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ON THE ROLE OF HEXADECAPOLE FORCES IN DESCRIBING γ-BAND STATES IN THE RARE-EARTH REGION

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In recent years the study of hexadecapole degrees of freedom in deformed nuclei attracts a great deal of interest. A rich experimental information has been gained. The collective low-lying states with $K^{\pi} = 3^{+}$ and 4^{+} have been reported (see, for instance [1,2]) which indicates the existence of a hexadecapole interaction with $\lambda\mu = 43$ and 44. A number of investigations of hexadecapole degrees of freedom has been performed within the quasiparticle-phonon nuclear model[3,4]. Nesterenko et al.[5] have succeeded in describing satisfactorily the energies, collectivity and principal two-quasiparticle components of low-lying $K^{\pi} = 3^{+}$ and 4^{+} states in the rare-earth nuclei at fixed values of the constants of the hexadecapole interaction $\lambda\mu = 43$ and 44. Earlier, the giant hexadecapole resonances have been investigated[6].

The recent experimental data indicate a necessity of introducing a strong hexadecapole interaction $\lambda\mu = 42$. Ichihara et al. have shown[7,8] that in the $(\bar{p},p')$ reaction with $E_p = 65$ MeV the experimental analysing powers and excitation cross sections for the level $I^{\pi}K = 4^{+}2_{\gamma}$ of the γ- band in the rare-earth nuclei can be reproduced by the coupled-channel calculations[9,10] only if the hexadecapole component β_{42} corresponding to a direct excitation of the $4^{+}2_{\gamma}$ level is included in the optical potential expansion. An analogous result was obtained for nuclei $^{166,168}Er$ in the (α,α') reaction at $E_{\alpha} =$ 36 MeV[11] and earlier at $E_{\alpha} = 50$ MeV[12]. It is most interesting that isoscalar transition rates $B(IS4, gr. \to 4^{+}2_{\gamma})_{exp}$ have unexpectedly large values amounting to 3-8 s.p.u.[7,8,11] ($B(IS4)_{exp}$ for ^{168}Er in[11] is twice as large as that in[7,8], most probably this is due to the fact that the coefficient 1/2 has been omitted in[11] in the expression for the $B(IS\lambda)_{exp}$ for interband transitions). To reproduce $B(IS4, gr. \to 4^{+}2_{\gamma})_{exp}$ the interaction $\lambda\mu = 42$ has to be so strong that a γ-vibrational state turns out to be hexadecapole one though traditionally only quadrupole forces $\lambda\mu = 22$ were used to describe this state. Moreover, $B(E2, gr. \to 2^{+}2_{\gamma})_{exp}$ and $B(IS2, gr. \to 2^{+}2_{\gamma})_{exp}$ cannot be described in this case[5]. Matsuo[13] has explained the dependence of $B(IS4)_{exp}$ on the mass number but did not succeed in describing $B(IS4)$-, $B(IS2)$- and $B(E2)$ - values simultaneously.

The present paper is aimed at elucidating extremely large values of $B(IS4)_{exp}$, providing a simultaneous description of the available experimental data and obtaining an estimate for the strength constant of the interaction $\lambda\mu$ = 42. For this purpose the $B(IS2)$ and $B(IS4)$ values have been calculated in the RPA with a common system of equations for $\lambda\mu$ = 22 and 42. For ^{168}Er with the maximal $B(IS4)_{exp}$ value the analysing powers and cross sections for the $(\vec{p},p')$ reaction have been calculated. The calculations were performed, as in[7,8], by the coupled-channel code ECIS79[10] but with the use of microscopic real inelastic form factors calculated within the folding-model. It is to be noted that experiments with polarised particles such as[7,8] provide more information and impose rigorous constraints on the calculations since the same set of parameters is used to describe not only the cross section but other characteristics as well such as the analysing power in our case.

