Angular correlation measurements on levels in ^{29}Si above 5 MeV excitation (populated in ^{26}Mg(α,n)^{29}Si reaction)

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Angular correlation measurements on levels in ^{29}Si above 5 MeV excitation

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Abstract. Angular correlation measurements have been made in ^{29}Si to determine spins and mixing ratios using the reaction ^{26}Mg(α, n)^{29}Si. The following spin and parity assignments have been made: $E_x = 6{\cdot}616$ MeV, $J^\pi = \frac{9}{2}^+$; $E_x = 7{\cdot}069$ MeV, $J^\pi = (\frac{3}{2}^+, \frac{7}{2})$; $E_x = 7{\cdot}139$ MeV, $J^\pi = \frac{11}{2}^+$; $E_x = 8{\cdot}331$ MeV, $J = (\frac{5}{2}, \frac{9}{2})$; $E_x = 8{\cdot}476$ MeV, $J^\pi = (\frac{7}{2}^+, \frac{11}{2}^+)$; $E_x = 8{\cdot}641$ MeV, $J^\pi = \frac{9}{2}^+$; $E_x = 8{\cdot}861$ MeV, $J^\pi = (\frac{3}{2}^-, \frac{5}{2})$. Previously undetermined mixing ratios have been measured for the following transitions: (5·653 MeV–4·742 MeV), $\delta = -0{\cdot}02 \pm 0{\cdot}20$; (5·813 MeV–3·068 MeV), $\delta = -0{\cdot}06 \pm 0{\cdot}03$. Mixing ratio alternatives were found for seven other transitions. The levels at 7·069, 7·522, 8·331 and 8·476 MeV were found to have mean lifetimes $\tau < 15$ fs, tnose at 8·641 and 8·861 MeV have mean lifetimes $\tau < 40$ fs.

1. Introduction

Bardin *et al* (1971) have studied states in ^{29}Si below 6·4 MeV excitation and measured mixing ratios and spins. Bailey *et al* (1972) have measured lifetimes in the nucleus up to 7·1 MeV excitation. In the present work we extend these results, measuring spins and mixing ratios for highly excited states and placing limits on the lifetimes of some states.

2. Experimental method

Beams of α particles with energies between 6·9 MeV and 11 MeV were used to populate states in ^{29}Si via the reaction ^{26}Mg(α, n)^{29}Si. The target was a layer of ^{26}Mg (enriched to 99·5%) 1 mg cm^{-2} thick on a thick gold backing. Gamma rays from the reaction were detected in an escape-suppressed spectrometer (Sharpey-Schafer *et al* 1971) whose principal element was a Ge(Li) crystal having a resolution of 2·4 keV at 1·33 MeV. At the same energy the efficiency of the crystal relative to a 76 mm × 76 mm NaI crystal was 9%. The spectrometer was calibrated for energy and efficiency using a ^{56}Co source for which the relative intensities and energies have been determined by Scott and van Patter (1969).

2.1. Angular distributions and linear polarizations

The angular distributions of γ rays were measured by collecting spectra at 0°, 30°, 45°, 60° and 90° to the beam. They were analysed by least squares fitting to the appropriate

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angular correlation formula to give spins and mixing ratios. Spin hypotheses were rejected at the 0·1 % confidence limit and errors on mixing ratios were assessed by the method of James *et al* (1973). The sign convention of Rose and Brink (1967) was used.

The statistical model program MANDY (Sheldon and van Patter 1966) was used to calculate the relative populations of the magnetic substates. For low spins we tested the effect of variations in the population parameters of about 10 %. No case was found in which these variations had an important effect. For high spins the expected angular distribution of emitted γ rays is mostly determined by restricting the number of substates populated to those with small magnetic quantum number. The details of the relative substate populations affect the analysis for high spins less than for low spins.

A three Ge(Li) Compton polarimeter was used to measure γ ray linear polarizations. The polarimeter and method of analysis have been described by Butler *et al* (1973).

2.2. *Lifetimes*

The data were used to obtain limits on the lifetimes of a number of states using the Doppler shift attenuation method. The stopping theory of Lindhard *et al* (1963) and Blaugrund (1966) was used in the analysis and the empirical normalization factors f_e and f_n were set to unity. All lifetime measurements were made at a bombarding energy of 10·5 MeV.

2.3. *Decay scheme and branching ratios*

A γ ray emitted after an (α, n) reaction near threshold, populating a state with $\tau_m < 100$ fs, should show little Doppler broadening. This is because the neutron is emitted with low energy and therefore the recoil velocity of the nucleus in the centre of mass frame as a result of neutron emission is small. Strong γ rays which were sharp near threshold compared to other γ rays in the spectrum were attributed to decays in ^{29}Si. The level to which the γ ray was attributed was determined from the approximate threshold of the γ ray and its energy. Approximate level energies for such assignments were obtained from the compilation of Endt and van der Leun (1967). The level numbers used in this paper refer to figure 1.

