# CONFLICT COUPLING IN THE $\pi(g_{9/2})^{-1}$ BANDS OF $^{119}$I*

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Lifetimes of 15 levels build on the $\pi g_{9/2}$ hole state in the $^{119}$I nuclei have been measured. The Doppler Shift Attenuation and Recoil Distance Methods were used. Modified model of “conflict coupling”, being an extension of “shears mechanism” model, reproduces experimental values of $B$(M1).

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## 1. Introduction

The present work is a part of systematic investigations of the $^{119}$I nucleus. Level scheme of $^{119}$I was established in [1]. The lifetimes of excited states in four bands formed by the $h_{11/2}$ proton coupled to axially asymmetric core were measured in [2, 3]. In the present paper the lifetimes of levels belonging to bands 1 and 4 (Fig. 1) are given and discussed. The experiment was performed at the Tandem Accelerator Laboratory of the Niels Bohr Institute. The $^{109}$Ag($^{13}$C,3n)$^{119}$I reaction was used at a bombarding energy of 54 MeV. The $\gamma$-$\gamma$ coincidences were collected and lifetime measurements (using Doppler Shift Attenuation and Recoil Distance Methods) were performed using the NORDBALL array equiped with plunger device. The details of experiment and data analysis are given in [2, 3].

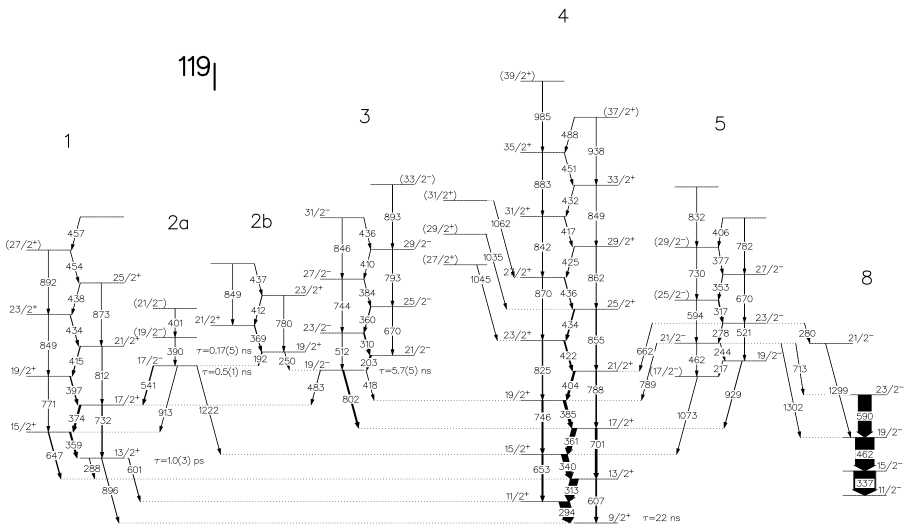


Fig. 1. Partial level scheme of $^{119}$I.

## 2. Transition probabilities

In the present paper we concentrate our attention on transition probabilities in bands 4 and 1. These bands (see Fig. 1) are interpreted as based on strongly coupled $g_{9/2}$ proton hole state. The levels of band 4 above backbending (which occurs at $I{\approx}27/2$) have $(\pi g_{9/2})^{-1}\otimes(\nu h_{11/2})^2$ configuration. The levels of the band 1 are interpreted as the $\gamma$-vibration built on the $(\pi g_{9/2})^{-1}$ state.

The results of our measurements are presented in Fig. 2. Very different behavior of $B$(E2) for band 1 (~20 W.u.), band 4 (~20 W.u. for states with

$I \leq 27/2$ and ~50 W.u. above backbending) and band 8 (~130 W.u.) is observed.