We proceed with the description of the method of calculations. The model Hamiltonian includes an average field as the Saxon-Woods potential, a monopole pairing interaction and the isoscalar and isovector forces with $\lambda\mu$ = 22 and 42. The parameters of the Saxon-Woods potential for the neutron and proton systems were taken from[14], the single-particle spectrum was taken from the bottom of the potential well up to +5 MeV. The pairing interaction constants were chosen from the pairing energies. The constant $\varkappa_0^{(42)}$ was considered as a free parameter with an upper estimate $\varkappa_0^{(42)} \leq 0.015$ fm^2/MeV[5]. For each value of $\varkappa_0^{(42)}$ the constant $\varkappa_0^{(22)}$ was chosen so as to reproduce the experimental energy of the $2^+2\gamma$ level. The isovector interaction constants were obtained from the relation $\varkappa_1^{(\lambda\mu)} = -1.2\,\varkappa_0^{(\lambda\mu)}$[5]. The Hamiltonian including the multipole forces $\lambda\mu$ = 22 and 42 is written through the phonon operators $Q^+_{\mu i}$ as

$$H = \sum_q \varepsilon_q B(qq) - \frac{1}{4} \sum_{\lambda=\lambda_1,\lambda_2} \sum_{ii'} \{ (\varkappa_0^{(\lambda\mu)} + \varkappa_1^{(\lambda\mu)})(D_n^{\lambda\mu i} D_n^{\lambda\mu i'} + D_p^{\lambda\mu i} D_p^{\lambda\mu i'}) + (\varkappa_0^{(\lambda\mu)} - \varkappa_1^{(\lambda\mu)})(D_n^{\lambda\mu i} D_p^{\lambda\mu i'} + D_p^{\lambda\mu i} D_n^{\lambda\mu i'}) \} \cdot (Q^+_{\mu i} + Q_{\mu i})(Q^+_{\mu i'} + Q_{\mu i'}), \tag{1}$$

where

$$Q^+_{\mu i} = \frac{1}{2} \sum_{qq'} \{ \psi^{\mu i}_{qq'} A^+(qq') - \varphi^{\mu i}_{qq'} A(qq') \}, \tag{2}$$

$$D_\tau^{\lambda\mu i} = \sum_{qq' \in \tau} f^{\lambda\mu}_{qq'} u_{qq'} (\psi^{\mu i}_{qq'} + \varphi^{\mu i}_{qq'}), \tag{3}$$

$$\sum_{qq'} (\psi^{\mu i}_{qq'} \psi^{\mu i'}_{qq'} - \varphi^{\mu i}_{qq'} \varphi^{\mu i'}_{qq'}) = \delta_{i,i'}. \tag{4}$$

Here $A^+(qq') \sim \alpha^+_q \alpha^+_{q'}$, $B(qq) \sim \alpha^+_q \alpha_q$, α^+_q - is the creation operator of the one-quasiparticle state q with energy ε_q, i is the one-phonon state number, $f^{\lambda\mu}_{qq'}$ is the single-particle matrix element of the operator $R(r)(Y_{\lambda\mu} + (-1)^\mu Y_{\lambda -\mu})$ with the radial dependence $R(r) = \partial V(r)/\partial r$ where $V(r)$ is the spherical Saxon-Woods potential, $u_{qq'} = u_q v_{q'} + v_q u_{q'}$ where u_q, v_q are the Bogolubov transformation coefficients, $\sum_{qq' \in \tau}$ is the summation over the neutron ($\tau = n$) or proton ($\tau = p$) states. Using the variational principle we get the secular equation for the phonon energies $\omega_{\mu i}$ (here index μ is omitted for simplicity)

