объединенный
институт
ядерных
исследований
дубна

E4-81-283

M.N.Kirchbach

ON ISOSPIN SPLITTING OF GIANT DIPOLE RESONANCE IN ^{13}C

Submitted to "Известия АН СССР" /сер. физ./

1981

1. Introduction

Recent studies of the effective p-h-interaction in the model subspace of all non-spurious $1\hbar\omega$ -excitations of light nuclei from ^{9}Be to ^{16}O have exposed the necessity of taking into account non-central components (tensor and spin-orbit) in order to clarify the systematics of the low-lying non-normal parity states (1,2) $(\pi = (-1)^{A+1})$ and to understand some features of high-lying non-normal parity states excited in intermediate-energy reactions (3,4). Improved photoabsorption data in ^{13}C (5-8) give rise to a more detailed comparison of different theoretical models in order to get some information about the structure of the effective interaction in the nucleus.

2. The ^{13}C (γ, n)-reaction data and possibility of their theoretical interpretation

Photoabsorption cross section of the reaction ^{13}C (γ, n) exhibits in the excitation energy region between 5 and 40 MeV a well known resonance behaviour. Between threshold and 10 MeV three small peaks at E_x=7.5, 8.2 and 9.1 MeV are measured , which are obviously due to E1 or M1-excitation of isolated $\frac{3^+}{2}$ and $\frac{1^-}{2}$ levels in ^{13}C (9). The so-called pygmy resonance is centred at about 13.5 MeV with a width of 5 MeV and then there follows the giant resonance with two peaks at E_x=20.5 and 23.5 MeV (6). In the framework of the nuclear shell model the states of the pygmy- and giant resonance are well understood as E1-excitations of the ground state of $^{13}C(J^\pi = \frac{1^-}{2}; T = \frac{1}{2})$ to states with spin and parity $J^\pi = \frac{1^+}{2}, \frac{3^+}{2}$ and isospin $T = \frac{1}{2}$ $(T_<)$ or $T = \frac{3}{2}$ $(T_>)$ (9). In papers (6,7) the experimental resonance at 20.5 MeV is assumed to correspond to the theoretical maximum at 19 MeV from the shell-model analysis of the ^{13}C (γ, n) cross section as obtained by Kissener et al. (9) with a pure central p-h-interaction (CAL) of Gillet and Sanderson (10) (fig.1). Therefore the predicted position of the first giant reso-

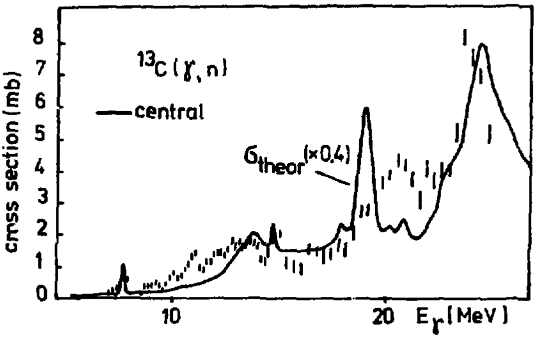


Fig.1. Comparison of the ^{13}C (γ, n) data [6] with the central force-calculation [9].

nance peak in ^{13}C is too low by about 1.5 MeV. The calculated resonance is ascribed to purely-$T_<$-dipole states [9], while according to estimations of Patrick et al. [5] the energy region of the measured resonance (above 20 MeV) is covered by $T_>$- states. The $T_<$ -dipole states are mainly centred below 20 MeV. As was noted by Woodworth et al. [7] the isospin splitting of the ^{13}C - giant resonance does not involve a complete energy separation of the $T=\frac{1}{2}$ and $T=\frac{3}{2}$ -states but rather a separation of the main regions of strength. By that reason a more precise treatment of the overlap of the $T_<$ - and $T_>$-states in the energy region between 20 and 21 MeV is expected to enable an improved theoretical prediction of position and isospin structure of the first giant resonance peak in ^{13}C .

3. Shell-model calculation with the non-central p-h-interaction of Millener and Kurath

In the present investigation the distribution of the dipole strengths (fig.2) and the cross section of the reaction ^{13}C (γ, n) are calculated by diagonalising an effective Hamiltonian [2] in the subspace of all non-spurious $1\hbar\omega$ -excitations. The p-h-interaction used contains except for a traditional central force, which remains very similar to the Gillet's force CAL, also tensor and spin-orbit components as proposed by Millener and Kurath [1] in order to get the relative separation of the $1d_{5/2}$ and $2s_{1/2}$ - single particle orbits as a function of mass number.