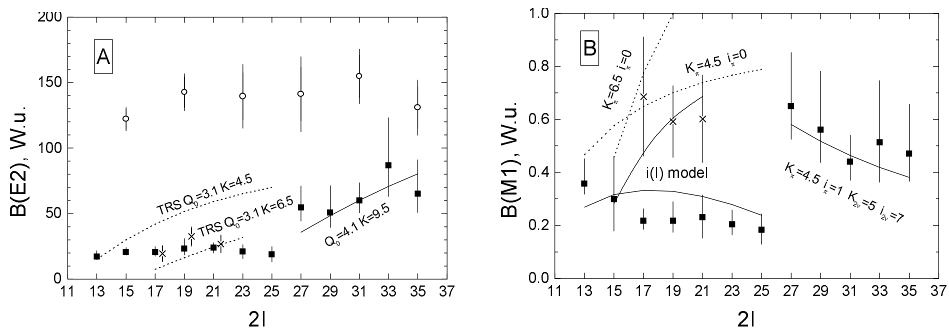


Fig. 2. A — experimental $B$(E2; $I \to I-2$) values for band 1 (crosses), band 4 (black squares) and band 8 (open circles ). The results of calculations are based on Eq. (1): dotted lines — for band 1 ($K = 6.5$, $(\pi g_{9/2})^{-1} \otimes \gamma$-vib.), and for low spin states of band 4 ($K = 4.5$, $(\pi g_{9/2})^{-1}$) and solid line for high spins states ($K = 9.5$, $(\pi g_{9/2})^{-1} \otimes (\nu h_{11/2)})^2$) of the band 4. B — experimental $B$(M1; $I \to I-1$) values for band 1 (crosses) and band 4 (black squares) compared with results of calculation based on Eq. (2). Dotted lines — calculations for band 1 ($K_1 = 6.5$, $K_2 = 0$, $i_2 = 0$) and for low spin part of band 4 ($K_1 = 4.5$, $K_2 = 0$, $i_2 = 0$), solid lines - calculations taking into account constant alignment of 3-qp part of band 4, and the $i(I)$ model (Eq. (3) and (4)) for 1-qp part of band 4 and for band 1.

Results of calculations shown in Fig. 2A were carried out in the frame of standard rotational formula with parameters corresponding to $^{119}$I:

$$B(E2; I_i \to I_f) = 114.4(Q_0 \langle I_\mathrm{i} K 20 | I_\mathrm{f} K \rangle)^2 (\mathrm{W.u.}). \tag{1}$$

Values of $Q_0$ are taken from TRS calculation [1] except $Q_0 = 4.1$ $e$b for high spin part of band 4 which was adjusted to reproduce absolute values of $B$(E2).

For band 4 one observes that also the $B$(M1) values increase rapidly above backbending. This effect can be explained by the "conflict coupling" mechanism. In our case it is coupling of 2 neutrons in the $h_{11/2}$ state with the $g_{9/2}$ proton hole. The designation "conflict coupling" is given to a coupling of two angular momenta, originally restricted to case of vectors perpendicular to each other [4, 5]. Later on it was generalized to cases when any angle, neither 0° nor 180° between angular momentum vectors is possible and studied by lifetime measurements [6–8]. Nowadays, similar mechanism leading to coherent enhancement of M1 transitions has been discovered for 4-qp bands [9] and for small deformation is called "magnetic rotation" [10].

Results of $B$(M1) calculations, shown in Fig. 2B were done using the formula [6] (similar to nowadays one — see *e.g.* [11]), valid for any orientation of quasiparticle spin $\boldsymbol{j}_1$ and $\boldsymbol{j}_2$ :

$$B(M1; I \to I-1) = 0.067(a\sqrt{1-x^2} - bx)^2(\mathrm{W.u.})\,, \tag{2}$$

where x $= (K_1 + K_2)/I$, $a = K_1 g_1{}^* + K_2 g_2{}^*$, $b = i_1 g_1{}^* + i_2 g_2{}^*$, $K_1$, $K_2$ and $i_1$, $i_2$ are projections of $\boldsymbol{j}_1$ and $\boldsymbol{j}_2$ on symmetry axis and collective rotation axis respectively, $g_1{}^* = g_1$ - $g_R$, $g_2{}^* = g_2$ - $g_R$ and $g_R \approx 0.45$.

For 3-qp part of band 4, with configuration $(\pi \mathrm{g}_{9/2})^{-1} \otimes (\nu \mathrm{h}_{11/2})^2$ it is deduced from [12] that $K_1 = K_\pi = 4.5$, $g_1 = 1.27$, $K_2 = 2K_\nu = 5$ and $g_2 =$ -0.21. The total alignment $i = i_1 + i_2 \approx 8$ is deduced from alignment plot [1]. Although each neutron in the $\mathrm{h}_{11/2}$ state can be aligned to $i_\nu = 4$ [12], but due to blocking effect one has $i_2 < 2i_\nu$. Assuming that for $\pi(\mathrm{g}_{9/2})^{-1}$ state $i_1 \approx 1$ (it follows from the initial alignment of band 4 — see Fig. 4 of [1]) we have got $i_2 \approx 7$. Calculations done with such parameters for 3-qp part of band 4 give satisfactory agreement with the experimental data (Fig. 2)

For 1-qp configuration of band 4 and band 1 the standard rotational formula ($K_1$ = const inside the band, no alignment, $K_2 = 0$, $i_2 = 0$) gives results shown by dotted lines in Fig. 2B. The lines are far away from experimental points. For both cases a model which takes into account experimental alignment $i(\mathrm{h}\omega) \equiv i(I)$ is proposed. It follows from the experimental data [1] that $i(I)$ dependence can be approximated by a linear function:

$$i(I) = i(I = K_0) + c \times (I - K_0)\,. \tag{3}$$

We took c = 0.33, $K_0 = 4.5$ (band 4) and $K_0 = 6.5$ (band 1) and $i(K_0)$ = 0.5 for both bands. Having $i(I)$ from Eq. (3) one can calculate value of $K(I)$ from the following condition:

