

Are the weak reaction channels really weak?

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It has been demonstrated experimentally in many systems that the fusion barrier between two nuclei does not have a unique value but rather a weighted distribution D_{fus} of heights. The measurements of the barrier distributions are the long lasting project of our group.

D_{fus} can be determined directly from fusion excitation function measurements [1]. There is also an alternative method of its determination: it has been shown both theoretically and experimentally that rather difficult fusion measurements can be replaced by much simpler quasi-elastic scattering measurements at backwards angles, giving rise to the barrier distribution D_{qe} , and there exist many experimental data confirming the basic equivalence of these two methods [2,3].

The studies of fusion cross-section at subbarrier energies show that there is a relation between reaction mechanism and structure of the interacting nuclei. The best theoretical description of this observable can be made within the Coupled-Channels Method where the interplay between various reaction channels is taken into account. In some cases the distribution turns out to be markedly structured and gives a fingerprint of the couplings involved [4,5].

In our experiments we have focused on the ^{20}Ne projectile, since this nucleus has extremely large deformation parameters: $\beta_2 = 0.46$, $\beta_3 = 0.39$, $\beta_4 = 0.27$ [6-8]. We have performed series of barrier distribution measurements for several targets: $^{112,116,118}\text{Sn}$, $^{\text{nat}}\text{Ni}$, $^{90,92}\text{Zr}$ and ^{208}Pb .

The results of first measurements were amazing: the barrier distributions for $^{20}\text{Ne} + ^{112,116,118}\text{Sn}$ turned out to be smooth [9] in contradiction with theoretical predictions, while for the $^{20}\text{Ne} + ^{\text{nat}}\text{Ni}$ system a clearly structured distribution [10] was obtained (in very good agreement with calculations based on the coupled-channels method).

A possible hypothesis is that the smoothing is due to the neutron transfer (pick-up) channel, which for the Ni target is expected to be much weaker than for Sn. This expectation relies on the Rehm transfer cross-section systematics [11], for which the effective Q-value [12] is the main factor influencing the transfer probability.

To check our hypothesis experimentally, we performed measurements for the $^{20}\text{Ne} + ^{90,92}\text{Zr}$ systems. According to the Rehm systematics, for the ^{90}Zr target, the neutron-transfer probability should be only slightly larger than for Ni, while being considerably smaller than for the ^{118}Sn target. For the ^{92}Zr target, the n-transfer probability should be similar to that for the ^{118}Sn target.

In agreement with our expectations, the barrier distributions for the ^{90}Zr and ^{92}Zr targets turned out to be different [13]: the former is structured, while the latter is structureless and wider.

However, one can ask whether the Rehm's systematics, which this reasoning relies on, is in this case sufficiently precise. To answer this question the transfer probability in backward scattering of ^{20}Ne ions on the $^{90,92}\text{Zr}$, and ^{208}Pb were measured. The experiment was performed at Heavy Ion Laboratory using ^{20}Ne beam delivered by Warsaw Cyclotron. ToF technique was employed to identification of transfer products. We will report some preliminary results of this experiment.

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