ISOSPIN AND ENERGY POSITION OF ISOVECTOR GIANT MULTIPOLE RESONANCES

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The energy position E_m of the dipole and quadrupole giant resonances versus the nuclear isospin T_0 is discussed. It is shown, that the proposed line $E = a + bT_0$ is in the better agreement with the experimental data of the dipole giant resonance, then in the case of Goldhaber-Teller and Steinwedel-Jensen models.

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Studies of giant resonances in nuclei have shown that isoscalar (IS) and isovector (IV) resonances with an identical multipolarity differ considerably in the energy position. For the quadruple giant resonance the IV resonance is located two times higher in energy than the IS resonance. Such a substantial change in the energy position is caused by the unit increment only of the state isospin in the nucleus. Presently the isovector dipole ((IVD), isoscalar quadruple (ISQ) and isovector quadruple (IVQ) giant resonances are studied most completely. The isospin splitting observed for the IVD resonance also affects the energy position.

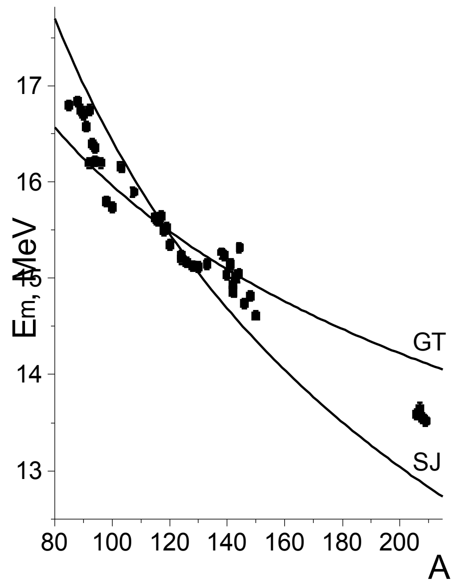

Fig. 1. *The excitation energy values E_m of the isovector dipole giant resonance versus nuclear mass A. The curves are plotted for the Goldhaber - Teller and Steinwedel - Jensen models. The fitting parameters are indicated in the table.*

For the IVD resonance the energy position is described by the expressions $E_m^J = K_1^J A^{-1/6}$ (1) (Goldhaber–Teller model [1]) or $E_m^J = K_2^J A^{-1/3}$ (2) (Steinwedel - Jensen model [2]), where E_m^J is the energy position of the resonance with the spin J, K_1^J and K_2^J are the fitting parameters, A is the nuclear mass. Both these expressions are obtained from the various versions of the hydrodynamic model. The G-T model regards a nucleus as the rigid neutron and proton spheres, which oscillate relative one another keeping their volumes unchangeable. The S-J model regards a nucleus as the neutron and proton liquids oscillating relative one another within the limits of a rigid sphere. Both these models show that on increasing the mass A of the nucleus the energy E_m decreases. Figure 1 shows the E_m values determined through fitting Lorentz curves to the measured photoneutron cross sections [3]. The accuracy of determining E_m is ≤ 50 keV. The expressions (1) and (2) were fitted to these data according to the method of least squares. The fitting parameters obtained are given in the Table and the curves are shown in Fig. 1. It is seen from the figure that both models describe the energy position of the giant dipole resonance for mean nuclear weight only qualitatively and they differ strongly from the values for heavy nuclei.

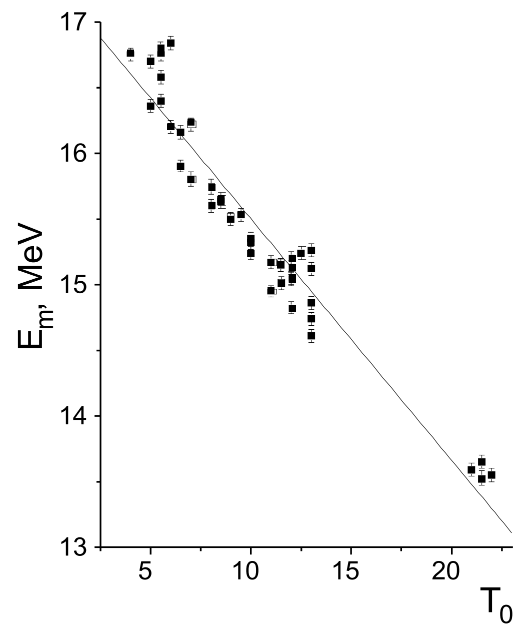

Fig. 2. *The excitation energy values E_m of the isovector dipole giant resonance versus the nuclear isospin T_0. .The curve is plotted for the expression (3) fitted to experimental data.*

