N/Z effect on reaction mechanisms cross sections in the $^{78}Kr + ^{40}Ca$ and $^{86}Kr + ^{48}Ca$ collisions at 10 AMeV

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Abstract. Nuclear reactions between medium-mass nuclei at low energy are characterized by the competition between binary and evaporation process in the compound nucleus de-excitation. A study of the influence of the neutron richness of the entrance channel on the decay paths of the compound nuclei formed in the $^{78}Kr +^{40} Ca$ and $^{86}Kr +^{48} Ca$ at 10 MeV/A is presented. The experiment has been performed at Laboratori Nazionali del Sud by using the CHIMERA 4π multidetector for charged particles. The Kinematical characteristics of the two reactions support the conclusion of a production via long lived system. Besides the results relative to the n-poor system are compared to those obtained at GANIL, performed at 5.5 AMeV, in order to study the energy influence.

1. Introduction

The N/Z ratio, strongly correlated to the isospin degree of freedom, influences the competition among the different reaction mechanisms and have important effects on the aspects characterizing the heavy ion collisions, like for example the production of fragments with an atomic

number $3 \leq Z \leq 20$, denoted as the Intermediate Mass Fragments, IMF. The characterization of the production source of the IMFs and the deep comprehension of the effects shown by their emission is one of the goal of nuclear physics in these last years.
In order to study the neutron enrichment effect on the decay modes of the compound nucleus, with a particular attention to the IMFs production, the experiment called ISODEC,[1],[2],[3] has been performed at Laboratori Nazionali del Sud in Catania, by using the beams delivered by the Superconductive Cyclotron and the detection and identification capability of the 4π multi-detector CHIMERA[4],[5]. In fact the reactions studied, $^{78}Kr + ^{40}Ca$ (n-poor) and $^{86}Kr + ^{48}Ca$ (n-rich), lead to the formation of two systems with N/Z ratios, respectively 1.11 and 1.39, providing the maximum difference available with stable beams.

2. Experimental Results

A deep study of the kinematical characteristic of the reaction products was performed, for details see [3]. The results of the analysis suggest that the IMFs were produced by the two studied systems trough the same mechanism, a fission-like process, but with different probability. In fact the values of the production cross sections of IMFs, plotted versus the atomic number in the fig.1 [3], are higher for the n-poor system compared to n-rich one. Moreover the strong influence of the isopin is also evident in the different oscillation amplitude of the even-odd effect presented by the charge distribution, that is more pronounced for the n-poor system in agreement with other examples in literature [6],[7].This effect is also observed in the plot IMF's yields versus the neutron number, shown in the fig.2, but in this case it is more pronounced for the n-rich system [6]. One should observe that in literature there are few examples of this kind of study, as it is requires an apparatus allowing a good isotopic discrimination; in the ISODEC experiment, the CHIMERA device through the ΔE-E technique provides, with high resolution, the isotopic composition of the fragments with $Z \leq 10$.

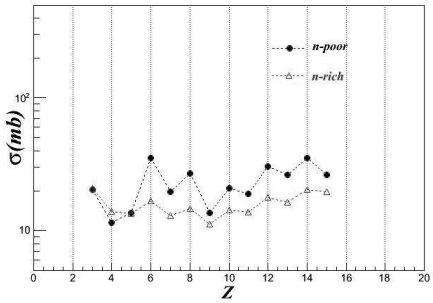

Figure 1. Production cross section for fragments with different atomic numbers for the two reactions $^{78}Kr + ^{40}Ca$ and $^{86}Kr + ^{48}Ca$. The error bars are inside the graphical symbols.

In order to understand if the IMFs are emitted in an excited state, the relative velocity of an IMF and an α particle emitted in coincidence was studied in the reference frame of the fission fragment. The $v \parallel v \perp$ plots, in the case of very asymmetric, asymmetric and symmetric fission, in the frame of the light fragment and in its complementary partner frame, are shown in the fig.3, compared to those relative of the experiment, realized at GANIL, with the INDRA device, where the $^{78}Kr + ^{40}Ca$ reaction was studied at 5.5 AMeV [8]. One observe that in the case of a very asymmetric fission, at higher energy the $v \parallel v \perp$ plot seems to present two coulomb rings, one centered around the velocity of the heavy fission fragment and the other around the

velocity of the light one, suggesting that at 10 AMeV, also the light fragment can emit α particles and is thus emitted in excited states. For a better comparison of the results obtained at the two different energies and between these experimental results and the theoretical predictions of statistical and dynamical models the cross sections of the different process will be calculated.

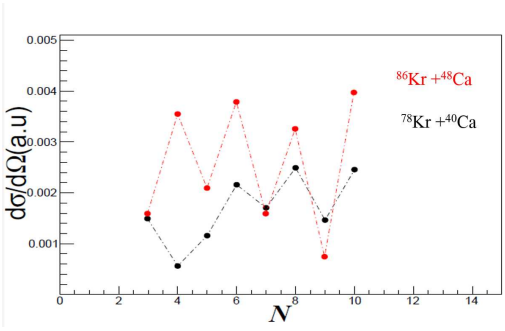

Figure 2. IMFs yields versus the neutron number in black for $^{78}Kr +^{40} Ca$ and in red for $^{86}Kr +^{48} Ca$. The error bars are inside the graphical symbols.

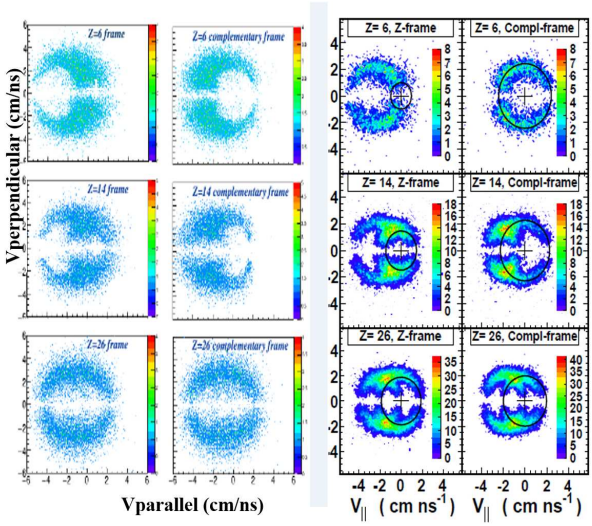

Figure 3. $v \parallel v \perp$ plot for the n-poor system, in the frame of the light fragment and in its complementary partner's referenceframe, on the left for incident energy E= 10AMeV and on the right for E=5.5 AMeV .

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