$$F(\omega) = \begin{vmatrix} \varkappa_+^{(\lambda_1)} X_n^{\lambda_1\lambda_1} - 1 & \varkappa_-^{(\lambda_1)} X_n^{\lambda_1\lambda_1} & \varkappa_+^{(\lambda_2)} X_n^{\lambda_1\lambda_2} & \varkappa_-^{(\lambda_2)} X_n^{\lambda_1\lambda_2} \\ \varkappa_-^{(\lambda_1)} X_p^{\lambda_1\lambda_1} & \varkappa_+^{(\lambda_1)} X_p^{\lambda_1\lambda_1} - 1 & \varkappa_-^{(\lambda_2)} X_p^{\lambda_1\lambda_2} & \varkappa_+^{(\lambda_2)} X_p^{\lambda_1\lambda_2} \\ \varkappa_+^{(\lambda_1)} X_n^{\lambda_1\lambda_2} & \varkappa_-^{(\lambda_1)} X_n^{\lambda_1\lambda_2} & \varkappa_+^{(\lambda_2)} X_n^{\lambda_2\lambda_2} - 1 & \varkappa_-^{(\lambda_2)} X_n^{\lambda_2\lambda_2} \\ \varkappa_-^{(\lambda_1)} X_p^{\lambda_1\lambda_2} & \varkappa_+^{(\lambda_1)} X_p^{(\lambda_1\lambda_2)} & \varkappa_-^{(\lambda_2)} X_p^{\lambda_2\lambda_2} & \varkappa_+^{(\lambda_2)} X_p^{\lambda_2\lambda_2} - 1 \end{vmatrix} = 0, \tag{5}$$

where $\varkappa_\pm^{(\lambda)} = \varkappa_0^{(\lambda)} \pm \varkappa_1^{(\lambda)}$,

$$X_\tau^{\lambda_1\lambda_2\mu} = (1 + \delta_{\mu,0}) \sum_{qq' \in \tau} \frac{f^{\lambda_1\mu}_{qq'} f^{\lambda_2\mu}_{qq'} u^2_{qq'} (\varepsilon_q + \varepsilon_{q'})}{(\varepsilon_q + \varepsilon_{q'})^2 - \omega^2_{\mu i}}. \tag{6}$$

Then

$$\psi^{\mu i}_{qq'} + \varphi^{\mu i}_{qq'} = N \sqrt{1 + \delta_{\mu,0}} \frac{(\varepsilon_q + \varepsilon_{q'}) u_{qq'}}{(\varepsilon_q + \varepsilon_{q'})^2 - \omega^2_{\mu i}} \cdot \{ f^{\lambda_1\mu}_{qq'} ((\varkappa_0^{(\lambda_1\mu)} + \varkappa_1^{(\lambda_1\mu)}) A_{41} + (\varkappa_0^{(\lambda_1\mu)} - \varkappa_1^{(\lambda_1\mu)}) A_{42}) + f^{\lambda_2\mu}_{qq'} ((\varkappa_0^{(\lambda_2\mu)} + \varkappa_1^{(\lambda_2\mu)}) A_{43} + (\varkappa_0^{(\lambda_2\mu)} - \varkappa_1^{(\lambda_2\mu)}) A_{44}) \} \tag{7}$$

where $A_{k\ell}$ is the cofactor of the $k\ell$ -th element of the determinant (6), $\mathcal{N}$ - is the normalization factor obtained from the condition (4). It is seen from (7) that both the amplitudes $\psi^{\mu i}_{qq'}$ and $\varphi^{\mu i}_{qq'}$ contain the quadrupole and hexadecapole terms. The transition rate of the isoscalar transition between the ground state 0^+0 and i -th state $I^\pi K$ has the form

$$B(IS\lambda, gr.\to I^\pi K) = (00\lambda\mu|IK)^2\Big\{\frac{Z}{A}\frac{1}{\sqrt{2}}\, e \sum_{qq'\in n,p} P^{\lambda\mu}_{qq'}\, u_{qq'} \cdot (\psi^{\mu i}_{qq'} + \varphi^{\mu i}_{qq'})\Big\}^2, \tag{8}$$

where $P^{\lambda\mu}_{qq'}$, is the single-particle matrix element of the operator $r^\lambda (Y_{\lambda\mu} + (-1)^\mu Y_{\lambda -\mu})$.

