magnitudes comparable to the transition rates $\lambda^{NN}_{n\to n+2}$ derived from nucleon — nucleon scattering data (Fig. 1). But in the lower energy region the empirical interpolation formula for W gives an energy dependence of λ^{W} differing from the energy behaviour of λ^{NN} (Fig. 2). Looking at λ^{W} as the transition rate $\lambda_{1\to 3}$, the n-dependence of λ proposed by Williams [5] $\left(\lambda_{n\to n+2} \sim \frac{1}{n+1}\right)$ may be introduced raising the preequilibrium spectrum at lower energies. The calculated spectra depend mainly on the interpolation formula for $W(\varepsilon)$, but change only slightly if the geometrical parameters of the optical potential are varied. In comparison with experimental data better results have been obtained with the best-fit potential (B) than with the global potential (A) (Fig. 3).

Using the potential (A) the investigations were extended over a larger mass region (^{27}Al, ^{55}Mn, ^{56}Fe, ^{115}In, ^{127}J, ^{181}Ta, ^{184}W). In all cases the pre-equilibrium spectra have been underestimated within factors between 2 and 10.

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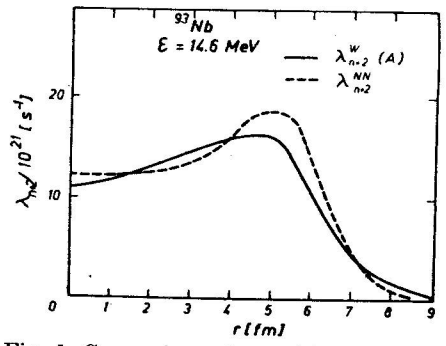

Fig. 1. Comparison of transition rates λ^{W} and λ^{NN}.

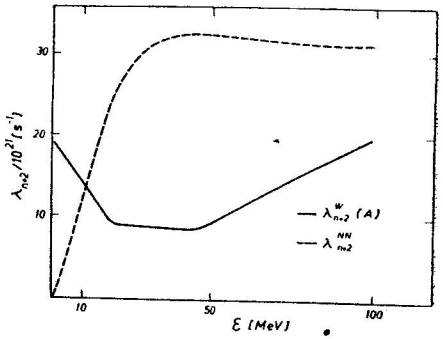

Fig. 2. Energy dependence of transition rates λ^{W} and λ^{NN} in the surface region for ^{93}Nb.

For neutron induced reactions the optical model approach to intranuclear transition rates has disadvantage that the energy dependence of the parameters of the imaginary part is generally not known precisely, mainly because of the lack of good experimental data for broader energy regions. The fits are less sensitive to the absorptive strength W.

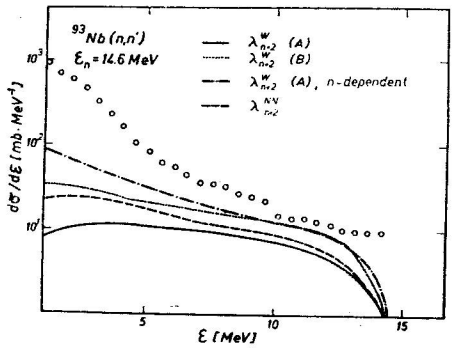

Fig. 3. Pre-equilibrium spectra of ^{93}Nb (n, n') for different transition rates. The calculations have been performed using a modified code of M. Blann. Experimental total spectra from Ref. [6].

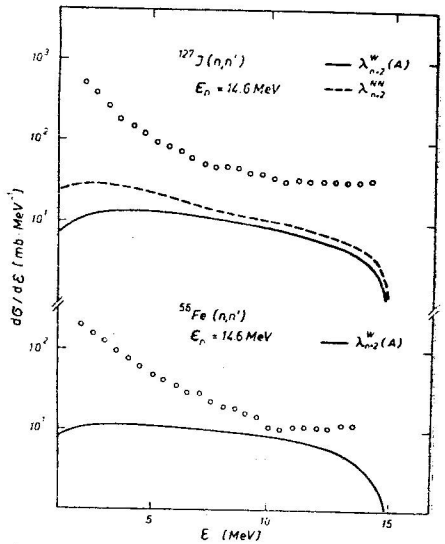

Fig. 4. Calculated pre-equilibrium and measured total spectra of 14 MeV neutrons nonelastically scattered from ^{56}Fe and ^{127}J. Experiments from Ref. [6].

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