Peculiarities of sub-barrier reactions with heavy ions

G.G. Adamian[1]
[1] *Bogoliubov Laboratory of Theoretical Physics,*
Joint Institute for Nuclear Research 141980 Dubna, Russia

The reduced-density-matrix formalism has been applied for describing the process of projectile-nucleus capture by a target nucleus. The calculated capture cross sections for the reactions ^{16}O, ^{19}F, ^{26}Mg, ^{28}Si, ^{32,34,36,38}S, ^{40,48}Ca, ^{50}Ti+^{208}Pb are in a good agreement with available experimental data. This supports the use of the formalism suggested to calculate the capture cross sections. The calculated capture cross sections strongly deviate from the experimental data in the case of the ^{52}Cr+^{208}Pb reaction with very small (large) fusion (quasifission) probability. We would argue that the reason creating such deviation is due to some drawback of our model but rather the system may decay by quasifission from configurations near the entrance channel that is not taken into consideration in the measurements. Note that the decay products near the entrance channel are mainly the quasifission products if $L \leq L_{crit}$. When the maximum angular momentum is equal to the highest trapped L wave, the capture cross section reaches the maximum value. The bombarding energy corresponding to the maximum of capture cross section decreases with increasing Coulomb repulsion in the entrance channel configuration. We predict that for the ^{58}Ni+^{208}Pb reaction the maximum of capture cross section is placed at bombarding energies about 15-25 MeV above the Coulomb barrier. The experimental verification of this effectwould allow us to discriminate between adiabatic and diabatic regimes of nucleus-nucleus interaction potential and determine the depth of the potential pocket.
Due to the change of the regime of interaction (the turning off the nuclear forces and friction) at sub-barrier energies, the decrease rate of the cross-sections is changed at about 3.5-5.0 MeV below the barrier. This change is reflected in the mean-square angular momentum, logarithmic derivative, and astrophysical S-factor. The mean-square angular momentum of a compound nucleus versus $E_{\rm c.m.}$ would have a minimum and then saturation at sub-barrier energies. This behavior would increase the expected anisotropy of the angular distribution of the products of fission following fusion. The energy increment of 0.2 MeV has to be used in the experiment to get the cross-sections suitable for calculating the value of logarithmic derivative and the barrier distribution.