Unlike[7,8], the excitation cross sections $d\sigma/d\Omega$ and analysing powers $A(\theta)$ for the 2^+2_γ and 4^+2_γ levels in the $(\bar{p},p')$ were calculated by using the microscopic real form factors for interband transitions. All the remaining channels were treated in the same way as in[7,8] within the phenomenological model of an asymmetric rotator with the same parameters. The imaginary, spin-orbital and Coulomb parts of the optical potential were calculated for all the channels including interband transitions as it has been done in[7,8].

The folding potential[15,16] for the proton-nuclear interaction is obtained by averaging the effective nucleon-nucleon interaction over the microscopic transition density $\rho(\bar{r})$ calculated within the quasiparticle-phonon model:

$$U_F(\bar{R}) = \int \rho(\bar{r})\, v(\bar{R}-\bar{r})\, d\bar{r} = \sum_{\lambda\mu} U_{\lambda\mu}(R)\, Y^*_{\lambda\mu}(\theta_R, \varphi_R), \tag{9}$$

where

$$U_{\lambda\mu}(R) = \frac{1}{2\pi^2}\int_0^\infty dk\, k^2 j_\lambda(kR)\, \tilde{v}(k)\, \tilde{\rho}_{\lambda\mu}(k) , \tag{10}$$

$$\tilde{v}(k) = 4\pi \int dr\, r^2 j_0(kr)\, v(r), \tag{11}$$

$$\tilde{\rho}_{\lambda\mu}(k) = 4\pi \int dr\, r^2 j_\lambda(kr)\, \rho_{\lambda\mu}(r). \tag{12}$$

The transition density in the RPA is written as

$$\rho_{\lambda\mu}(r) = \sqrt{\frac{2I_i+1}{2}}\,(I_i 0 \lambda\mu | I_f K_f) \sum_{qq'\in n,p} \rho^{\lambda\mu}_{qq'}(r) \cdot u_{qq'}(\psi^{\mu i}_{qq'} + \varphi^{\mu i}_{qq'}), \tag{13}$$

where $\rho^{\lambda\mu}_{qq'}(r)$ is the single-matrix element of the operator $(r')^{-2}\delta(r-r')(Y_{\lambda\mu}(\hat{r}') + (-1)^\mu Y_{\lambda -\mu}(\hat{r}'))$.

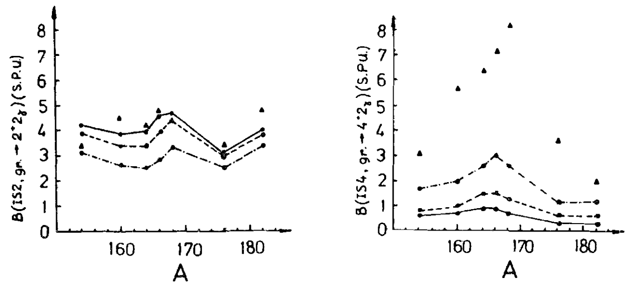
As an effective interaction $v(r)$ one usually uses the isotopically independent $M3Y$ interaction[16,17]

$$v(r) = 7999\,\frac{\exp(-4r)}{4r} - 2134.25\,\frac{\exp(-2.5r)}{2.5r}. \tag{14}$$

An exchange term responsible for antisymmetrization between an incident nucleon and target-nucleons is taken in the form of the zero-range pseudopotential[18]

