# COLLECTIVE STATES IN $^{156}$Dy

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Collective states in the $^{156}$Dy nucleus were described within the IBM1 phenomenology, when the Hamiltonian parameters and the effective charges of the $E2$-transition operator are determined such as to obtain the best description of the characteristics of several collective bands. The difference between experimental and theoretical energy states of the ground band for $I \le 8$ are smaller 7 keV and for $I = 10^+, 12^+, 14^+, 16^+, 18^+$ according smaller 24, 75, 120, 245, and 355 keV. The increasing difference between the phenomenological and experimental energies beginning with spin $I = 10^+$ can be caused by both the influence of the high-spin quasiparticle pairs and by possible influence of the interaction members $(d^+d^+d^+)^{(\lambda)}\cdot(ddd)^{(\lambda)}$ which are absent in the standard IBM1 Hamiltonian. Experimental energies of the states of the beta and gamma bands with an identical spins are rather close in values, which cannot be quantitatively reproduced by calculations. In addition, the description of the beta band is lower in quality than the description of the gamma band. This may point to a pair-vibrational character of this band.

Another way to consider properties of collective states involves microscopic calculations of the IBM parameters using the spherical mean field. A special modified quasiparticle random phase method is implemented, which allows for the fact that there is a number of quadrupole phonons in each collective state. The problem of mutliphonon states is solved by going over from phonons to ideal bosons. Noncollective quadrupole phonons and pairs with spin $J^\pi \le 6^+$ are considered using renormalizations of the parameters of the Hamiltonian and $E2$-transition operators in terms of quadrupole $d$-bosons. Interaction of multiphonon states with states including high-spin two-quasiparticle pairs with moments $J = 8^+, 10^+$ are additionally considered [1]. This gives a satisfactory description for the states of the ground-state band up to the spin $I \le 16$. The gamma band can also be described by slightly varying the spin-orbit interaction constant of the mean field. In the ground-state band, states with spin $I \le 10^+$ are exhausted by $D$ and others phonons with $J \le 6$ that determine renormalizations of boson parameters of operators. For the state with $I = 12^+$ the component with the pair $J = 10^+$ is about a half of the overall normalization. This allows having smooth variation in $B(E2)$ for all transitions considered in the ground-state band.

Among the states in $^{156}$Dy there is $8^+$ state populated by the $\beta^+$ decay of the isomeric $9^+$ state in $^{156}$Ho. Based on the single-particle states and the fact of the decay, one can assume that the $8^+$ state with the energy of 2788 keV is determined by either the $(h_{9/2})^{2(8+)}$ or the $(f_{7/2}h_{9/2})^{(8+)}$ configurations. In this energy region there are more than ten states with this spin. Beta decay separates one of them [2]. Experimental value $B(E2;\, 8_q \rightarrow 10_1)/B(E2;\, 8_q \rightarrow 6_1) = 8.9$. If $8_q$ is determined by the $(h_{9/2})^{2(8+)}$ neutron configuration, this ratio is 3 and if the configuration is $(f_{7/2}h_{9/2})^{(8+)}$, the ratio will be 0.4.

1. A.D.Efimov, V.M.Mikhajlov // Bull. RAS. Ser. Phys. 2018. V.82(9).
2. V.G.Kalinnikov *et al.* // Int. Conf. on Nucl. Phys. «Nucleus-2018». Abstracts.