Scaling of heavy ion fusion excitation functions with regard to Wongs expression

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Introduction

Cross sections for heavy ion reactions below the Coulomb barrier is characterized by a marked enhancement of the fusion cross sections over the predictions of the one dimensional barrier penetration model, as also the associated isotope dependence. A large number of experimental data has accumulated over the years for such sub-barrier fusion enhancements[1].

The fusion enhancements is usually ascribed to coupling of the fusion channel with other degrees of freedom such as nuclear deformation, low lying collective excitations as well as by nucleon transfer etc. An alternative approach applied to many cases has been the distribution of barriers[2].

With the accumulation of large volume of experimental data it would be desirable to have a general scaling of appropriate parameters describing the fusion excitation functions. Some attempts have already been reported[3].

Here we describe one such attempt.

Wong’s formula

The one dimensional barrier penetration model predicts the following expression, given by Wong [4] for the fusion cross section :

\[
\sigma = \frac{\pi R_B^2 h\omega}{2E_{cm}} \ln \left[ 1 + e^{2\pi(E_{cm}-V_B)/h\omega} \right] \] (1)

The above formula is obtained by replacing the partial fusion probabilities by the transmission coefficients through an inverted parabolic barrier formed by the Coulomb, nuclear and centrifugal potentials. The parameters refer to the position \( (R_B) \), barrier magnitude \( (V_B) \) and the barrier curvature \( (h\omega) \) at \( r = R_B \).

Along the lines of the scheme of barrier distributions for describing the near barrier experimental fusion excitation functions we suggest that the effect of couplings can be accounted for by using a mean effective barrier, again described by three parameters similar to the ones in the Wong formula. These parameters are obtained by a non linear least squares fit to the Wong formula through the experimental data points.

Results and discussion

We have collected near barrier experimental data for about 500 heavy ion systems from the Nuclear Reaction Videos web site [1] and applied the above procedure to them.

Fig 1 shows a typical plot of the excitation function, illustrating the goodness of the fit through the experimental data points for the \(^{16}\text{O} + ^{112}\text{Sn} \) system.

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The following parameters for the different systems have been considered:
1. Coulomb potential at touching radius.
2. Distance of closest approach in a head on collision under Coulomb field alone.
4. Fissility.
5. Neutron separation energy in the compound nucleus.
6. Grazing angular momentum at the barrier energy.

When the third category is considered, the individual groups are found to have either the same projectile or the same target. It is hoped that such plots can be used to predict the fusion excitation function parameters for any arbitrary system.

**References**


