Nuclear reactions at near-barrier energies with quantum diffusion approach

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The quantum diffusion approach was applied to study the sub-barrier capture reactions with well and loosely bound nuclei [1]. We demonstrated a good agreement of the theoretical calculations with the experimental data. We found that the influence of the neutron transfer on the capture cross section occurs owing to the change of the isotopic composition and the deformations of the reaction partners. The $1n-$ or $2n-$transfer indirectly influences the quadrupole deformation of the nuclei. When after the neutron transfer the deformations of nuclei do not change or decrease, the neutron transfer weakly influences or even suppresses the capture cross section. Good examples for this effect at sub-barrier energies are the capture reactions ^{32}S+^{96}Zr,^{94,96,98,100}Mo,^{100,102,104}Ru, ^{104,106,108,110}Pd,^{112,114,116,118,120,122,124}Sn. The relative enhancement of the sub-barrier fusion cross sections for the reactions with ^{32}S to those with ^{36}S is mostly related to the deformation of the light nucleus. The point of view that the sub-barrier capture (fusion) cross section strongly increases if the neutron transfer has with a positive Q value has to be revised. The neutron transfer can enhance and suppress the sub-barrier fusion.

Our approach revealed that due to the change of the regime of interaction (the turning-off of the nuclear forces and friction) at sub-barrier energies, the first derivative in energy of the cross sections is changed at about $3.5 - 5.0$ MeV below the barrier [2]. This change is reflected in the logarithmic derivative $L(E_{\rm c.m.})$ and astrophysical $S(E_{\rm c.m.})$ factors.

By analyzing the extracted breakup probabilities, we showed that there are no systematic trends of breakup in the reactions studied [3]. Moreover, for some system with larger (smaller) Z_T we found the contribution of breakup to be smaller (larger). Almost for all reactions considered we obtained a satisfactory agreement between calculated capture cross section and experimental fusion data, if the calculated capture cross section or the experimental fusion data are renormalized by some average factor that does not depend on the bombarding energy.

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