Branching ratios were calculated from the zero order coefficients (A_0) obtained from a Legendre polynomial fit to the angular distributions of the form:

$$W(\theta) = A_0[1+a_2P_2(\cos\theta)+a_4P_4(\cos\theta)].$$

3. Results

The results for lifetimes, branching ratios, spins and mixing ratios are summarized in tables 1 and 2. Table 3 gives the Legendre polynomial coefficients of the observed angular distributions and figures 2, 3, 5 and 6 show angular distributions and plots of χ^2 as a function of the mixing ratio. The results for some levels are discussed in more detail below. The decay scheme in figure 1 summarizes the properties of ^{29}Si relevant to the present discussion. Transition strengths are given in Weisskopf units (Wu) (Skorka *et al* 1966).

Table 1. Experimentally measured level energies, F factors and mean lifetimes

Initial level number†	E_i (keV)	Final level number†	E_f‡ (keV)	E_γ§ (keV)	F	τ‖ (fs)
30	7069 ± 2	2	2028	5041 ± 2	1·1 ± 0·1	< 15
36	7622 ± 1	5	3624	3998 ± 1	1·04 ± 0·04	< 15
49	8331·0 ± 0·6	5	3624	4706·8 ± 0·5	1·02 ± 0·01	< 15
53	8475·7 ± 0·9	7	4742	2823·9 ± 0·5	1·05 ± 0·02	< 15
60	8641 ± 1	7	4742	3899·0 ± 0·9	0·98 ± 0·03	< 40
62	8760·6 ± 0·7	11	5255	3505·6 ± 0·8	0·98 ± 0·01	< 15
62	8760·6 ± 0·7	25	6781	1979·2 ± 0·5	1·01 ± 0·01	
65	8861 ± 1	10	4934	3927·4 ± 0·7	0·99 ± 0·03	< 40

† Level numbers refer to figure 1.

‡ Energies taken from Bailey *et al* (1972).

§ All γ ray assignments except (30–2) are made for the first time in this work.

‖ An allowance of 25 % has been made for possible systematic errors in the stopping theory.

Table 2. Experimentally measured mixing ratios and branching ratios

Transition†	E_i (MeV)	J_i^π	J_f^π	δ	Branching ratio (%)
11–5	5·255	$\frac{9}{2}^-$	$\frac{7}{2}^-$	−0·46 ± 0·02	
12–1	5·286	$\frac{7}{2}^+$	$\frac{3}{2}^+$	0	10 ± 1‡
12–2	5·286	$\frac{7}{2}^+$	$\frac{5}{2}^+$	0·18 ± 0·02	73 ± 4‡
13–4	5·653	$\frac{9}{2}^+$	$\frac{5}{2}^+$	0	
13–7	5·653	$\frac{9}{2}^+$	$\frac{9}{2}^+$	−0·02 ± 0·20	
14–2	5·813	$\frac{7}{2}^+$	$\frac{5}{2}^+$	1·8 ± 0·2	
14–4	5·813	$\frac{7}{2}^+$	$\frac{5}{2}^+$	−0·06 ± 0·03	
16–3	6·108	$\frac{3}{2}^+$	$\frac{3}{2}^+$	0·60 ± 0·08	
				or	
		or		3·4 ± 0·8	
		$\frac{5}{2}$		−0·04 ± 0·02	
17–2	6·193	$\frac{7}{2}^-$	$\frac{5}{2}^+$	−0·04 ± 0·01	
22–2	6·616	$\frac{9}{2}^+$	$\frac{5}{2}^+$	0	65 ± 3
22–5	6·616	$\frac{9}{2}^+$	$\frac{7}{2}^-$	0·01 ± 0·02	35 ± 3
25–5	6·781	$\frac{11}{2}^-$	$\frac{7}{2}^-$	0	40 ± 5
25–11	6·781	$\frac{11}{2}^-$	$\frac{9}{2}^-$	−0·30 ± 0·06§	60 ± 5
30–2	7·069	$\frac{7}{2}$		0·19 ± 0·01	
		or			
		$\frac{3}{2}$		−1·3 ± 0·5	
31–6	7·139	$\frac{11}{2}^+$	$\frac{7}{2}^+$	0	
49–5	8·331	$\frac{9}{2}$	$\frac{7}{2}^-$	−0·01 ± 0·03	
		or			
		$\frac{5}{2}$		−0·15 ± 0·06	
				or	
				$\delta^{-1} = -0{\cdot}02 \pm 0{\cdot}04$	
53–7	8·476	$\frac{11}{2}$	$\frac{9}{2}^+$	0·29 ± 0·08	
				or	
		or		1·5 ± 0·3	
		$\frac{7}{2}$		$-2{\cdot}75 < \delta < -0{\cdot}46$	
60–7	8·641	$\frac{9}{2}^+$	$\frac{9}{2}^+$	−0·59 ± 0·08	
62–11	8·761	$\frac{13}{2}^-$	$\frac{9}{2}^-$	0	58 ± 3

Table 2—continued

Transition†	E_i (MeV)	J_i^π	J_f^π	δ	Branching ratio (%)
62–25	8·761	$\frac{13}{2}^-$	$\frac{11}{2}^-$	−0·5±0·2§	42±3
65–10	8·861	$\frac{3}{2}^-$	$\frac{3}{2}^-$	0·6±0·1	
				or	
		or		3·7±1·3	
		$\frac{5}{2}$		−0·05±0·04	

† Level numbers refer to figure 1.