Compared to the central-force calculation [9] the noncentral parts of the interaction of Millener and Kurath cause in the energy

Fig.2. Dipole strength distribution (> 2 MeV.mb) for the non-central p-h-interaction (2) .

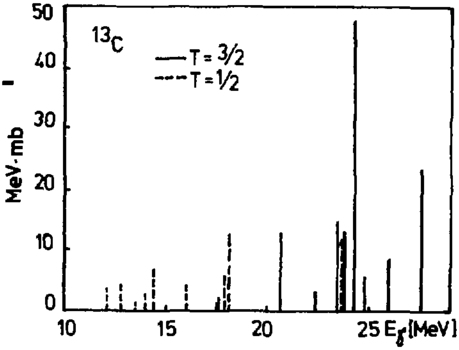


Fig.3. Dipole strengths in the excitation energy region E_x=20...22 MeV for the central force CAL (9) and the non-central p-h-interaction (2).

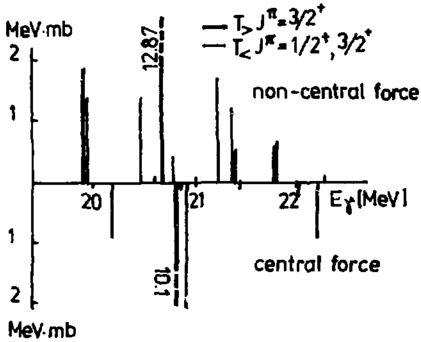
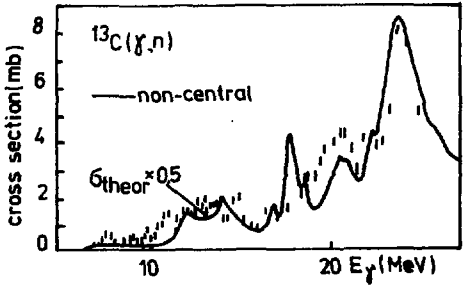


Fig.4. Photoabsorption cross-section in ^{13}C for the non-central p-h-interaction (2) . Smooth curve is obtained by spreading the strength over 1 MeV Breit-Wigner shapes .



interval between 20 and 22 MeV a doubling of the dipole strength density and an increasing of the dipole strength concentration by about 50% (fig.3). Hence a separated peak at E_x=20.69 MeV with a mixed $(T_< + T_>)$- structure is created (fig.4). It reproduces the position and nearly the width of the first giant resonance peak at 20.5 MeV and its isospin structure agrees with estimations of the isospin splitting of the GDR in ^{13}C (5,7,8) . The theoretical maximum at 19 MeV from the central-force calculation (9) appears in the non-central force calculation at 18 MeV and is obviously a fine structure effect. The position of the main peak at 23.5 MeV (6) is also better described by the present calculation.

4. Conclusion

The isospin splitting of the GDR in ^{13}C is shown to be sensitive to tensor and spin-orbit parts of the p-h-interaction. Therefore the conclusion can be made that non-central components of the effective p-h-interaction can affect properties of high-lying non-normal parity states excited in intermediate-energy reactions.

We thank Drs. H.-U.Jäger and R.A.Eramzhian for stimulating discussions. We are grateful to Dr.H.R.Kissener for supplying us with his subroutine for E1-transitions.

References

1. Millener D.J. and Kurath D. Nucl.Phys., 1975, A255, p.315.
2. Jäger H.-U. and Kirchbach M. Nucl.Phys., 1977, A291, p.52.
3. Teeters W.D. and Kurath D. Nucl.Phys., 1977, A275, p.61.
4. Kirchbach M. and Jäger H.-U. Sov.J.of Nucl.Phys., 1978, 29, p.1191.
5. Patrick B.H., Bowey E.M., Winhold E.J., Reid I.M. and Muirhead E.G. J. of Phys., 1975, G1, p.874.
6. Koch R. and Thies H.H. Nucl.Phys., 1976, A272, p.296.
7. Woodworth J.G., McNeill K.G., Jury J.W., Georgopulos P.D. and Johnson R.G. Can.J.Phys., 1977, 55, p.1704; Nucl.Phys., 1979, A327, p.53.
8. Jury J.W., Berman B.L., Faul D.D., Meyer P., McNeill K.G. and Woodworth J.G. Phys.Rev., 1979, C19, p.1684.
9. Kissener H.R., Aswad A., Jäger H.-U. and Eramzhian R.A. Nucl.Phys., 1974, A219, p.601.
10. Gillet V. and Sanderson E.A. Nucl.Phys., 1964, 54, p.472.

Received by Publishing Department
on April 24 1981.