$$v^{EX}(\bar{r}_{12}) = -276(1 - 0.005E_p)\,\delta(\bar{r}_{12}). \tag{15}$$

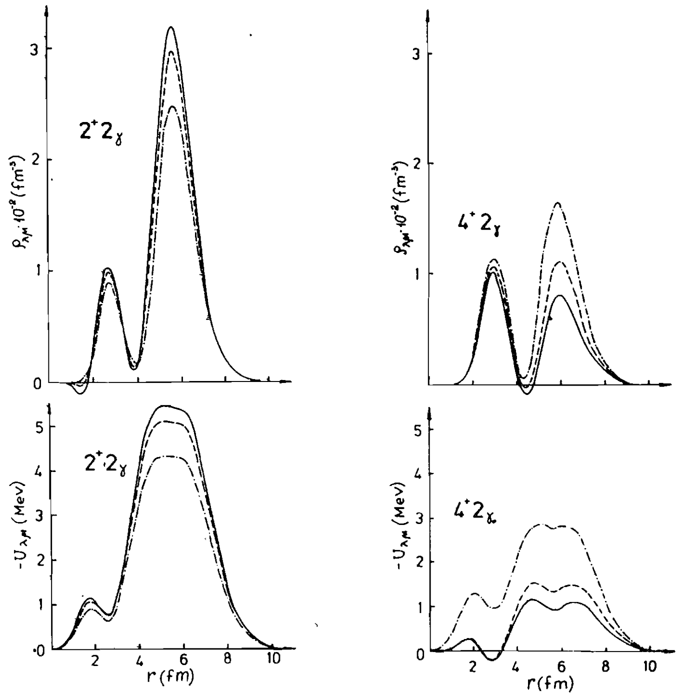
The results of our calculations are shown in figs. 1-3. It is seen from fig.1 that for a group of rare-earth nuclei the transition rates $B(IS2)$ decrease and $B(IS4)$ increase with increasing constant of the isoscalar hexadecapole interaction $\varkappa_0^{(42)}$. However, even at $\varkappa_0^{(42)}$ = 0.012 fm^2/MeV when the calculations provide somewhat underestimated values for $B(IS2)$ (according to our calculations, an analogous behaviour takes place for



F i g. 1. Isoscalar transition rates $B(IS2, gr.\to 2^+2_\gamma)$ (left) and $B(IS4, gr.\to 4^+2_\gamma)$ (right). Triangles are the experimental values. The results of calculations with $\varkappa_0^{(42)}$ = 0 are connected by the solid lines, the same with $\varkappa_0^{(42)}$ = 0.006 fm^2/MeV - by the dashed lines, the same with $\varkappa_0^{(42)}$ = 0.012 fm^2/MeV - by the dashed-dotted lines.

$B(E2, gr.\to 2^+2_\gamma))$, the $B(IS4)$ -values are several times as less as the experimental ones. The calculations show that $B(IS4)$ -values are close to the experimental data only when the quadrupole forces are completely switched off ($\varkappa_0^{(42)} = 0.019$ fm^2/MeV, $\varkappa_0^{(22)} = 0$), i.e. when the 2^+2_γ state is generated only by hexadecapole forces. However, in this case the $B(IS2)$ - and $B(IS4)$ -values are underestimated by 3-6 times as compared to the experimental data and the 2^+2_γ state becomes the pure hexadecapole one in contradiction with the generally accepted γ-vibrational nature of this state (for comparison, at $\varkappa_0^{(42)} = 0.012$ fm^2/MeV the hexadecapole parts of the two-quasiparticle amplitudes of the 2^+2_γ state amount to 40%, whereas at $\varkappa_0^{(42)} = 0.006$ fm^2/MeV they are not more than 20%). Note also that the value of $\varkappa_0^{(42)} = 0.019$ fm^2/MeV exceeds the upper estimate $\varkappa_0^{(42)} < 0.015$ fm^2/MeV given in /5/. So, a strong hexadecapole interaction necessary to reproduce $B(IS4)_{exp}$ seems to be in contradiction with other available data. Such a discrepancy is due to the fact that expressions (2) in /8,9/ and (4.7) in /11/ used to calculate the transition rates $B(IS\lambda)_{exp}$ contain the contributions from both direct and indirect channels of excitation of 2^+2_γ and 4^+2_γ states. We have repeated calculations of $B(IS2, gr.\to 2^+2_\gamma)_{exp}$ and $B(IS4, gr.\to 4^+2_\gamma)_{exp}$ using the formula (4.7) from /11/ and it turned out that the contribution of indirect channels to $B(IS2, gr.\to 2^+2_\gamma)_{exp}$ is about 10% and to $B(IS4, gr.\to 4^+2_\gamma)_{exp}$ is 60%. Thus, extremely large values of $B(IS4)_{exp}$ are mostly due to the contribution of indirect excitation channels. The results of the RPA calculations of transition rates, which take into account only direct excitations of the 2^+2_γ and 4^+2_γ levels, (see (8)), should be compared with the values of $B(IS2)_{exp}\cdot 0.9$ and $B(IS4)_{exp}\cdot 0.4$ (3.9 s.p.u and 3.3 s.p.u. are for ^{168}Er , respectively). In this case, at $\varkappa_0^{(42)} = 0.006$-$0.012$ fm^2/MeV one obtains a quite satisfactory description of $B(IS2)$, $B(E2)$- and $B(IS4)$- values.