‡ A (12–3) transition was observed very close to the (9–2) peak. No mixing ratio could be extracted for this transition but the branching ratio was estimated as 17±4%. A limit of less than 10% was placed on the (12–4) transition.

§ These mixing ratios were obtained from the same data as in Viggars *et al* (1973). The errors differ from that reference because in this paper errors have been calculated by the method of James *et al* (1973).

Table 3. Legendre polynomial coefficients found in the present work

Transition†	E_γ (MeV)	Bombarding energy (MeV)	a_2‡	a_4‡
11–5	1·631	6·9	0·45±0·02	0·10±0·02
12–1	4·013	6·9	0·42±0·06	−0·20±0·06
12–2	3·258	6·9	−0·67±0·02	0·07±0·02
13–4	2·585	6·9	0·48±0·04	−0·25±0·04
13–6	1·572	6·9	0·06±0·04	0·21±0·05
13–7	0·911	6·9	0·39±0·12	0·15±0·10
14–2	3·785	6·9	−0·86±0·08	0·41±0·10
14–4	2·745	6·9	−0·22±0·04	−0·04±0·04
16–3	3·683	8·0	−0·26±0·03	0·07±0·04
17–2	4·165	8·3	−0·23±0·01	−0·02±0·02
22–2	4·588	8·3	0·46±0·02	−0·23±0·02
22–5	2·992	8·3	−0·34±0·03	−0·05±0·04
25–5	3·157	8·5	0·42±0·06	−0·10±0·06
25–11	1·526	8·5	0·28±0·05	−0·11±0·06
30–2	5·041	8·5	−0·67±0·03	0·05±0·04
31–6	3·058	8·5	0·38±0·05	−0·20±0·05
49–5	4·707	10·5	−0·34±0·05	0·10±0·05
53–7	3·734	10·5	−0·86±0·06	0·19±0·06
60–7	3·899	11·0	0·52±0·02	−0·08±0·02
62–11	1·979	10·5	0·43±0·04	−0·25±0·05
62–25	3·506	10·5	0·42±0·09	0·34±0·09
65–10	3·927	10·5	−0·21±0·06	−0·10±0·06

† The level numbers refer to figure 1.

‡ The coefficients a_2 and a_4 are defined in § 2.3 and are corrected for solid angle effects.

3.1. Level 11 at 5·255 MeV

This level was assigned by Bardin *et al* (1970) to be $\frac{9}{2}$ from the angular distribution of γ rays produced following the reaction ^{26}Mg(α, n)^{29}Si. They assigned negative parity from the lifetime of the state. Spear *et al* (1971), using the same reaction, confirmed the

