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ISOSPIN TRANSPORT IN ^{84}Kr + ^{112,124}Sn REACTIONS AT FERMI ENERGIES — FIRST PHYSICS RESULTS FROM FAZIA*

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The FAZIA Collaboration studied collisions of a ^{84}Kr beam at 35 AMeV with ^{112}Sn and ^{124}Sn targets by means of a three-layer telescope. A good isotopic resolution up to $Z = 20$ was reached. The isotopic content of the products was found to depend on the neutron richness of the target, which is an evidence of isospin diffusion. Neutron-rich light fragments emitted from the phase space close to the centre-of-mass were observed, which can be interpreted as an effect of isospin drift in the neck region of low density.

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1. Introduction

Traditionally, the $\Delta E - E$ method has been used for the measurement of charge and mass of the fragments produced in nuclear reactions, for instance, in INDRA [1] and CHIMERA [2] detectors. However, the isotopic separation of these detectors is limited to $Z = 6$ and $Z = 13$, respectively [3]. The rapid

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development of radioactive ion beams facilities propelled nuclear physicists to design a new detector with improved isotopic separation. Not only will it enhance the knowledge of the equation of state and, in particular, of the density dependence of its symmetry term [3], but also it will be useful in studies focused on nuclear isospin phenomena, where the N/Z ratio will be a key experimental observable [4]. For this reason, in 2001, a group of French and Italian scientists established a collaboration aiming to improve the detection and identification of charged particles released in heavy ion reactions. This initiative later became the FAZIA project [5], currently grouping more than ten institutions from six countries. First physics results from FAZIA test experiment [6] have been recently published [7] and are concisely summarized below.

2. Experiment

2.1. Experimental setup

The experiment took place at the Superconducting Cyclotron of the Laboratori Nazionali del Sud in Catania. A 35 AMeV ^{84}Kr beam impinged on two targets, neutron-poor ^{112}Sn and neutron-rich ^{124}Sn. The measurement was performed by means of a single telescope consisting of three layers: two silicon detectors of thicknesses 305 μm and 510 μm, and a 10 cm thick CsI(Tl) crystal. Although, in principle, it is possible to identify fragments stopped in the first silicon layer based on the pulse shape analysis (see, for example, Ref. [8]), only particles stopped either in the second Si layer or in the CsI(Tl) were accepted for the analysis. The Reader is referred to [6] for a more exhaustive description of the setup.

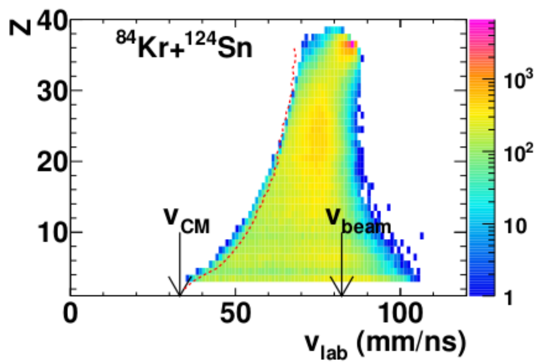

Fig. 1. (Color online) Distribution of charge *versus* velocity for fragments with $Z \geqslant 3$ passing the first silicon detector for the reaction with ^{124}Sn target. Center-of-mass and beam velocities are marked by arrows. The dashed line is the expected threshold for passing the first silicon layer. The figure is adapted from [7].

The telescope was placed just beyond the grazing angles for the two reactions and, as can be inferred from Fig. 1, this position of the detector allowed to select fragments mainly emitted from the phase space of the projectile.

2.2. Results

Figure 2 proves the excellent isotopic resolution of the FAZIA telescope, owing to which it was possible to measure the average isospin for all the products with $Z \leqslant 20$. The particle identification spectra for carbon (a) and magnesium (b) isotopes are shown. Black lines and dashed (red) lines are used for reactions with neutron-rich and neutron-poor targets, respectively, and for each element the two spectra are normalised to the same number of counts. Looking at the isotopic composition of the fragments, it can be seen that the neutron-rich side is more populated for reaction with ^{124}Sn target, while the lighter isotopes are more abundant for the neutron-poor ^{112}Sn target. Since the measured fragments principally belong to the quasi-projectile region of the phase space, this difference can be ascribed to isospin diffusion process, resulting in the fragment isospin dependence on the neutron richness of the target.

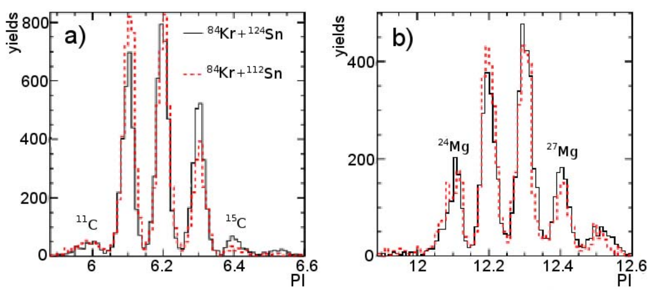

Fig. 2. (Color online) Isotopic spectra for carbon (a) and magnesium (b) for the reactions ^{84}Kr + ^{124}Sn (solid/black histograms) and ^{84}Kr + ^{112}Sn (dashed/red histograms). For each element, the black and red spectra are normalised to the same number of counts. The figure is adapted from [7].

The observation from the last paragraph is further supported by data presented in Fig. 3, where the $\langle N \rangle / Z$ ratio is plotted as a function of velocity for selected elements. The black circles, corresponding to the neutron-rich system, are always above the dots (red) referring to reaction with neutron-poor ^{112}Sn. These plots are, at the same time, characteristic for another reason. For lighter elements, one sees very clearly the increase of the average isospin when approaching the velocities of the centre-of-mass, with notably high values of $\langle N \rangle / Z$ (over 1.3). These fragments are likely to have been emitted from a neck-like region of smaller density formed between quasi-projectile and quasi-target, and the observed effect can be interpreted as an evidence of isospin drift, *i.e.* a migration of neutrons towards the neck region and of protons towards projectile-like and target-like fragments (see Ref. [9] for a very good overview of similar processes).

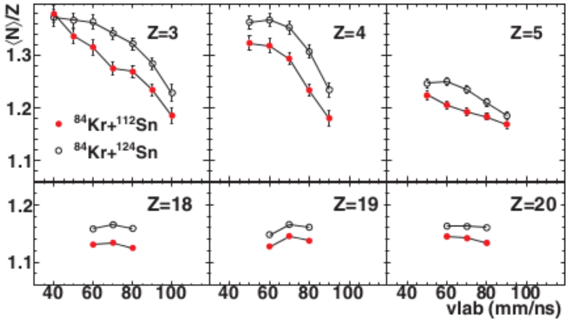

Fig. 3. (Color online) $\langle N\rangle/Z$ as a function of the laboratory velocity for selected elements. The black circles and red dots correspond to ^{84}Kr + ^{124}Sn and ^{84}Kr + ^{112}Sn reactions. The figure is adapted from [7].

Outstanding performance of the FAZIA telescope enabled us to isotopically resolve fragments up to $Z = 20$ and to investigate isospin diffusion and isospin drift. More sophisticated experiments and hence further results concerning the isospin transport will be possible when more FAZIA telescopes are available. The FAZIA project is currently in the phase of building a demonstrator comprising 192 telescopes, expected to be ready in 2014 [3].

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