$$K^2(I) + i^2(I) = K_0^2 + i^2(I_0) = \mathrm{const.} \tag{4}$$

In Fig. 2B the results of calculations using Eqs. (2)–(4) with $K_2 = 0$ and $i_2 = 0$ are shown by solid lines. It is the result of application of the "conflict coupling" approach in which vectors $\boldsymbol{j}_\pi$ and $\boldsymbol{R}$ are coupled. An angle $\theta$ between them is decreasing along a band. This kind of coupling in semiclassical approximation is shown schematically in Fig. 3. In Fig. 3A the case for $\theta = 90°$ corresponding to standard rotational approach is shown. Fig. 3B illustrates more general case. Coupling described by Eq. (3) and Eq. (4) is similar to one used in "shears" model [13, 14], but here "shears" are built by $\boldsymbol{j}_\pi$ and rotation $\boldsymbol{R}$ vectors.

Fig. 3A corresponds to one point ($I = 17/2$) on dotted line $K_\pi = 4.5$, $i_\pi = 0$ of Fig. 2B. Fig. 3B corresponds to the similar point on solid line of Fig. 2B for band 4.

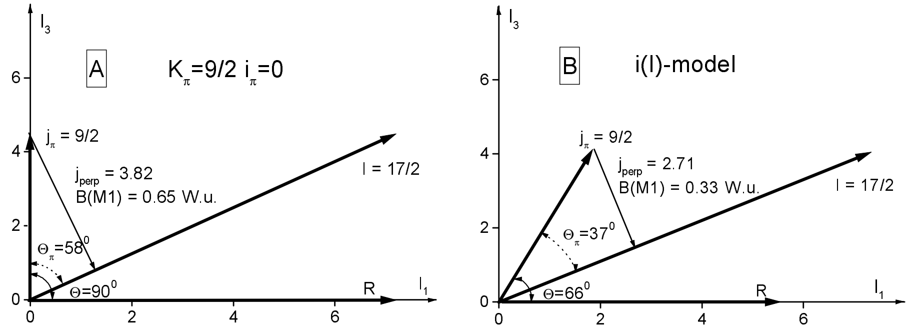


Fig. 3. Illustration of "conflict coupling" of $\boldsymbol{j}_\pi$ and $\boldsymbol{R}$ for 1-qp part of band 4 in a way similar to the shears mechanism (Fig. 1 of [14]). A — illustration of standard strong coupling in rotational axially symmetric model ($\theta = 90°$, $K_\pi = 4.5$ inside the band, no alignment). Projection of $\boldsymbol{j}_\pi$ on $I_3$ axis is equivalent to $K_\pi$ and projection on $I_1$ axis to alignment $i$. B — illustration of generalised "conflict coupling" mechanism, which takes into account variation of alignment inside the band (Eq. (3) and (4)).

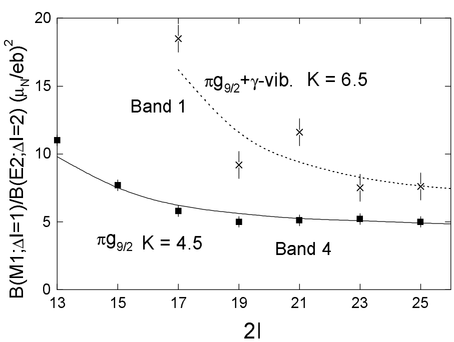


Fig. 4. Experimental $B(\mathrm{M1};I \to I-1)/B(\mathrm{E2};I\to I-2)$ ratio for 1-qp structure in band 1 (crosses) and band 4 (black squares). Smooth lines - calculations using standard rotational formula: Eq. (1) for $B$(E2) and Eq. (2) for $b$(M1) (no alignment, $K_2 = 0$ $i_2 = 0$).

In Fig. 4 experimental $B(\mathrm{M1})/B(\mathrm{E2})$ values based only on branching ratios are compared with results of calculations where standard rotational formulae 1 and 2 with condition $K =$ const, no alignment, $K_2 = 0$, $i_2 = 0$, were used. Fig. 4 shows that the results of calculations agree very well with experimental $B(\mathrm{M1})/B(\mathrm{E2})$ ratios although the theory does not reproduce the absolute $B$(M1) and $B$(E2) values obtained from lifetime measurements (Fig. 2). It means that $B(\mathrm{M1})/B(\mathrm{E2})$ ratio alone can leads to ambiguous conclusions.

## 3. Summary

Using simple formula for "conflict coupling" and its generalization for the case of 1-quasiparticle with increasing alignments, one can well reproduce the $B$(M1) values for 1-qp, 3-qp and 1-qp coupled to $\gamma$-vibrations. Additionally absolute $B$(E2) values of 3-qp structure are well reproduced by the simple rotational formula. We found that $B$(M1)/$B$(E2) experimental ratio can be well reproduced by simple rotational formulae even in case when absolute $B$(M1) and $B$(E2) are not reproduced.

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