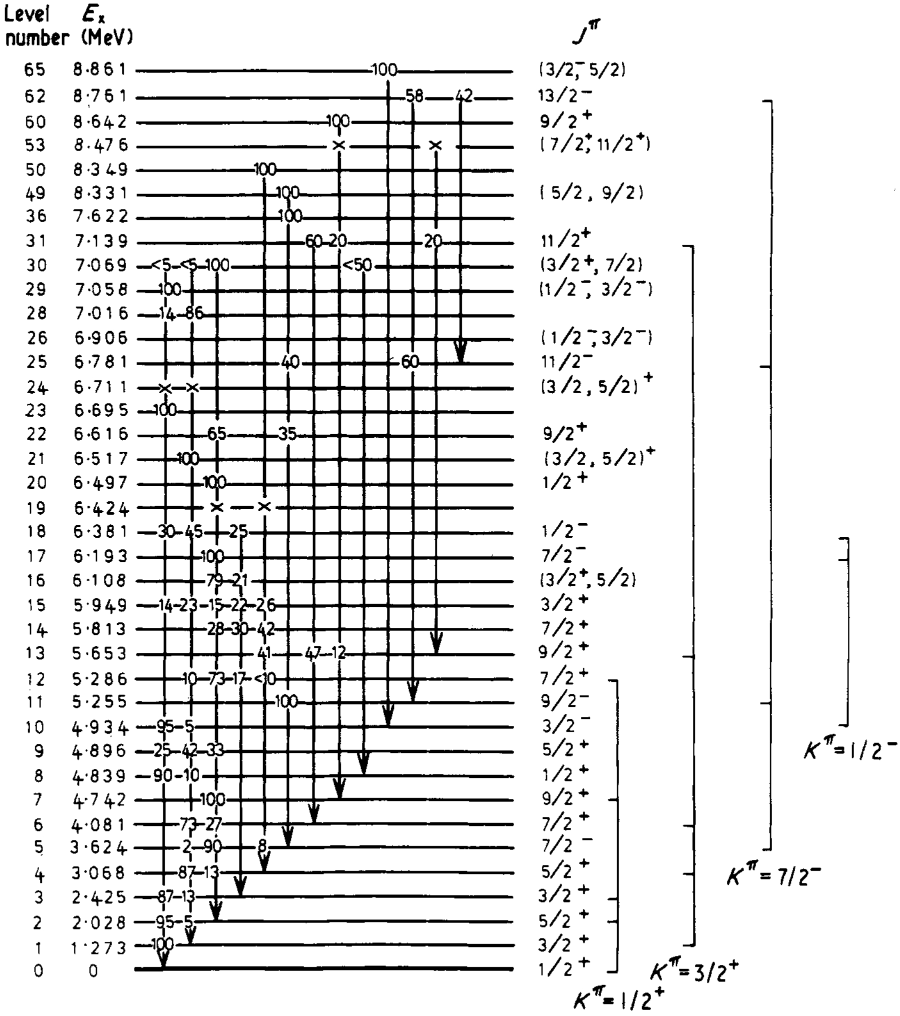

Figure 1. Decay scheme of ^{29}Si. Branching ratios are those measured in the present work or by Bailey *et al* (1972) except for levels 8, 10 and 15 for which the results of Bardin *et al* (1971) are used. Levels 19, 24 and 53 were all observed to decay by two branches both in the present work and in the work of Bailey *et al* (1973) but the γ rays were not fully resolved from other peaks.

parity assignment by measuring the linear polarization of γ rays from the decay of the 5·255 MeV level with a polarization sensitive planar Ge(Li) detector. They noted, however, that the data also allowed $J^\pi = \frac{5}{2}^-$ if the population of the first magnetic substate of the level approached 100%. This was because in these circumstances the expected angular distribution and polarization for $J^\pi = \frac{5}{2}^-$ with $\delta_{5/2} \simeq 1{\cdot}2$ are very similar to those for $J^\pi = \frac{9}{2}^-$ with $\delta_{9/2} = -0{\cdot}49$ (as measured by Bardin *et al* 1970). They therefore assigned the level to be $(\frac{5}{2}, \frac{9}{2})^-$.

Figure 2 shows the data obtained in the present work at a bombarding energy of 6·9 MeV and the details of the fits using the statistical model predictions. The $J = \frac{5}{2}$ solution is excluded. To obtain a fit to the data for which χ^2 is below the 0·1 % confidence

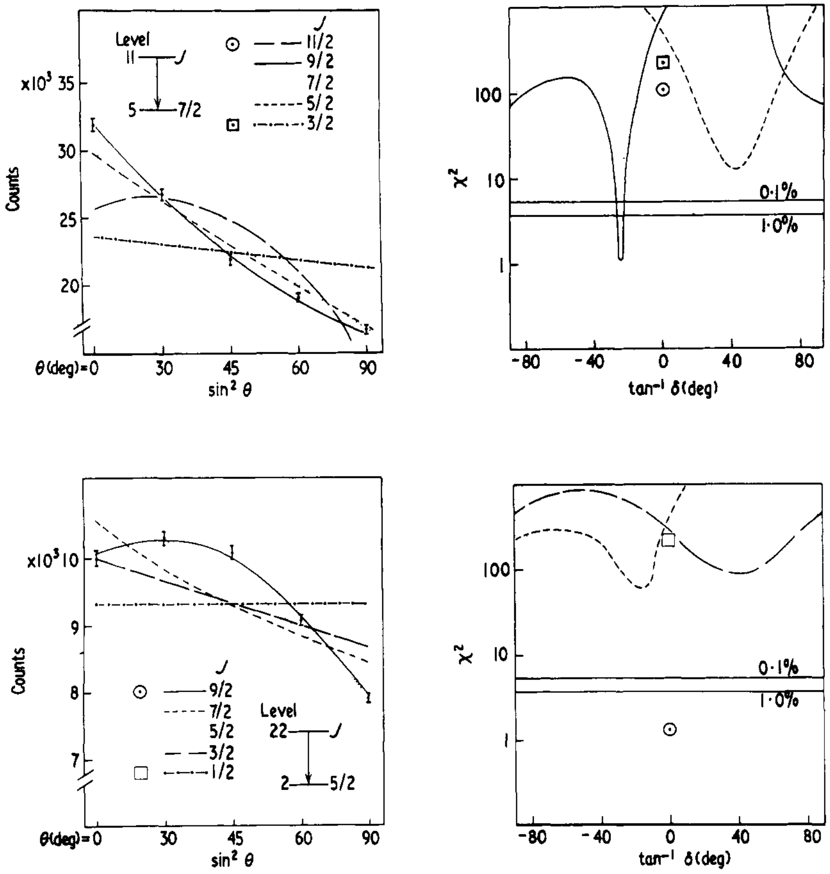

Figure 2. Angular distributions and plots of χ^2 as a function of mixing ratio for the transitions (11–5) and (22–2).

limit with $J = \frac{5}{2}$ requires $P_{5/2}(\frac{1}{2}) > 0{\cdot}87$. The statistical model prediction is $P_{5/2}(\frac{1}{2}) = 0{\cdot}74$. Accepting this prediction the spin of level 11 can be assigned as $\frac{9}{2}^-$.

