Constraining the symmetry energy from nuclear giant resonances

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The nuclear symmetry energy appearing in the equation of state (EoS) of nuclear matter is essential in understanding many aspects of nuclear physics as well as astrophysical phenomena. The structure of neutron star, supernovae explosion, heavy-ion collision dynamics etc. depend on the structure of EoS, i.e., in turn on the bulk properties of nuclear matter like symmetry energy (J) and incompressibility modulus (K). Empirical liquid-drop mass formula predicts the value of J around normal nuclear density to be of the order of 30 MeV. Nuclear giant resonances provide much important information about the nuclear structure and the bulk properties of the nuclear matter. The value of another important bulk property of nuclear matter, i.e., the value of K for symmetric matter is constrained to be 230 ± 20 MeV from the nuclear isoscalar giant monopole resonance (ISGMR) data. The uncertainty of 20 MeV is mainly due to the uncertainty in the value of J.

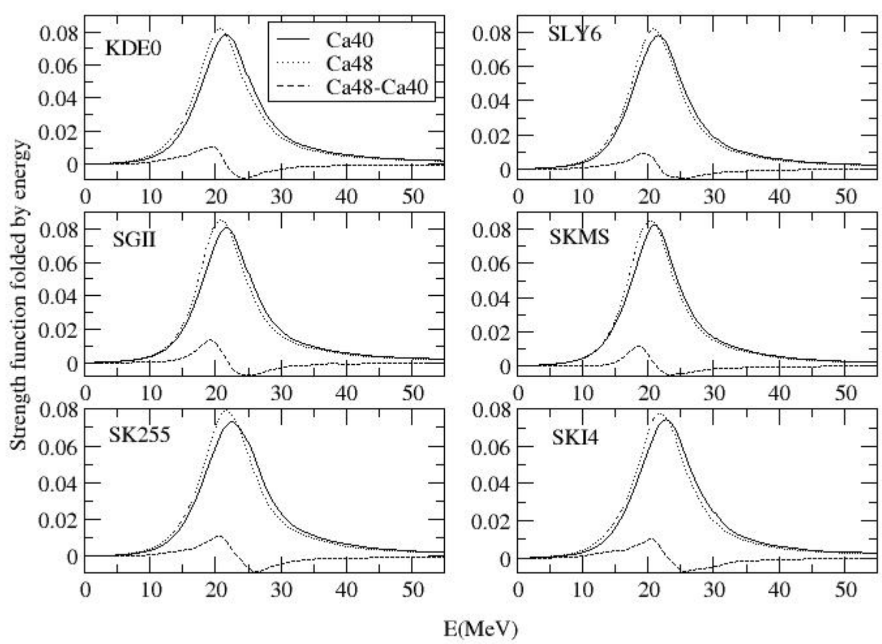

Figure 1. ISGMR strength distributions for ^{40}Ca and ^{48}Ca.

It has been shown in Ref. [1] that the distribution of the strength of ISGMR in ^{208}Pb is sensitive to the density dependence of the symmetry energy. This motivates us to study the force dependence of the ISGMR strength distribution for calcium isotopes. Experimental data for ISGMR for the symmetric nucleus ^{40}Ca is already available and it is possible now to do experiment with the asymmetric nucleus ^{48}Ca. In the figure, we plot the ISGMR strength functions for ^{40}Ca and ^{48}Ca, obtained from highly accurate and fully self-consistent Hartree-Fock based RPA [2] calculations using various forces having different values of J and K. We also plot the difference of the strength functions of ^{40}Ca and ^{48}Ca. By comparing these theoretical values with experimental data we hope to constrain the value of the symmetry energy.

[1] J. Piekarewicz, Phys. Rev. C **69**, 041301 (2004).
[2] T. Sil, S. Shlomo, B. K. Agrawal and P.-G. Reinhard, Phys. Rev. C **73**, 034316 (2006).