Isovector giant dipole resonances in ^{44}Ca, ^{54}Fe, ^{64,68}Zn and ^{56,58,60,68}Ni and the energy weighted sum rule enhancement factor

G. Bonasera, S. Shlomo, D.H. Youngblood, Y.-W. Lui, Krishichayan, and J. Button

We carried out fully self-consistent Hartree-Fock (HF)-based random phase approximation (RPA) calculations of the centroid energies for the isovector resonances up to L=3 multipolarity for the isotopes of ^{44}Ca, ^{54}Fe, ^{64,68}Zn and ^{56,58,60,68}Ni [1]. The calculations were done using 33 different Skyrme-type effective nucleon-nucleon interaction commonly adopted in the literature. The interactions considered are associated with a wide range of nuclear matter properties. For the single particle orbits of the open shell nuclei we used the occupation number approximation to perform the calculations.

The Pearson Linear Correlation coefficient, C, is calculated between the centroid energies, E_{CEN}, of each giant resonance and every nuclear matter (NM) property. We then compare our theoretical calculation to the available experimental data and in the cases where we have high correlation we can set limiting values on the NM properties. Here we report on a strong correlation between the centroid energies of the Isovector Giant Dipole Resonances and the energy weighted sum rule enhancement factor κ. In Fig. 1 we show the centroid energies of the isovector giant dipole resonance as a function of κ. We obtained a strong Pearson linear correlation coefficient, for all shown nuclei, between the calculated values of E_{CEN} and κ with C~0.80. From the comparison with the experimental data, we find that for ^{44}Ca, ^{56,60}Ni and ^{64}Zn the interactions associated with a higher value of κ are closest to reproducing the data. Conversely, for ^{54}Fe and ^{68}Zn interactions associated with a smaller value of κ reproduce the data, while for ^{58,68}Ni the intermediate region of κ = 0.25-0.7 reproduces the data. Overall, we find that the region of κ = 0.25-0.7 is the best at reproducing most of the data.

These results confirm a similar analysis done for a wide mass range of spherical nuclei [2] and can be used as part of a set constrains on NM properties to determine the next generation nuclear energy density functional with improved predictive power for properties of nuclei and nuclear matter.

[1] G. Bonasera *et al*., in preparation.
[2] G. Bonasera, M.R. Anders, and S. Shlomo, Phys. Rev. C **98**, 054316 (2018).

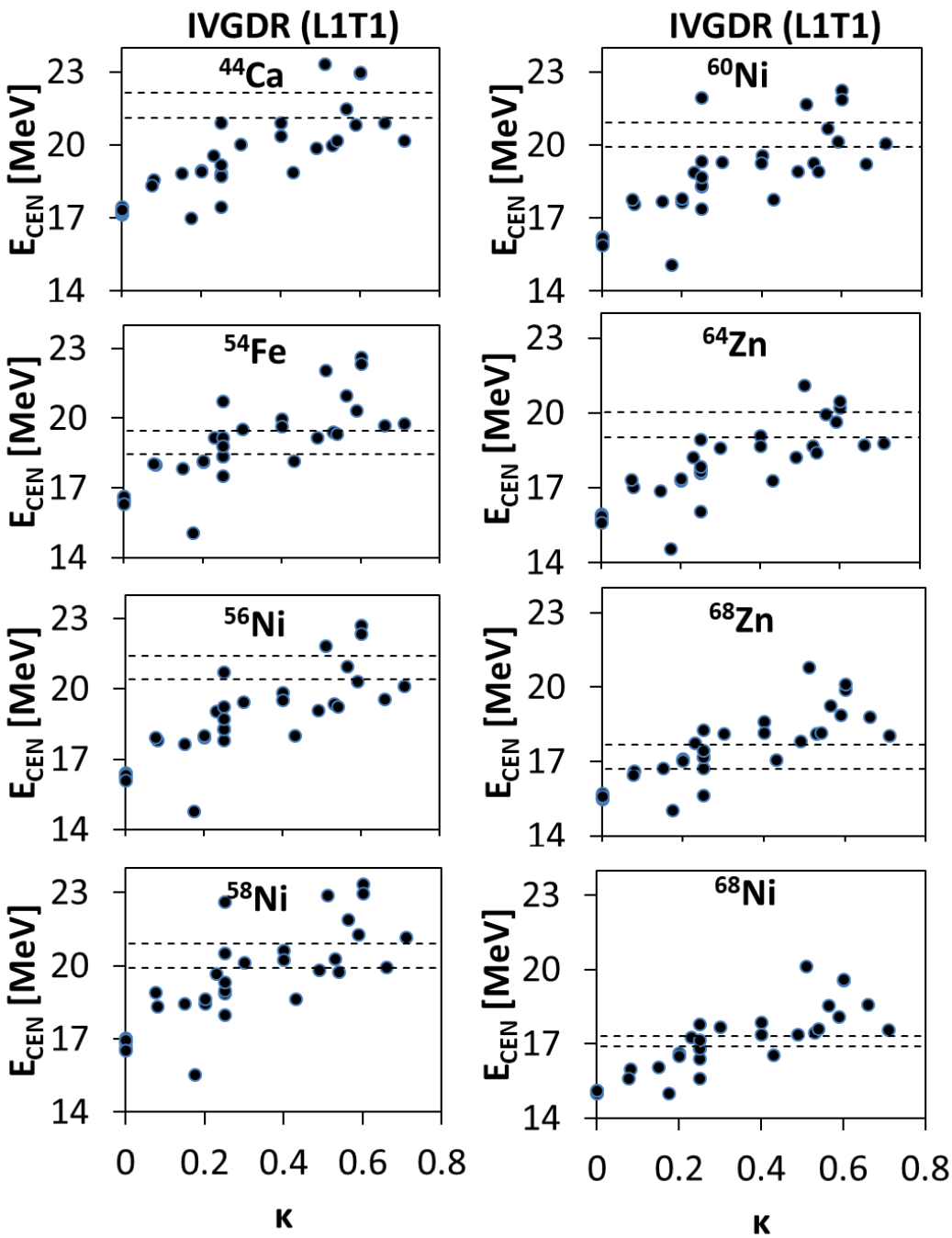

FIG. 1. Calculated centroid energies E_{CEN} in MeV (full circle) of the Isovector Giant Dipole Resonance, for the different interactions, as a function of the isovector dipole enhancement factor κ. Each nucleus has its own panel and the experimental uncertainties are contained by the dashed lines. We find strong correlation between this NM property and the calculated E_{CEN} with a Pearson Linear Correlation C ~0.80 for all considered nuclei.