3.2. Level 22 at 6·616 MeV

At $E_\alpha = 8{\cdot}3$ MeV the angular distribution of the (22–2) γ ray gives a clear $\frac{9}{2}$ assignment with $\delta = 0$ (figure 2). The lifetime of the level is less than 35 fs (Bailey *et al* 1972). Negative parity for the level would imply an M2 strength for this transition of more than 66 Wu. We therefore make the new assignment of $\frac{9}{2}^+$ for this level. The decay to level 5 gives no spin selection. If the level is $\frac{9}{2}^+$ then the mixing ratio for this transition is consistent with zero as expected.

3.3. Levels 23 and 24 at 6·695 MeV and 6·711 MeV

The decays of these levels to the ground state were not resolved in our experiment. (In figure 1 of Bailey *et al* 1972 the peak below the 6·711 MeV transition, incorrectly labelled as a single escape peak, is the 6·695 MeV to ground transition.)

3.4. Level 30 at 7·069 MeV

We observe only the (30–2) transition. (In figure 1 of Bailey *et al* 1972 the peak mislabelled 'Si (30–0) 7074 keV' should be labelled 'Si (29–0) 7058 keV'.) Analysis of the distribution of the (30–2) γ ray obtained at $E_\alpha = 8{\cdot}5$ MeV gave an assignment of ($\frac{3}{2}$, $\frac{7}{2}$) as shown in figure 3. If the level had $J^\pi = \frac{3}{2}^-$ the M2 strength of the (30–2) transition would be greater than 75 Wu, which may be excluded. The level therefore has $J^\pi = (\frac{3}{2}^+, \frac{7}{2})$.

Meyer-Schutzmeister *et al* (1969) reported a (30–1) transition. We place a limit of less than 5 % on this branch. They also suggested tentatively that (30–0) and (30–8) transitions may occur. We place a limit of less than 5 % on the (30–0) transition. A (30–8) transition would be obscured by the ^{29}Al (3–0) peak and we can only place an upper limit of less than 50 % on this branch.

3.5. Level 31 at 7·139 MeV

All the decays observed by Bailey *et al* (1972) were seen in the present work, but only the (31–6) γ ray was clearly resolved. Its angular distribution was measured at a bombarding energy of 8·5 MeV (figure 3). This showed that the level has spin $\frac{11}{2}$ or $\frac{7}{2}$. These

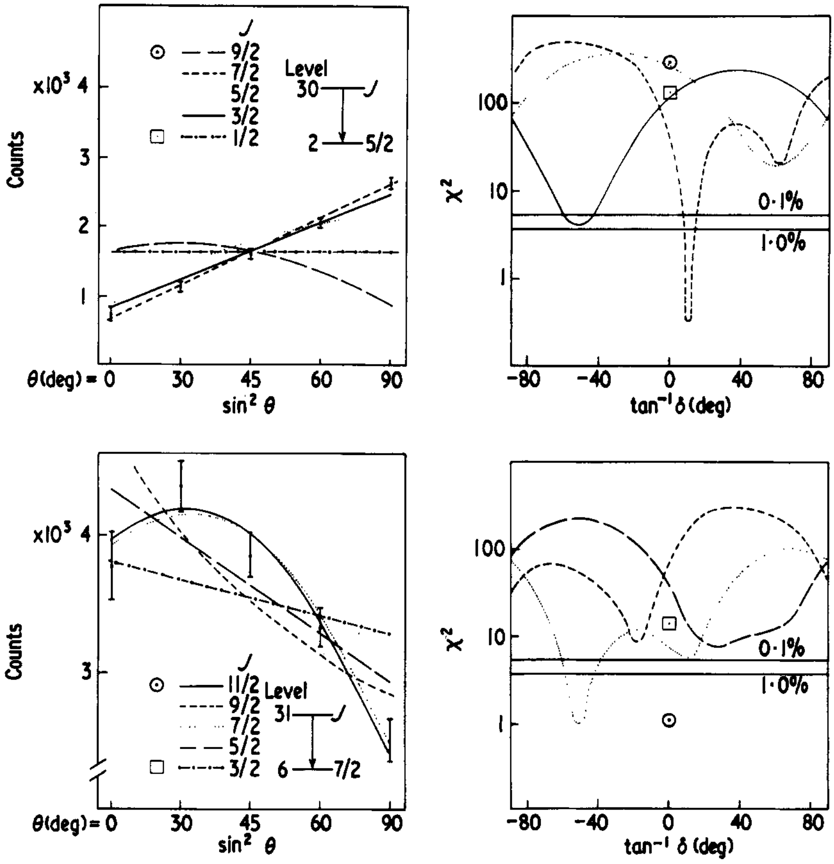

Figure 3. Angular distributions and plots of χ as a function of mixing ratio for the transitions (30–2) and (31–6).

two possibilities would give M2 strengths of more than 260 Wu or more than 130 Wu for the (31–6) transition if the level had negative parity. It must therefore have $J^\pi = (\frac{11}{2}, \frac{7}{2})^+$. A measurement of the linear polarization of the (31–6) γ ray at a bombarding energy of 9 MeV gave $P = 1{\cdot}1 \pm 0{\cdot}4$. When these data were combined with the angular distribution data in a least squares fit for the $\frac{7}{2}^+$ and $\frac{11}{2}^+$ hypotheses the $\frac{7}{2}^+$ solution could be rejected (figure 4). The level therefore has $J^\pi = \frac{11}{2}^+$.

