ISTITUTO NAZIONALE DI FISICA NUCLEARE

Laboratori Nazionali di Frascati

F. Palumbo and A. Richter:

SPLITTING OF THE MAGNETIC DIPOLE GIANT RESONANCE AND TRIAXIAL DEFORMATION

SPLITTING OF THE MAGNETIC DIPOLE GIANT RESONANCE AND TRIAXIAL DEFORMATION

F. Palumbo
INFN - Laboratori Nazionali di Frascati, P.O.Box 13 - 00044 Frascati, (Italy)

A. Richter
Institut für Kernphysik der Techniscen Hochshule Darmstadt, 6100 Darmstadt
Germany

The magnetic dipole giant resonance predicted in heavy deformed nuclei[1] has been experimentally confirmed[2] in ^{156}Gd, ^{158}Gd, ^{160}Gd, ^{154}Sm, ^{164}Dy, ^{168}Er, ^{174}Yb. In two of these nuclei (^{164}Dy and ^{174}Yb) the M1 strength is equally distributed between two levels very close in energy, suggesting a splitting of the collective state.

In the theoretical papers on the subject[3] there is no mention of such an effect, although the natural possibility of fragmentation has been considered. The purpose of this note is to point out that a splitting of the collective state can be explained in the framework of the two-rotor model by assuming triaxial symmetry, and can be related to the γ-parameter by the equation

$$\frac{|\omega_1 - \omega_2|}{\omega_1 + \omega_2} \approx \frac{2}{\sqrt{3}} \; tg\, \gamma. \tag{1}$$

We do not mean that the splitting is by itself a proof of triaxial deformation[4], especially in view of the fact that the existence of nuclei with such a shape has not been firmly established so far. What we suggest is that the splitting should be taken as an indication of triaxial symmetry. If such an indication can be substantiated Eq. (1) provides a very sensitive test. The splitting $|\omega_1 - \omega_2| = 0.2$ MeV in ^{174}Yb, for instance, corresponds to a value of γ of $3°$.

In the two-rotor model protons and neutrons are assumed to form two separate rigid bodies of ellipsoidal shape, free to rotate around a common axis with opposite velocities. If the nucleus has axial symmetry such a rotation can only occur around one of the axes orthogonal to the symmetry axis. If the nucleus has triaxial symmetry, rotations around each of the three axes are obviously possible. Let us assume a small deviation from axial symmetry and let us consider relative rotations around the axes orthogonal to the axis of approximate symmetry. In such a case to first order in the deformation parameters we can retain the results of the two-rotor model with the exception of the calculation of the restoring force which is now dependent on the axis of relative rotation

$$\omega_1 = \sqrt{\frac{C_1}{\mathscr{I}_1}} \approx \sqrt{\frac{C_o}{\mathscr{I}}} \; \frac{R_3 - R_2}{R_o} \tag{2}$$

$$\omega_2 = \sqrt{\frac{C_2}{\mathscr{I}_2}} \approx \sqrt{\frac{C_o}{\mathscr{I}}} \; \frac{R_3 - R_1}{R_o}.$$

In the above formulae ω_i is the frequency of relative rotation around the i-th axis, $R_0 = 1/3 (R_1 + R_2 + R_3)$, $\mathscr{T} = 1/2 (\mathscr{T}_1 + \mathscr{T}_2)$, $C_0 = \frac{2^7}{9\pi} \varrho \frac{V_0}{r_0} R_0^4$, with ϱ the nuclear density, V_0 the neutron-proton potential and r_0 its range.

Eqs. (2) can be derived keeping $R_1 \neq R_2$ in the procedure of Ref. (5) for the evaluation of the restoring force.

Using the definition of γ

$$R_k - R_0 = \sqrt{\frac{5}{4\pi}} \beta R_0 \cos (\gamma - k \frac{2\pi}{3})$$

we get Eq. 1.

Needless to say, there will also be excitations corresponding to relative rotations of protons and neutrons around the axis of approximate symmetry.

By a naive application of the two-rotor model we estimate the energy and strength of these excitations to be of the order γ/δ of the corresponding quantities for rotations around one of the axes orthogonal to the approximate symmetry axis. A detailed analysis requires a reformulation of the two-rotor model in order to include the necessary additional degrees of freedom.

REFERENCES

(1) N. Lo Iudice and F. Palumbo, Phys. Rev. Letters 41, 1532 (1978).

T. Suzuki and D.J. Rowe, Nuclear Phys. A289, 461 (1977).

F. Iachello, Nuclear Phys. A358, 89c (1981); A.E.L. Dieperinik, Prog. Part. Nucl. Phys. 9, 121 (1983).

(2) D. Bohle, A. Richter, W. Steffen, A.E. Dieperink, N. Lo Iudice, F. Palumbo and O. Scholten, Phys. Letters 137B, 27 (1984).

D. Bohle, G. Küchler, A. Richter and W. Steffen, Phys. Letters 148B, 260 (1984).

U.E.P. Berg, C. Bläsing, J. Drexler, R.D. Heil, U. Kneissel, W. Naatz, R. Ratzek, S. Schennach, R. Stock, T. Weber, M. Wickert, B. Fisher, M. Hollick and D. Kollewe, Phys. Letters 149B, 59 (1984).

(3) E. Lipparini and S. Stringari, Phys. Letters 130B, 139 (1983); D.R. Bes and R.A. Broglia, Phys. Letters 137B, 141 (1984); R.R. Hilton, Z. Phys. A316, 121 (1984); Van Isacker, P.K. Heyde, J. Jolie, M. Waroquier, J. Moreau, O. Scholten, Phys. Letters 144B, 1 (1984); S. Iwasaki and K. Hara, Phys. Letters 144B, 9 (1984); G. De Franceschi, F. Palumbo and N. Lo Iudice, Phys. Rev. C29, 1496 (1984); S. Pittel, J. Dukelsky, R.P.J. Perazzo and H.M. Sofia, Phys. Letters 144B, 145 (1984); H. Kurasawa and T. Suzuki, Phys. Letters 144B, 151 (1984).

(4) An alternative explanation of the splitting due to the coupling of a hexadecapole mode with the present M1 mode has been suggested by F. Iachello and K. Heyde (Private communication).

(5) N. Lo Iudice and F. Palumbo, Nucl. Phys. A326, 193 (1979).