One should be convinced that the structure of the γ-vibrational state used in the calculations of the $B(IS\lambda)$ -values will also give the good description of the experimental data for the cross sections and analysing powers /7,8/. Let us consider the nucleus ^{168}Er. In this nucleus the γ -vibrational state has the following structure: pp 411↑ 411↓ - 39%, nn 523↓ 521↓ - 18%, nn 521↑ 521↓ - 11%, pp 413↓ 411↓ - 8%. These contributions of the basic two-quasiparticle components to the state normalization depend rather weakly on the value of $\varkappa_0^{(42)}$.



F i g. 2. Transition densities $\rho_{\lambda\mu}(r)$ and inelastics form factors $-U_{\lambda\mu}(r)$ for transitions of multipolarities $\lambda\mu$ = 22 and 42 from the ground state to the levels 2^+2_γ (left) and 4^+2_γ (right). The calculations have been made with $\varkappa_0^{(42)} = 0$ (solid curves), $\varkappa_0^{(42)} = 0.006$ fm^2/MeV (dashed curves) and $\varkappa_0^{(42)} = 0.012$ fm^2/MeV (dashed-dotted curves).

Figure 2 shows the transition densities $\rho_{\lambda\mu}(r)$ and inelastic form factors $-U_{\lambda\mu}(r)$ for transitions from the ground state to the states 2^+2_γ with ω = 0.821 MeV and 4^+2_γ with ω = 0.995 MeV. They were calculated by formulae (13) and (10) for different values of $\varkappa_0^{(42)}$. It is seen from fig.2 that the form factors for both the transitions have a surface-peaked nature though $\rho_{42}(r)$ has a large peak inside the nucleus. With increasing $\varkappa_0^{(42)}$ the values of $\rho_{22}(r)$ and $-U_{22}(r)$ decrease whereas the values of $\rho_{42}(r)$ and $-U_{42}(r)$ increase.

The cross sections $d\sigma/d\Omega$ and analysing powers $A(\theta)$ in the $(\bar{p}, p')$ reaction for the 2^+2_γ and 4^+2_γ levels calculated with different values of $\varkappa_0^{(42)}$ are shown in fig.3. It is seen that the agreement with the experimental data is better at $\varkappa_0^{(42)} = 0.012$ fm^2/MeV and the excitation cross sections are quite well described in this case. Some discrepancy of the cross sections at large angles probably may be removed by taking the spin-orbital interaction /19/ and the antisymmetrization effects between incident nucleon and target-nucleons /20/ into account more exactly. As can be seen from fig.3 the description of the analysing powers $A(\theta)$ is inferior to that of the cross sections. However, theoretical curves reproduce on the whole the behaviour of the experimental dependences of $A(\theta)$, in particular, the position of maxima and minima. For the $2^+2\gamma$ level with increasing $\varkappa_0^{(42)}$ the calculations give almost the same results for $A(\theta)$. It is well seen that $A(\theta)$ for the $4^+2\gamma$ level in the region $\theta \leq 60^\circ$ is better described at $\varkappa_0^{(42)} = 0.012$ fm^2/MeV.