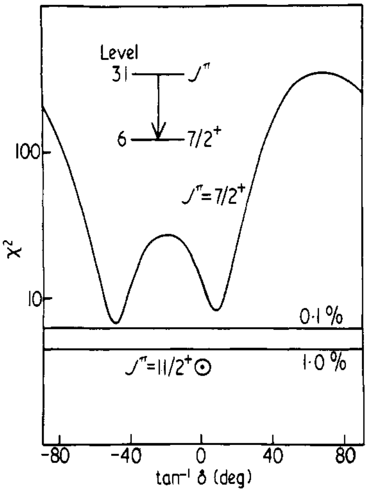

Figure 4. Plot of χ^2 as a function of mixing ratio for the (31–6) transition with polarization data included in the least squares fitting procedure.

3.6. Level 49 at 8·331 MeV

A strong γ ray of energy $4706{\cdot}8 \pm 0{\cdot}4$ keV with a threshold between 9·5 MeV and 10 MeV bombarding energy was observed, and using the criteria of § 2.3 was attributed to the (49–5) transition. Analysis of the angular distribution of this γ ray at $E_\alpha = 10{\cdot}5$ MeV gave $J = (\frac{5}{2}, \frac{9}{2})$ as shown in figure 5. The lifetime of the level is less than 15 fs.

3.7. Level 53 at 8·476 MeV

In a recent experiment using the (α, n) reaction and detecting neutrons and γ rays in coincidence Betz and Ropke (1973, private communication) have observed a (53–7) transition. This γ ray, with $E_\gamma = 3733{\cdot}8 \pm 0{\cdot}6$ keV, was observed in the present experiment and its angular distribution at a bombarding energy of 10·5 MeV gave $J = \frac{7}{2}$ or $\frac{11}{2}$ (figure 5). For $J = \frac{7}{2}$ the mixing ratio was $-2{\cdot}75 < \delta_{7/2} < -0{\cdot}46$ and for $J = \frac{11}{2}$ we obtained $\delta_{11/2} = 0{\cdot}29 \pm 0{\cdot}08$ or $\delta_{11/2} = 1{\cdot}5 \pm 0{\cdot}3$. The lifetime of the level was less than 15 fs. If the level has negative parity $\delta_{11/2} = 0{\cdot}29 \pm 0{\cdot}08$ implies an M2 strength greater than 18 Wu, and the mixing ratio for $\frac{7}{2}$ implies an M2 strength greater than 20 Wu. This suggests that the level has positive parity.

A γ ray was observed at $2824{\cdot}0 \pm 0{\cdot}5$ keV which was attributed to a (53–13) transition. The γ ray was too close to the 2808 keV (6–1) γ ray to allow measurement of its angular distribution.

