ON EMPIRICAL REGULARS IN ROTATIONAL BANDS AND POSSIBLE MECHANISM OF ROTATIONAL MOMENTUM FORMATION

G. M. Amalsky

A comparison of rotational bands of different nuclei permits to observe empirical regularities, which show that rotational states are more standard, then it is considered, and allow to propose new interpretation of these states.

Ground rotational bands of the most deformed even-even nuclei with mass number $A \geq 100$ to the rotational energy $\varepsilon(\mathcal{J}) \leq 5$ MeV can be fitted by proposed in paper [1] empirical formula $\varepsilon(\mathcal{J}) = \varepsilon_0 \sin^2(\pi \mid \vec{\mathcal{J}} \mid /N)$ with a constant $\varepsilon_0 = 6.7$ MeV and with one fitting parameter N, close to charge of nucleus Z.

The rotational energies $\varepsilon(\mathcal{J}) - \varepsilon(\mathcal{J}_0)$ of greater part of rotational bands of other nuclei can be fitted by sets $\varepsilon_N(R) - \varepsilon_N(R_0)$, calculated with this formula, with $R - R_0 = \mathcal{J} - \mathcal{J}_0$, where R_0 is whole-number second fitting parameter. It is proposed to interpret parameter R_0 as a contribution of collective rotational momentum in complete angular momentum of band's ground state $\mathcal{J}_0$; for deformed nuclei R_0 is usually close to $\mathcal{J}_0$.

Average energies of pairs of close levels of the "split" rotational bands of A-add nuclei, which consist of pairs of close levels with difference of their angular momenta $\delta\mathcal{J} = 1$ and with difference of average momenta of adjoining pairs $\Delta\mathcal{J} = 2$, can be fitted by such sets too. Parameter R_0 is usually equal to average angular momentum of lower pair or to 0 (for split band with nonsplit ground state). Angular momenta of states of such bands can be proposed as $\mathcal{J} = R \pm 1/2$.

Many strong distorted bands with nonmonotonous dependence of energy levels $\varepsilon(\mathcal{J})$ can be proposed as bands, formed by pairs of strong split levels with angular momenta $\mathcal{J} = R \pm S'$ with adjoining pairs difference average momenta $\Delta R = 2$. Average energy of such pairs $< \varepsilon(R) >= (\varepsilon(R+S') + \varepsilon(R-S'))/2$, can usually be fitted by sets $\varepsilon_N(R) - \varepsilon_N(R_0)$, e. g. the bands with $\mathcal{J} = R \pm 3/2$ on the states $3/2^-$ 990 keV ^{239}**Pu** and $1/2^-$ 424 keV ^{161}**Ho**, the band with $\mathcal{J} = R \pm 5/2$ on the state $1/2^-$ 71.3 keV ^{171}**Lu** and the band with $\mathcal{J} = R \pm 7/2$ on the state $5/2^-$ 186 keV ^{181}**Re**.

Ground rotational bands of intermediate between deformed and spherical even-even nuclei can usually be fitted by sets $\varepsilon_N(R) - \varepsilon_N(R_0)$ with the same (or close) parameter N, as

for bands of adjoining deformed nuclei, e. g. ground bands of deformed nucleus ^{156}**Gd** and intermediate nuclei ^{154}**Gd** and ^{152}**Gd** can be fitted by sets with different parameters $R_0 = 0, 1, 5$ and with close parameters $N = 68$ and $N = 70$, ground bands of ^{78}**Kr** and ^{78}**Se** can be fitted with different $R_0 = 1$ and $R_0 = 2$ and with the same $N = 38$.These coincidences with shifted "standard" bands allow to propose nuclear angular momentum in such band as difference of rotational and "nonrotational" contributions $\mathcal{J} = R - S'$, where $S' = R_0$.An existence of momentum S' of some "nonrotational" nature is confirmed by presence of rotational bands with great momenta of their ground states $\mathcal{J}_0$, which can be fitted by sets with great differences $\mathcal{J}_0 - R_0$.This allows to assume an addition of contributions of rotational and "nonrotational" momenta in nuclear angular momentum $\mathcal{J} = R + S'$ in such bands.

This assumption of rotational and "nonrotational" contributions R and S' allows to explain variety of different bands by different structure of nuclear momentum in different bands without supposition of strong interaction between rotational and other nuclear degrees of freedom, but contradicts to traditional interpretation of these nuclear states as created by rotation of internal system of coordinates (with preserving projection $K = \mathcal{J}_0$ of angular momentum $\mathcal{J}$ on rotating axis of symmetry of nucleus). However, specific "Josephson" formula $\varepsilon = \varepsilon_0 \sin^2(\Delta\varphi/2)$ for rotational spectra allows to propose the alternative interpretation of these states: it may be assumed that collective nuclear momentum is created by reserved tunnel current $j = j_0 \sin\Delta\varphi$ of pairs correlated nuclons. Using a similarity of this formula and spectrum of spin wave in system of N ferromagnetic atoms [2], an analogy of deformed nucleus with such system may be proposed. Using this analogy, it may be supposed that all nuclons give the same contributions in energy and collective nuclear momentum, an amplitude j_0 of tunnel current around axis of symmetry corresponds to motion of one (or two) pair of nuclons in the whole nucleus, and rotational band created by keeping of axis of symmetry (directed along preserving projection of angular momentum).

REFERENCES

1. *Amalsky G.M.* J.of Nucl.Phys., 1993. V.56. N°9. P.70.
2. *Feynman R.P.* Statistical Mechanics, W.A.Benjamin, inc.Massachusetts., 1972. Ch.7.