In summary, it has been shown that extremely large values of $B(IS4, gr. \to 4^+2\gamma)_{exp}$ result from a considerable contribution to them of indirect excitation channels. By extracting the contribution of indirect channels from $B(IS4)_{exp}$, one succeeds in simultaneous description of $B(IS2)$-, $B(E2)$- and $B(IS4)$ - values within the RPA.

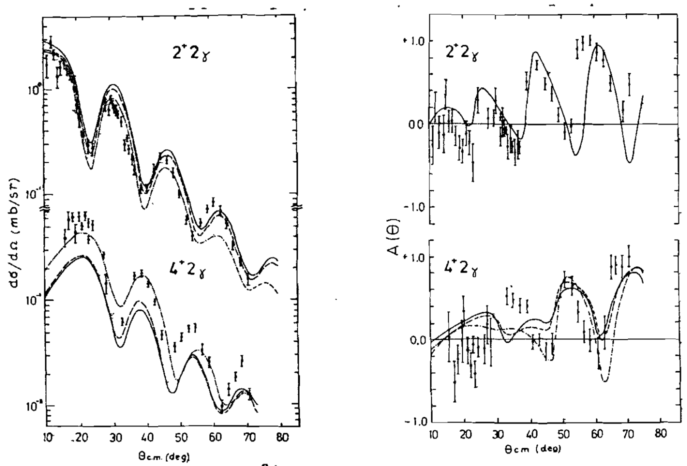


Fig. 3. Cross sections $d\sigma/d\Omega$ (left) and analysing powers $A(\theta)$ (right) for the $2^+2\gamma$ and $4^+2\gamma$ levels. The calculations have been made with $\varkappa_0^{(42)} = 0$ (solid curves), $\varkappa_0^{(42)} = 0.006$ fm^2/MeV (dashed curves) and $\varkappa_0^{(42)} = 0.012$ fm^2/MeV (dashed-dotted curves).

On the whole the most satisfactory description of the transition rates as well as cross sections and analysing powers is obtained at $\varkappa_0^{(42)} = 0.012$ fm^2/MeV. Nevertheless, the existence of the hexadecapole interaction $\lambda\mu = 42$ in deformed nuclei can be well established only after the calculations for a larger number of nuclei excited in various reactions. So, the results of this paper should be considered as an indication of a large probability for this interaction to exist. The value $\varkappa_0^{(42)} = 0.012$ fm^2/MeV is merely an estimated strength for the $\lambda\mu = 42$ interaction (for comparison, in rare-earth nuclei the constants of some other interactions have mean values: $\varkappa_0^{(22)} = 0.021$-$0.024$ fm^2/MeV, $\varkappa_0^{(44)} = 0.022$ fm^2/MeV and $\varkappa_0^{(43)} = 0.015$ fm^2/MeV /5/). It should also be noted that for the first time the coupled-channel calculations of the cross sections and analysing powers in deformed nuclei have been performed in a microscopic way.

