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Nuclear symmetry energy in charge and isotopic distributions

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Abstract. Isotopic yields of nitrogen and boron fragments from the decay of the single nucleus with $A_0 = 186$, $Z_0 = 75$ were studied on the basis of the statistical multifragmentation model, and compared with data from the MSU experiments for central collisions of ^{124}Sn + ^{124}Sn at $E/A = 50$ MeV. We have reconfirmed that a significant reduction of the symmetry term coefficient is necessary to reproduce the experimental isotopic distributions.

1. Introduction

Nuclear multifragmentation has attracted great interest due to its similarity to the collapse and explosion of massive stars. By this reason, the importance of isotopic effects in nuclear multifragmentation are related to astrophysical processes such as supernova simulations and neutron star models. We have interpreted MSU data for central collisions of ^{124}Sn + ^{124}Sn at $E/A = 50$ MeV. In this presentation, we investigate the influence of the expected decrease of symmetry energy extracted from the isotopic distributions for N and B isotopes within the microcanonical Markov-chain version of the statistical multifragmentation model [1, 2]. For simulation we have considered the decay of a single source with $A_0 = 186$, $Z_0 = 75$, which is presumably formed during the central collisions of ^{124}Sn + ^{124}Sn. Then, we compare the results with MSU experimental data [3].

2. Theoretical calculations and results

For the calculations of charge and isotopic yields we consider the statistical multifragmentation model (SMM) [1]. In the SMM, it is assumed that a statistical equilibrium is reached at low density in the freeze-out region. It is also assumed that all breakup channels are composed of nucleons, and the laws of the conservation of energy E^*, momentum, angular momentum, mass number A and charge number Z are taken into account. Besides the breakup channels, the compound-nucleus channels are also included, and a competition among all channels is permitted. In this way, the SMM covers the conventional evaporation and fission processes occurring at low excitation energy as well as the transition region between the low- and high-energy de-excitation regimes. In the thermodynamic limit, SMM is consistent with the liquid-gas phase transition when the liquid phase is represented by an infinite nuclear cluster.

As was demonstrated earlier [4, 5], varying surface and symmetry terms can essentially influence the characterization of the fragments produced in multifragmentation. In Fig. 1, we show the results of a reasonably small variation of the surface energy term B_0 in between 16 and 20 MeV (panels a and b), and the results of the variation of the symmetry term (panels c and

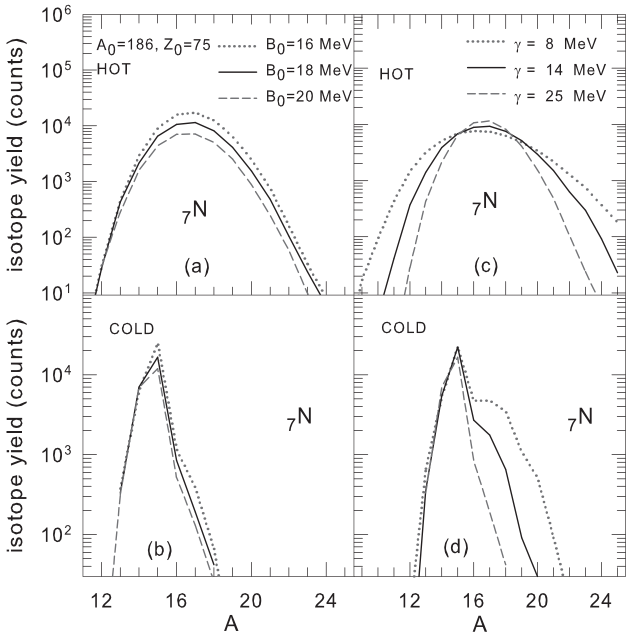

Figure 1. Predicted isotope distributions for nitrogen fragments from the multifragmentation of the single source $A_0 = 186$, $Z_0 = 75$, at various surface energy B_0 (panels a and b) and symmetry energy γ values (panels c and d).

d). It is seen that the surface energy term B_0 does not produce significant changes in the isotope distributions for nitrogen fragments, but the symmetry term causes significant changes. This was also confirmed in Ref. [4] within SMM-ensemble calculations performed for the interpretation of ALADIN experimental data. In Ref. [6], we showed that the symmetry energy has a small influence on fragment mass and charge distributions, however, its effect is more pronounced in

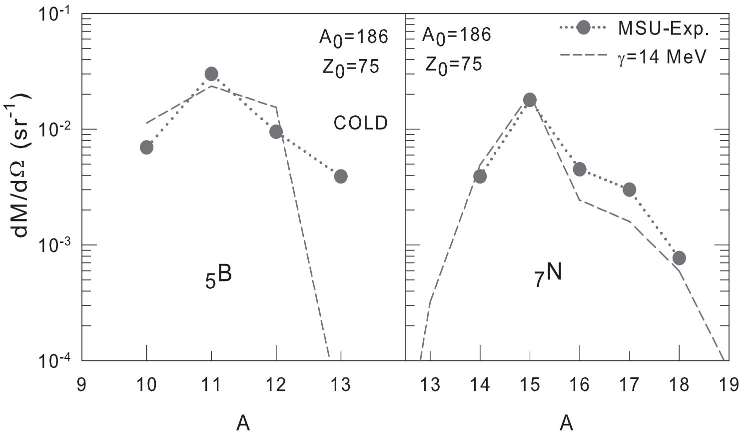

Figure 2. Predicted isotope distributions for boron and nitrogen fragments from the decay of the single nucleus with $A_0 = 186$, $Z_0 = 75$. The dashed lines are the present results for cold fragments at γ= 14 MeV, and the solid circles are the MSU data.

the isotopic distributions. By means of this sensitivity, we can estimate the symmetry energy by comparing the predicted distributions with experimental data.

In Fig. 2, we compare our results for isotopic yields with MSU data. One can conclude from this figure that our secondary cold fragment distributions compare well with the experimental data at the reduced gamma values around $\gamma = 14$ MeV, as was already obtained in our analyses of other observables [7, 8, 9].

3. Conclusions

It has been demonstrated that it is possible to investigate, in experiments, the modification of the liquid drop parameters of fragments, such as the symmetry energy coefficient, at subnuclear densities in the dense environment of the nucleus undergoing fragmentation. This is important for the equation of state of nuclear and stellar matter in terms of the density dependence of symmetry energy.

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