Using light cluster production to determine the density dependence of the nuclear symmetry energy

S. N. Soisson, L. W. Chen, E. Bell, B. A. Li, D. V. Shetty, G. A. Souliotis, A. L. Keksis, S. J. Yennello and the NIMROD Collaboration

Using a coalescence model for treating cluster production from an isospin dependent transport model, it has been shown that the multiplicities and the energy spectra of light clusters produced is sensitive to the density dependence of the nuclear symmetry energy but not to the isospin-independent part of the nuclear equation of state or the in-medium cross sections [1,2]. Using an isospin-dependent Boltzmann-Uehling-Uhlenbeck (IBUU) transport model [2] coupled to a coalescence model the comparison of the energy spectra, multiplicities and the ratio of ^{3}H and ^{3}He production for the systems of ^{58}Fe + ^{58}Fe and ^{58}Ni + ^{58}Ni at 45 MeV/nucleon has been studied.

Previously, we have shown that the measured ^{3}H to ^{3}He ratio shows no significant dependence on centrality and that the iBUU-coalescence model does not reproduce the production ratio of ^{3}H to ^{3}He well [3]. In recent studies [4], a constraint of the x parameter, found in the momentum and isospin-dependent single nucleon potential [5] in the iBUU calculation has been proposed to be between 0 and -1. These values correspond to parameterization of the symmetry energy of $E_{sym}(\rho) \approx 31.6(\rho/\rho_o)^{0.69}$ to $E_{sym}(\rho) \approx 31.6(\rho/\rho_o)^{1.1}$. We have run the iBUU-coalescence model to reflect this constraint. In Figure 1 we see the experimental double ratio of $(^3H/^3He)_{FeFe}/(^3H/^3He)_{NiNi}$ compared to four different x values for a momentum dependant iBUU calculation. In Table I we see the slope of the best fit line for

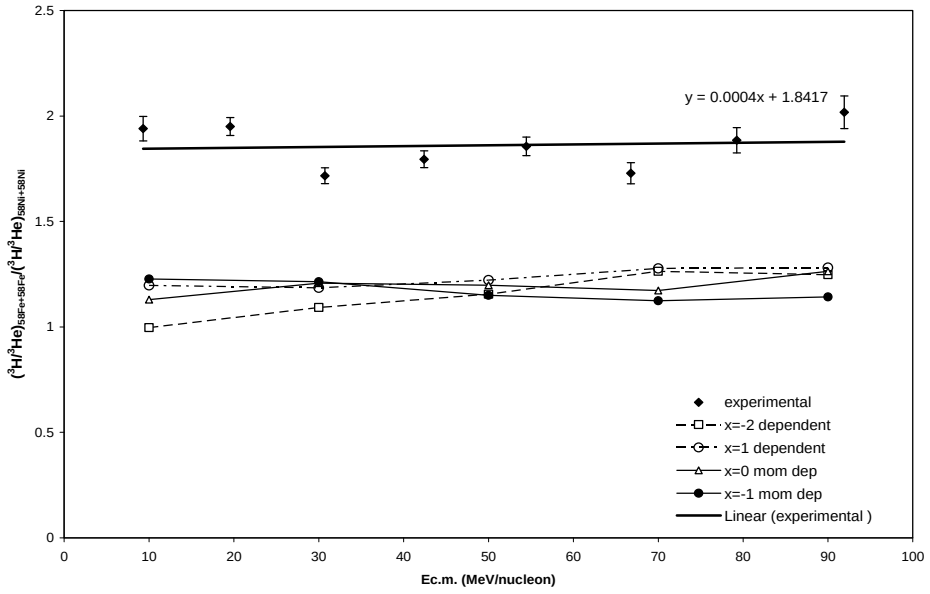

Figure 1. The double ratio of $(^3H/^3He)_{FeFe}/(^3H/^3He)_{NiNi}$ compared to 4 different iBUU-coalescence calculations.

each x value. The slope of the experimental best fit straight line is 0.0004 for the energy range of 0 to 100 MeV/nucleon. The double ratio is nearly flat which signals that there is no energy dependent differential production of ^{3}H and ^{3}He due to the N/Z of the parent system. When comparing this to the iBUU-coalescence extracted double ratio best fit slopes for this energy region we find that it lies between x = -1 and x = 0. However, the slopes of the lines for all calculations are similar and no definitive conclusion can be made though this type of analysis. The under prediction of the double ratio could reflect the distillation of the systems that is not being accounted for in the calculation. For this to be a good observable, it is possible that a greater N/Z difference is needed.

Table I. x value used in iBUU calculation with its corresponding slope of the best fit line for the double yield ratio.

x value	Slope
-2	0.0034
-1	-0.0013
0	0.0012
1	0.0013

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