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REFERENCES

1. Burke D.G., Blezius J.W. Can. J.Phys., 1982, v.60, p. 1751.
2. Burke D.G., Shahabuddin M.A.M., Boyd R.N. Phys.Lett., 1978, 78B, p. 48.
3. Soloviev V.G. Theory of complex nuclei, Nauka , Moscow, 1971 (Transl. Pergamon Press, 1976).
4. Soloviev V.G. and Shirikova N.Yu. Yad.Fiz., 1982, v. 36, p. 1376.
5. Nesterenko V.O., Soloviev V.G., Sushkov A.V. and Shirikova N.Yu. Yad.Fiz., 1986, v.44, p. 1443.
6. Kiselev M.A., Malov L.A., Nesterenko V.O. and Soloviev V.G. Izv. Akad. Nauk SSSR, Ser. Fiz., 1978, v. 42, p. 1842.
7. Ichihara T. et al. Phys.Lett., 1984, 149B, p. 55.
8. Ichihara T. et al. Phys.Lett., 1986, 182B, p. 301.
9. Tamura T. Rev.Mod.Phys., 1965, 37, p. 679.
10. Raynal J., code ECIS79, unpublished; Phys.Rev., 1981, C23, p.2571.
11. Govil M. et al. Phys.Rev., 1986, 33, p. 793.
12. Machintosh R.S. Phys.Lett., 1969, 29B, p. 629.
13. Matsuo M. Preprint Kyoto University, KUNS 845, Japan, 1986.
14. Gareev F.A. et al. Part. Nucl., 1980, v. 11, p. 301.
15. Satchler G.R. Direct Nuclear Reactions, New York, Oxford, University Press, 1983.
16. Satchler G.R., Love W.G. Phys.Rep., 1979, 55, p. 183.
17. Satchler G.R. Nucl.Phys., 1979, A329, p. 233.

18. Lowe W.G., Owen L.W. Nucl.Phys., 1975, A239, p. 74.
Golin M., Petrovich F., Robson D. Phys.Lett., 1976, 64B, p. 253.
19. Raynal J. In: "The Structure of Nuclei", IAEA-SMR-8/8, Vienna, 1972, p. 75.
20. Knyazkov O.M. and Nekrasov A.A. Yad.Fiz., 1983, v. 38, p. 36,
Dao Tien Khoa and Knyazkov O.M. Preprint JINR, P4-86-814, Dubna, 1986.

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Нестеренко В.О. и др. E4-87-492
О роли гексадекапольных сил при описании состояний γ-полосы в ядрах редкоземельной области

В рамках ПХФ с общей системой уравнений для $\lambda\mu$ = 22 и 42 сделаны расчеты изоскалярных приведенных вероятностей B(IS2, gr. → $2^+2\gamma$) и B(IS4, gr. → $4^+2\gamma$), а также формфакторов в приближении фолдинг-потенциала. При использовании микроскопических формфакторов для уровней $2^+2\gamma$ и $4^+2\gamma$ в ^{168}Er в рамках метода связанных каналов сделаны расчеты анализирующих способностей и сечений возбуждения в реакции ($\vec{p}$, p') с E_p = 65 МэВ. Показано, что экстремально большие значения B(IS4, gr. → $4^+2\gamma$), полученные в реакциях ($\vec{p}$,p') и (α, α'), обусловлены в основном вкладом непрямых каналов возбуждения, а не сильным гексадекапольным взаимодействием $\lambda\mu$ =42. Имеющиеся экспериментальные данные удается удовлетворительно описать при умеренном значении гексадекапольного взаимодействия $\varkappa_0^{(42)}$ = 0,012 фм^2/МэВ.

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Nesterenko V.O. et al. E4-87-492
On the Role of Hexadecapole Forces in Describing γ-Band States in the Rare-Earth Region

Calculations are made for the isoscalar transition rates B(IS2, gr. → $2^+2\gamma$) and B(IS4, gr. → $4^+2\gamma$) in the RPA with a common system of equations for $\lambda\mu$ = 22 and 42, and for the inelastic form factors in the folding-model. The analysing powers and cross sections in the ($\vec{p}$, p') reaction with E_p = 65 MeV are calculated within the coupled-channel method by using the microscopic form factors for the levels $2^+2\gamma$ and $4^+2\gamma$ in ^{168}Er. It is shown that extremely large values of B(IS4, gr. → $4^+2\gamma$) obtained in the ($\vec{p}$,p') and (α,α') reactions are mostly due to the contribution of indirect excitation channels but not to a strong hexadecapole interaction $\lambda\mu$ = 42. A moderate value of the hexadecapole interaction constant $\varkappa_0^{(42)}$ = 0.012 fm^2/MeV provides a satisfactory description of the available experimental data.

The investigation has been performed at the Laboratory of Theoretical Physics, JINR.

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