Target-spin effect on the reaction mechanisms of the $^{16}O+^{63}Cu$ system

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After measuring the quasi-elastic barrier distribution for some even-even systems, like $^{16,18}O+^{58}Ni$ [1], $^{16,18}O+^{92}Mo$ [2] and $^{16}O+^{64}Zn$ [3], our group decided to investigate how the nuclear structure details of the odd-mass target nucleus influence the reaction mechanism in the system $^{16}O+^{63}Cu$ at energies near and below the Coulomb barrier. The ^{63}Cu nucleus has a large static ground-state deformation (Q= –0.211 b) and spin $3/2^-$, and these features could have important role in the quantum interference of different reaction channels in this system. Precise quasi-elastic excitation function and alpha-transfer excitation function, at $\theta_{LAB}=161^o$, for the $^{16}O+^{63}Cu$ system have been measured at energies near the Coulomb barrier. A representation of the quasi-elastic barrier distribution was deduced from the precise quasi-elastic data. Several new elastic scattering angular distributions for this system are also presented. All these data, including a fusion excitation function already published, compose a large data set that was compared with complete and free-parameter coupled channel calculations.

In the last 30 years, it has been proved that the reaction mechanisms of systems that contain an odd-mass nucleus can be very affected by the spin of such nucleus. The diffraction minima in elastic scattering of light particles from odd-mass targets can be dominated by the ground-state target-spin reorientation process [4,5,6]. When more massive projectiles are involved, in some cases, the elastic scattering at large angle can be dominated by the same reorientation process of the odd-mass nucleus used as projectile (or target) [7,8]. The influence of the reorientation of excited states of even-mass nucleus on the reaction mechanism was also investigated several years ago. However, most of those works used simple coupled channel calculations that included very few channels in the coupling matrix and they were obliged to use an imaginary potential to account for the channels not included in the calculation. In all of those works, the conclusions were that: if the reorientation effects are considered, the strength of the optical model imaginary potential can be reduced and good fits to data are obtained. Of course, if all open reaction channels are included no imaginary potential at surface is necessary.

In the present work, in order to avoid the use of imaginary potential at nuclear interaction region of the $^{16}O+^{63}Cu$ system, we did coupled channel calculations (CCC) as complete as possible by including all excitation channels for which the experimental B(E2) values were available in the literature. In addiction, the bare nuclear interaction between the projectile and the target was the free-parameter double-folding potential used in the São Paulo Potential [9]. The FRESCO code was used. In this way, we performed theoretical predictions to be compared to data. This is a very important point of our theoretical approach: we are not interested to obtain the best fit to our data by freely changing a lot of potential parameters, but instead of that we coupled, one by one, every excited state of the projectile and target in order to make the imaginary potential unnecessary. Once the nuclear bare potential was fixed by the double-folding procedure, and all nuclear structure parameters used in the calculations was extracted from the literature, its results have clean physical meaning. During this analysis, it was possible to evaluate e the relative importance of the different reaction channels in the quantum competition by the reaction flux. And, what is very interesting, it became clear the real physical origin of the imaginary optical potential commonly used. In fact, a very short-range imaginary potential was used (to simulate the incoming wave boundary condition) to account for the fusion process.

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