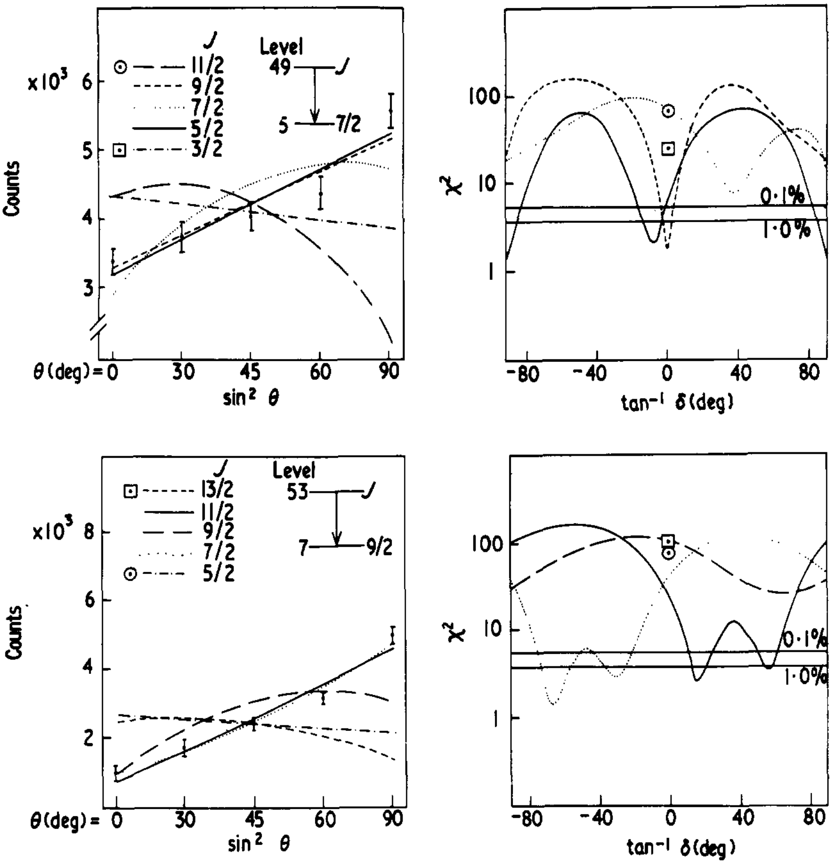

Figure 5. Angular distributions and plots of χ^2 as a function of mixing ratio for the transitions (49–5) and (53–7).

3.8. Level 60 at 8·641 MeV

In a recent neutron–γ coincidence experiment Betz and Ropke (1973, private communication) have observed a (60–7) transition. This γ ray was observed in the present work with $E_\gamma = 3899 \pm 1$ keV. The lifetime of the level was measured as less than 15 fs. The angular distribution of the γ ray at $E_\alpha = 11$ MeV gave a unique spin assignment of $\frac{9}{2}$ (figure 6). If the level were $\frac{9}{2}^-$ the M2 strength of the (60–7) transition would be greater than 106 Wu. The level therefore has $J^\pi = \frac{9}{2}^+$.

3.9. Level 65 at 8·861 MeV

This level decays by a γ ray of energy $3927{\cdot}4 \pm 0{\cdot}7$ keV to the $\frac{3}{2}^-$ level at 4·934 MeV. The threshold for this γ ray is between 10 MeV and 10·5 MeV. At 10·5 MeV it is sharp. We obtained its angular distribution at 10·5 MeV and found $J = \frac{3}{2}$ with $\delta_{3/2} = 0{\cdot}6 \pm 0{\cdot}1$ or $\delta_{3/2} = 3{\cdot}7 \pm 1{\cdot}3$ or $J = \frac{5}{2}$ with $\delta_{5/2} = -0{\cdot}05 \pm 0{\cdot}04$ (figure 6). The lifetime was found to be less than 40 fs. If the level is $\frac{3}{2}^+$ then the M2 strength of the (65–10) transition using $\delta_{3/2} = 0{\cdot}6 \pm 0{\cdot}1$ is more than 22 Wu which may be rejected as may the $\delta_{3/2} = 3{\cdot}7 \pm 1{\cdot}3$ possibility. The level is therefore $(\frac{3}{2}^-, \frac{5}{2})$.