The energy position of the giant resonance changes with changing the nuclear isospin T_0. It decreases with T_0 increasing. In expressions (1) and (2) the isospin is neglected. To take into account the effect of the nuclear isospin on the IVD resonance energy position, the measured data from the (γ,n) reaction [1] were arranged in dependence on T_0. It was found that this dependence is well described by the straight line $E_m=a+bT_0$ (3) with the fitting parameters a and b, given in the table and in Fig. 2. The values of the χ^2 quantities characterizing the quality of fitting to measured data show (cf. Figs. 1, 2 and the Table) that the straight line (3) furnishes a substantially better description of data and thus it may be used for estimating the energy position of the IVD resonance in nuclei with the better accuracy than that of formulas (1) and (2).

Formula	Parameter values (MeV)	χ^2
1	K1=34,40 ± 0,02	1341
2	K2=76,27 ± 0,04	3047
3	a=17,32±0,02; b=-0,183±0,002	877

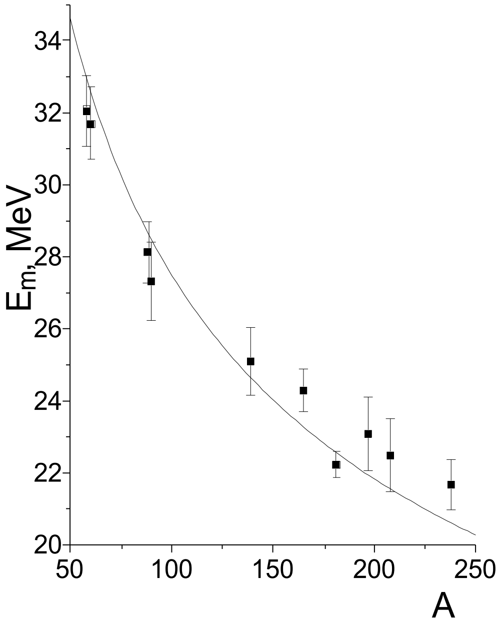

Fig. 3. *The excitation energy values E_m of the isovector quadrupole giant resonance versus the nuclear mass A. The curve is plotted for the expression (2) fitted to experimental data.*

For the IVQ resonance there are obtained much less data than for the IVD one. Figures 3 and 4 show the available data [4], arranged against A and T_0 ,to which the expressions (2) and (3) are fitted. Both expressions describe the measured data sufficiently well and may be used for estimating the IVQ resonance in other nuclei.

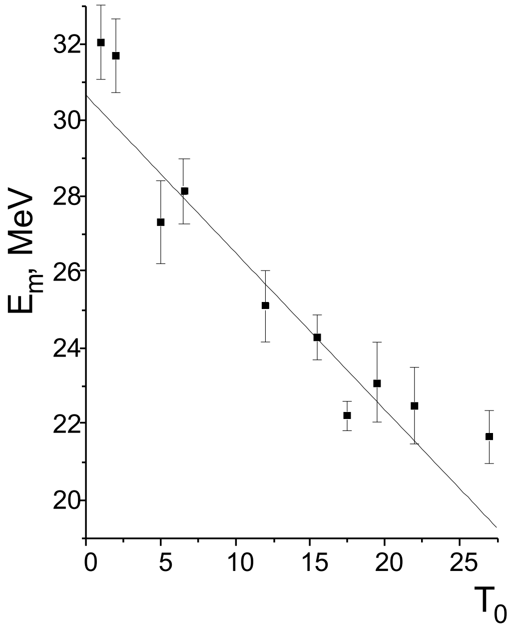

Fig. 4. *The excitation energy values E_m of the isovector quadrupole giant resonance versus the nuclear isospin T_0. The curve is plotted for the expression (3) fitted to experimental data.*

The results obtained show that the energy position of IV giant resonances is in stronger dependence on the isospin T_0=(N-Z)/2 (the latter is determined by the difference between the number of neutrons N and protons Z in the nucleus), as compared with the surface tension (G-T model) or the density (S-J model).

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