Experimental Determination of the Symmetry Energy of a Low Density Nuclear Gas

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In a recent theoretical paper, Horowitz and Schwenk have reported the development of a Virial Equation of State (VEOS) for low density nuclear matter [1]. This equation of state, derived from experimental observables should be "model-independent" and therefore can be used to "set a benchmark for all nuclear equations of state at low densities." Its importance in both nuclear physics and in the physics of the neutrino sphere in supernovae is emphasized in the VEOS paper [1]. An important feature of the VEOS is the natural inclusion of clustering which leads to large symmetry energies at low baryon density.

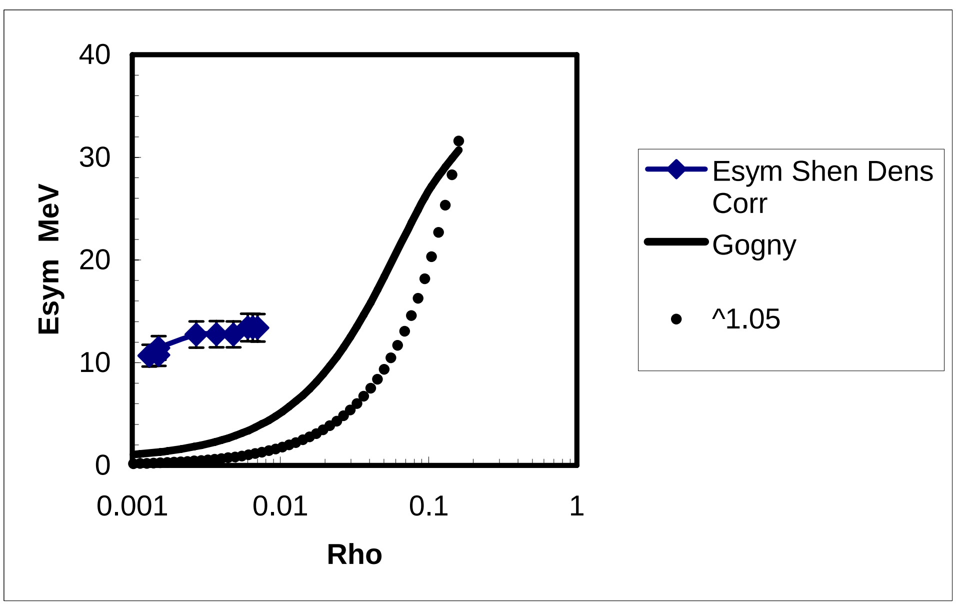

Figure 1. Derived symmetry energy coefficients as a function of baryon density. Solid diamonds indicate results using densities of column 4 in Table 1..Solid line indicates the variation predicted by the Gogny interaction. The dotted line represents the function 31.6 x $(\rho/\rho_0)^{1.05}$ [3].

The reactions of 35 MeV/nucleon ^{64}Zn projectiles with ^{92}Mo and ^{197}Au target nuclei were studied at the K-500 Super-conducting Cyclotron Facility at Texas A\&M University, using the 4π detector NIMROD. For nuclear gases with average proton fraction, Yp ~0.44, and densities at and below 0.05 times normal nuclear density, experimental symmetry energy coefficients of 10 – 14 MeV have been derived from experimentally determined symmetry free energies , F_{sym} , determined using the isoscaling method. A detailed description of this work may be found in reference 2. The symmetry energies are far above those obtained in common effective interaction calculations and reflect cluster formation, primarily of alpha particles, not included in such calculations. The symmetry energy coefficients are plotted against density in Figure1 where they are compared to those which are predicted by the Gogny effective interaction and to the 31.6 x $(\rho/\rho_0)^{1.05}$ dependence suggested by a recent analysis of isospin diffusion data [3].

[1] C.J. Horowitz and A. Schwenk, ArXiv preprint nucl-th/0507033 (2005).
[2] S. Kowalski et al, ArXiv Preprint nucl-ex/0602023, Phys. Rev. C (submitted).
[3] L.W. Chen, C.M. Ko nd B.A. Li, Phys. Rev. Lett. **94**, 032701 (2005).