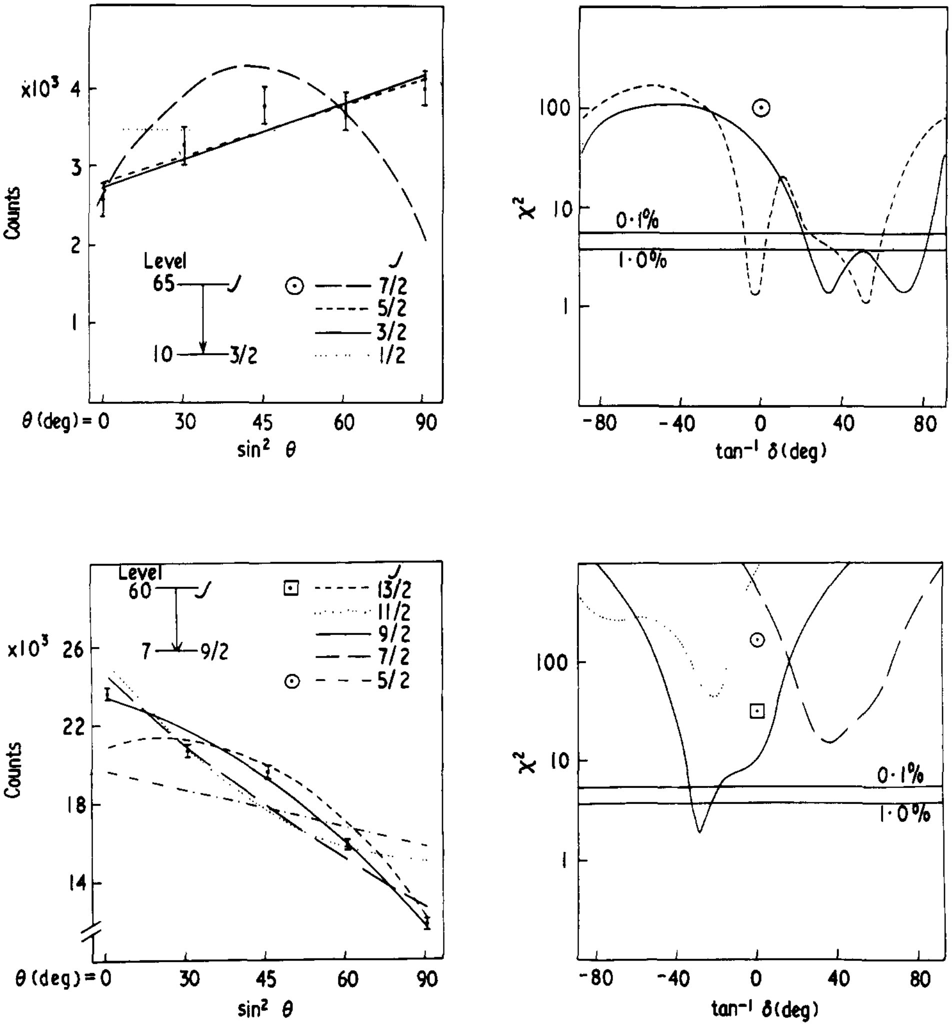

Figure 6. Angular distributions and plots of χ^2 as a function of mixing ratio for the transitions (60–7) and (65–10).

4. Discussion

4.1. Rotational model

Ragnarsson and Nilsson (1970) have predicted an oblate ground state deformation with $\epsilon = -0{\cdot}43$ for ^{29}Si using the core renormalization method of Strutinsky (1967). They predict a ground state $K^\pi = \frac{1}{2}^+$ band, bands with $K^\pi = \frac{3}{2}^+$, $\frac{7}{2}^-$ and $\frac{3}{2}^-$ with oblate deformation and bands with $K^\pi = \frac{5}{2}^+$ and $\frac{1}{2}^-$ with prolate deformation, all with band heads below 5 MeV. There is also a possibility of an additional $K^\pi = \frac{1}{2}^+$ band with small prolate deformation.

4.1.1. $K^\pi = \frac{1}{2}^+, \frac{3}{2}^+$ and $\frac{7}{2}^-$ bands. Various authors (Bromley *et al* 1957, Main *et al* 1970, Pilt *et al* 1972, Spear *et al* 1971, Bardin *et al* 1970, 1971) have discussed the assignment of low-lying states to rotational bands and the consensus has been that the levels at 0, 2·028, 2·425, 4·742 and 5·286 MeV belong to a $K^\pi = \frac{1}{2}^+$ band based on the ground state, the levels at 1·273, 3·068, 4·081 and 5·653 MeV have $K^\pi = \frac{3}{2}^+$ and the levels at 3·624 and 5·255 MeV have $K^\pi = \frac{7}{2}^-$. Bailey *et al* (1972) proposed that a level at 7·139 MeV might be the $\frac{11}{2}^+$ member of the $K^\pi = \frac{3}{2}^+$ band on the evidence of its decay scheme and energy. This is consistent with the assignment of $\frac{11}{2}^+$ for the level made here. We have already discussed elsewhere the 6·781 MeV and 8·761 MeV levels which are the $\frac{11}{2}^-$ and $\frac{13}{2}^-$ members of the $K^\pi = \frac{7}{2}^-$ band (Viggars *et al* 1973).

Bardin *et al* (1971) have discussed a calculation carried out by Hirko (1969 unpublished) in which the ground state and first excited state bands were allowed to mix via the Coriolis interaction. This calculation reproduces the experimental energies and transition strengths for the lower members of the bands reasonably well. For the $\frac{7}{2}$ and $\frac{9}{2}$ members the predicted energies are considerably too high. A calculation which allowed mixing with other positive parity bands at higher excitation and also allowed different bands to have different moments of inertia might well be more successful.

4.1.2. $K^\pi = \frac{1}{2}^-$ *band.* The calculations of Ragnarsson and Nilsson (1970) indicate that prolate deformation can occur in ^{29}Si leading to a rotational band based on the [330] $\frac{1}{2}^-$ Nilsson orbital. Levels exist at 4·934, 6·193 and 6·381 MeV with spins $\frac{3}{2}^-, \frac{7}{2}^-$ and $\frac{1}{2}^-$ respectively which could be the lowest three members of such a band. In support of this suggestion we note that this choice of levels gives a decoupling parameter of $a = -3{\cdot}2$ and a moment of inertia parameter of $\hbar^2/2\mathscr{I} = 220$ keV. These values are consistent with a [330] $\frac{1}{2}^-$ band. Some authors have taken the strength of the 4·934 MeV level in the (d, p) reaction as indicative of $2p_{3/2}$ single particle character. However the relative strengths of the 4·934, 6·193 and 6·381 MeV levels in the (d, p) reaction are 2·3 : 2·7 : 0·8 (Betigeri *et al* 1966, El-Naiem and Reif 1972, El-Bedewi and Shalaby 1972) which is consistent with the values of the c_j coefficients for a [330] $\frac{1}{2}^-$ band (Davidson 1968).

It thus seems possible that a prolate $K^\pi = \frac{1}{2}^-$ band co-exists with the known oblate bands in ^{29}Si.

The next members of this band would be states with $J^\pi = \frac{11}{2}^-$ and $\frac{5}{2}^-$ at 9·2 MeV and 9·5 MeV respectively.

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