SHORT COMMUNICATIONS

ON THE LOW EXCITED STATE OF Li^7 †

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From the mass of evidence reflecting on the low excited state of Li^7, it seems very probable that the spin is either $\frac{1}{2}$ or $5/2$. The main experimental result favouring $\frac{1}{2}$ is the isotropy of the γ-radiation, and this from several reactions. Inglis (1951) considered the α-γ correlation of $B^{10}(n, \alpha)Li^{7*}\gamma Li^7$ (Rose and Wilson 1950) and concluded that the observed isotropy could only be reconciled with spin $5/2$ if the γ-radiation is a particular mixture of magnetic dipole and electric quadrupole.

Subsequent correlation experiments (Newton 1951 ; Class and Hanna 1952 ; Uebergang and Tanner 1953) have all indicated isotropy. The simplest conclusion is spin $\frac{1}{2}$ for the decaying state. If spin $5/2$ is assumed for Li^{7*} then the experimental results can be satisfied under the conditions :

(*a*) Li^{7*} decays by the same multipole mixture notwithstanding the way in which it is formed.

(*b*) A given interfering multipole mixture can cause isotropy of the γ-radiation for all ways in which the 478 keV level is excited and for all methods of observing the radiation.

The first condition is assumed to be true *a priori*. The second is suggested by the approximate formulae of Lloyd (1951) and the explicit calculations of Devons (1949) and Ling and Falkoff (1949).

Lloyd has considered the modification of a calculated X-γ correlation (pure magnetic γ-radiation) to the case in which a small admixture of electric radiation occurs ; only interference terms are introduced, the pure electric component being neglected. For the radiation of interest here, magnetic dipole plus electric quadrupole, the condition for isotropy through multipole interference reduces to a simple expression depending only on the parameters of the γ-decay, and not on the way in which the decaying state is formed.

More generally one may consider a state of spin J, with degenerate magnetic substates designated by the quantum numbers m, decaying to a state of spin J'. It is fundamental in angular correlations that the magnetic substates m are not equally populated and that the relative populations $P(m)$ depend on the way in which the state is formed. For simplicity the phases of the substates are assumed to be random ; this is satisfied providing the previous radiations involved in

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the correlation are parallel or anti-parallel and are taken as the axis of quantization (see Biedenharn, Arfken, and Rose 1951). If the γ-decay is an interfering mixture of 2^L-pole magnetic and 2^{L+1}-pole electric radiation, then according to Ling and Falkoff (1949) the angular distribution of that radiation is given by

$$\begin{aligned} W(\theta)=\sum_{Mm}[P(m)\{|\alpha|^2(JLmM\mid J'M+m)^2F_L^M(\theta) \\ +|\beta|^2(JL+1mM\mid J'M+m)^2F_{L+1}^M(\theta) \\ +(\alpha\beta^*+\alpha^*\beta)(JLmM\mid J'M+m)(JL+1mM\mid J'M+m)F_{L,L+1}^M(\theta)\}], \end{aligned} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where M is the magnetic quantum number associated with the γ-radiation,
α, β are the complex amplitudes of the dipole and quadrupole radiations respectively,
$F_L^M(\theta)$ is the classical angular distribution of 2^L-pole γ-radiation (magnetic or electric),
$F_{L,L+1}^M(\theta)$ is the classical angular distribution of the interference component.

The remaining factors are transformation coefficients for vector addition as defined and tabulated by Condon and Shortley (1935).

For the case of the α-γ correlation of $B^{10}(n, \alpha)Li^{7*}\gamma Li^7$, Devons (1949) had shown that a quadrupole intensity admixture of about 4 per cent. can cause isotropy. It seems then, that terms in $|\beta|^2$ can be omitted. Making this necessary simplification, the angular distribution of radiation $W_m(\theta)$ from one of the degenerate magnetic substates m is given by

$$\begin{aligned} W_m(\theta)=\sum_{M}\{(JLmM\mid J'M+m)^2F_L^M(\theta) \\ +2\delta(JLmM\mid J'M+m)(JL+1mM\mid J'M+m)F_{L,L+1}^M(\theta)\}, \end{aligned} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where

$$2\delta=\frac{\alpha\beta^*+\alpha^*\beta}{|\alpha|^2}.$$

Evaluation of equation (2) for the case of $L=1$ and $J'=J-1$ leads to the isotropy condition

$$\delta=\tfrac{1}{2}\left(\frac{2J+2}{30(J-1)}\right)^{\frac{1}{2}}, \qquad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

which is independent of m. Hence isotropy through multipole interference does not depend on the populations of the substates, that is, the way in which the decaying state is formed or observed.

Applying (3) to Li^{7*} with $J=5/2$ gives $\delta=1/5$ in approximate agreement with the formulae of Devons (1949) and also Lloyd (1951). It remains then that, although a 4 per cent. relative quadrupole intensity is considered unlikely (Inglis 1951), an unexpected effect may be occurring which causes isotropy of the 478 keV γ-radiation by multipole interference. Assignment of spin $\frac{1}{2}$ to the state in question does not seem to be completely beyond doubt.

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