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Role of neutron transfer processes on the ^{6}Li+^{120}Sn and ^{7}Li+^{119}Sn fusion reactions

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Abstract

The results concerning the study of ^{6}Li+^{120}Sn and ^{7}Li+^{119}Sn systems are presented. These two sistems are characterised by very similar structures of the interacting nuclei and by different Q-value for one- and two- neutron transfer. Our aim is to disentangle the possible effects due to the different n-transfer Q-values, at sub-barriers energies, by comparing the two fusion excitation function. In these experiments the fusion cross section has been measured by using a stack activation technique. No particular differences in the two fusion excitation functions have been observed.

The influence of transfer channels on fusion cross-section has been object of investigations in the last years. In particular, the possible dependence of the fusion cross-section on the sign of the neutron transfer Q-value has been much debated in literature. The systematic approach used for the study of the Ca+Zr systems [1] provided relatively clear evidence of the relation between sub-barrier-cross section and the sign of the neutron transfer Q-value, in a model-independent way. According to experimental

observations, authors concluded that the enhancement observed in the case of the ^{40}Ca+^{96,94}Zr fusion cross section, with respect to the other isotopic counterparts (^{40,48}Ca+^{90}Zr and ^{48}Ca+^{96}Zr), could be explained as due to the fact that for these two reactions the Q-values for neutron transfer are positive and larger than in the other studied systems. However, in recent works [2, 3], similar sub-barrier fusion cross-sections have been measured even if the studied systems present very different Q-values for multi-neutron transfer. Also from the theoretical point of view, the relation between the two processes is still an open issue. Beckerman et al. [4] proposed that the enhancement at sub-barrier energy could be linked to an increase in the kinetic energy of the system, due to the neutron transfer channels with positive Q-value, which favored the fusion. On the contrary, other authors [5] suggested that the multineutron transfers could influence, the sub-barrier capture probability indirectly, through the changes of the deformations of the colliding nuclei.
For further investigate the possible relation between the presence of positive neutron transfer Q-value and the sub-barrier enhancement of fusion cross-section, we measured the fusion cross section of ^{6}Li+^{120}Sn and ^{7}Li+^{119}Sn. These two system are characterized by very similar entrance channels and present different Q-values for one-neutron ($1n$) and two-neutron ($2n$) transfers, thus resulting very suitable for this kind of study.

The ^{6}Li+^{120}Sn and ^{7}Li+^{119}Sn measurements were performed at the Laboratori Nazionali del Sud in Catania using the beams delivered by the Tandem van de Graaff accelerator. A centre of mass energy range between 16-24 MeV was investigated. As in our previous experiments [6–8], we measured the fusion excitation function by using an activation technique, based on the off-line detection of the atomic X-rays emitted after the electron capture decay of the evaporation residues (ER) produced in the reaction. The compound nucleus formed in both fusion reactions studied in the present work is the ^{126}I.
In the inset of figure 1 a typical X-ray spectrum measured off-line is shown. It is possible to distinguish the K_α and K_β X-ray emission of Iodine, the only element which could be produced after complete fusion, and of Sb, which is produced in the incomplete fusion of d or t with the target. The contribution of different Iodine isotopes can be unfolded by following the activity of the X-ray lines of interest and by fitting it using the known half-lives. Figure 1 shows a typical decay curve for the ^{7}Li+^{119}Sn reaction obtained by monitoring the activity of the Iodine peak. It is characterized by three different slopes which correspond to different isotopes produced

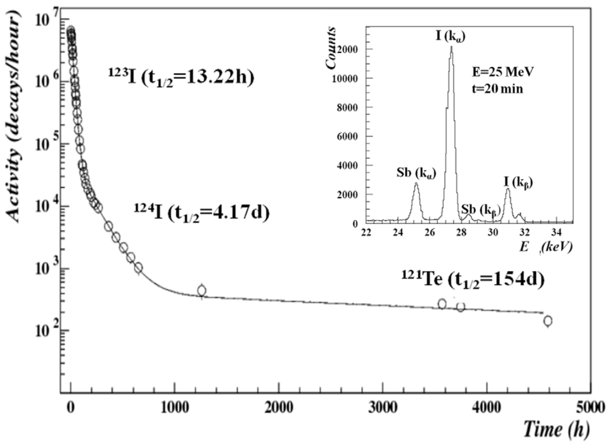

Figure 1: (Inset) X-ray spectrum measured off-line, 20 minutes after the end of the irradiation, for the reaction ^{7}Li+^{119}Sn at E_{LAB}= 25 MeV; Decay curve obtained by monitoring in the time the k_α peak of I isotopes.

in the reaction. One can distinguish the contribution of ^{123}I and ^{124}I. The third component has been identified with the ^{121}Te, which can be produced in the incomplete fusion of an α with the target nucleus. The ^{121}Te is metastable and decays by internal conversion thus emitting X-rays. By fitting the activation curves for each ER one obtains its activity at the end of the irradiation time, needed for the evaluation of the fusion cross-section. By knowing also, the efficiency of the Si(Li) detector, the K_α fluorescence probability, the beam current as a function of time and the target thickness, it is possible to obtain the production cross section for each residue produced in the reaction. The fusion cross section is obtained by summing the contribution of all the ER produced inside the target.
In figure 2 the reduced fusion excitation functions for the two studied reactions are reported. The data have been reduced by dividing the fusion cross-section by the square of the barrier radius (R_B^2) and subtracting from the center-of-mass energy the height of the Coulomb barrier V_b. At energies below the barrier, the two curves do not present significative differences, which could be imputable to the different 1n- and 2n- transfer Q-values of the two reactions. At energies above the barrier, the fusion excitation function of the ^{7}Li+^{119}Sn system is higher that the one of the ^{6}Li+^{120}Sn. This difference could be attributed to the different breakup probability of the two projectiles [9].

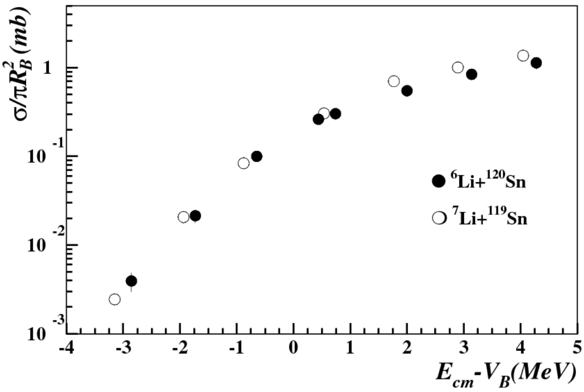

Figure 2: ^{6}Li+^{120}Sn (filled circles) and ^{7}Li+^{119}Sn (open circles) fusion excitation function reduced as $\sigma/\pi R_B^2$ vs $E_{cm} - V_B$.

In conclusion, by measuring the fusion cross section induced by the weakly bound ^{6}Li and ^{7}Li projectiles on different Sn isotopes, we looked for effects on fusion cross section which can be attributed to the neutron transfer channels. No difference imputable to the different n-transfer Q-values can be deduced from our data. This behavior seems to be consistent with the one observed recently in fusion reaction of heavier systems [2, 3].

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