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Вычисление E1-радиационных силовых фнукций в полумагических ядрах

В рамках полумикроскопического подхода рассчитаны E1-радиационных силовые функции ряда полумагических ядер. Получено хорошее согласие с экспериментальными данными.

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Calculation of E1-Radiative Strength Functions in Semimagic Nuclei

E1-radiative strength functions for some semimagic nuclei are calculated in the frame of semimicroscopic method. They are in a good agreement with experimental data.

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

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The model developed in ref.[1] is applied to the description of the fragmentation of one-phonon states over two-phonon ones in spherical nuclei. The model Hamiltonian contains the isoscalar and isovector components of the residual multipole-multipole strengths. We use the apparatus[2] for the calculation of E1 strength functions for the transitions from the ground states of doubly even spherical nuclei. The neutron resonance wave function has the form:

$$\Psi_{\nu}(JM) = \{ \sum_{i} R_{\nu}(J_{i}) Q^{+}_{JMi} + \sum_{\substack{\lambda_1 i_1 \\ \lambda_2 i_2}} P^{\lambda_1 i_1}_{\lambda_2 i_2}(J_{\nu}) [Q^{+}_{\lambda_1 \mu_1 i_1} Q^{+}_{\lambda_2 \mu_2 i_2}]_{JM} \} \Psi_0 , \tag{1}$$

where Q^{+}_{JMi} is the phonon production operator, Ψ_0 - is the ground state wave function. Following refs.[2, 3], to calculate the radiative strength functions, we use the method allowing one to calculate the average values without solving secular equations. The strength function for E1-transitions to the levels in the energy interval $\eta - \Delta/2$, $\eta + \Delta/2$ has the form:

$$b(E1,\eta) = \frac{1}{2\pi} \sum_{\nu} \frac{\Delta}{(\eta-\eta_{\nu})^2 + \frac{\Delta^2}{4}} B(E1, 0^+_{g.s.} \to 1^-_{\nu}). \qquad (2)$$

Here B(E1) is the reduced transition probability from the ground state to a state described by the wave function (1). The radiative width for E1-transitions from the 1^- levels to the ground state is determined as:

$$\Gamma_{\gamma_o} = 0.35 E_{\gamma}^3 B(E1, \uparrow) \ \text{eV}, \qquad (3)$$

where $B(E1,\uparrow)$ is found from (2) and is taken in units of $e^2 fm^2$, E_{γ} in MeV. The following definition of the radiative strength functions

$$S_{\gamma} = \sum_{\Delta E} \Gamma_{\gamma_o} / \Delta E, \qquad (4)$$

where Γ_{γ_o} and ΔE are in eV, is widely used.

The results of our calculation and the corresponding experimental data are given in Table 1. The parameters are taken the same as in ref./2/ and the averaging interval is $\Delta E = 0.4$ MeV. The values of S_{γ} are given for Sn which are averaged over the doubly even isotopes $^{116-124}$Sn as in ref./4/ As it is seen from Table 1, we correctly describe the average radiative strength functions. It should be noted that the calculated results depend on the choice of the averaging interval. For instance, for ^{138}Ba $S_{\gamma} \times 10^5$ changes in the range of 9.9 to 4.4 with changing ΔE from 0.5 MeV

Table 1

E1-Radiative Strength Functions

Nuclei	E_γ, MeV	S_γ x 10^5		
		Experiment	Reference	Calculation
^{56}Fe	11.2	3.95	7	3.5
		3.5	8	
^{90}Zr	8.7	4.3	4	4.5
	10.0	10.2		48
	11.3	18.1		24
	11.6	22.9		20.5
	11.9	24.0		25.0
	12.1	25.3		40.3
Sn	6.2	1.4	4	1.8
	6.4	3.2		2.0
	7.0	3.5		3.8
	8.6	12.9		14.7
	9.1	13.7		35.9
^{138}Ba	8.6	6.5	5	9.9
^{140}Ce	9.08	4.2	9	3.7

to 2.0 MeV. The experimental values, taking into account the errors /5/, are within the range $S_\gamma \times 10^5 = 5.8-9.8$. Thus, the variation of the averaging interval does not change our results considerably. For the rest nuclei of Table 1 S_γ may change by a factor of 1.5-2 with changing ΔE from 0.5 to 2.0 MeV.

The reactions (γ,γ') are widely used to measure the partial widths in the excitations of some nuclei. Table 2 shows the experimental data /6/ on the quantities Γ_{γ_0} and the results of our calculation. The

Table 2

Partial E1-Widths

Nuclei	EXPERIMENT		CALCULATION	
	η, MeV	Γ_{γ_0}, meV	η, MeV	Γ_{γ_0}, meV
^{118}Sn	6.988	128 ± 3	6.38	534
^{120}Sn	7.696	70 ± 20	7.78	775
^{140}Ce	5.66	12 ± 2	5.74	158

calculated values of Γ_{γ_0} are approximately larger by an order of magnitude than the experimental ones. This discrepancy is not surprising, since we calculate essentially the sum in the energy interval, and the experimental conditions are such that Γ_{γ_0} is measured for one level which is randomly chosen. The experimental study of the reactions (γ,γ') with the state excitation in the energy interval of several keV is of great interest.

In conclusion we should like to note that we can correctly calculate the radiative strength functions at the excitation energy of an order of the neutron binding energy B_n without using any free parameters. The parameters of the Hamiltonian are fixed in the study of the low-lying states and giant resonances /2/ . We could not expect the experimental data to be described at energies of an order B_n . The values of the E1-radiative strength function in semimagic nuclei is mainly defined by the 1^- states near B_n and changes slightly when the dipole resonance is taken into account.

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References

1. Soloviev V.G., Malov L.A. Nucl.Phys., A196, 433, 1972.
2. Soloviev V.G., Stoyanov Ch. Vdovin A.I. JINR, E4-10397, Dubna, 1977.
3. Malov L.A., Soloviev V.G. Nucl.Phys., A270, 87, 1976.
4. Axel P., Min K.K., Sutton D.C. Phys. Rev., C2, 689, 1970.
5. Holt R.J., Jackson H.E. Phys.Rev.,C12, 56, 1975.
6. Wolf A., Moreh R., Shahal O. Nucl.Phys., A227, 373, 1974.
7. Abramov A.I., Kitaev V.Ya., Yutkin M.G. Yad.Fiz., 20, 438, 1974.
8. Balgman R.J., Bowman C.D., Berman B.L. Phys.Rev., C3, 672, 1971.
9. Laszewski R.M., Holt R.J., Jakson H.E. Phys.Rev., C13, 2257, 1976.

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