Isoscalar Giant Resonances and Nuclear Incompressibility

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We have illustrated so far the possible consequences of various numerical approximation and violation of self-consistency on centroid energies for isoscalar giant monopole (ISGMR) and dipole (ISGDR) resonances. We showed that renormalization of the particle-hole interaction V_{ph} may not be a plausible way to restore self-consistency. Because, by renormalizing V_{ph} one can shift the spurious state to close to zero as desired, but at the same time this changes significantly the incompressibility associated with V_{ph}. Here we report (1) our numerically accurate and fully self-consistent results for the centroid energy E0 for ISGMR and E1 for ISGDR obtained using a class of simplified Skyrme type effective nucleon-nucleon interaction taken as

$$V_{12} = \delta(r_1 - r_2)[t_0 + \frac{1}{6} t_3 \rho^{\alpha} (\frac{r_1 + r_2}{2})] \qquad (1)$$

leading to

$$V_{ph} = \delta(r_1 - r_2)[\frac{3}{4} t_0 + \frac{3}{8} t_3 \rho] \qquad (2)$$

The parameter t_0 and t_3 are determined by fixing the values of Fermi momenta (k_f) and the binding energy per nucleon (E/A) for nuclear matter. One thus obtains

$$t_0 = -\frac{4}{15\alpha}(\frac{3\pi^2}{2k_f^3})$$

$$[(3\alpha+1)\frac{\hbar^2}{m}k_f^2 - 10(\alpha+1)\frac{E}{A}]$$

$$t_3 = \frac{8}{5\alpha}(\frac{3\pi^2}{2k_f^3})^{(\alpha+1)}(\frac{\hbar^2}{m}k_f^2 - 10\frac{E}{A})$$

We have tabulated below the values of t_0, t_3, and the nuclear matter incompressibility coefficient K_{nm} for several values of ∀, taking $\frac{E}{A} = -16$ MeV and k_f = 1.333 f_m^{-1} $\rho_0 = 0.16\,\mathrm{fm}^{-3}$.

As expected, we find that K_{mm} increases with ∀. We use these values of ∀, t_0, and t_3 to calculate the ISGMR and ISGDR strength functions.

Table 1:

∀	t_0	t_3	K_{nm}
1/6	-2972.32	19031.59	201.16
1/3	-1803.77	12914.92	236.22
½	-1414.25	11685.50	271.28
2/3	-1219.49	11894.75	306.33
5/6	-1102.64	12914.92	341.39
1	-1024.73	14606.84	376.45

In Fig. 1 we display the variation of square of centroid energy (M_1 / M_0) as a function of K_{nm}. Here, M_1 and M_0 are the zeroth and the first moments of the strength function. We see that for both the ISGMR and ISGDR, square of centroid energy increases more linearly with K_{nm}.

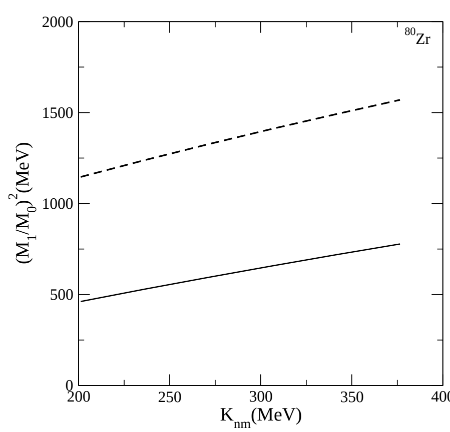

Figure 1: Variation of square of centroid energy of the ISGMR (solid line) and the ISGDR (dashed line) with K_{nm} for ^{80}Zr.

References

[1] B. K. Agrawal, S. Shlomo, and A. I. Sanzhur, to be published.