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Directional correlations of gamma transitions in ^{105}Rh

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Abstract. The directional correlations of various gamma transitions in ^{105}Rh have been measured from the β^- decay of 4·4 h ^{105}Ru utilising a Ge(Li)–NaI(Tl) spectrometer. The measurements have been carried out for the 489–149, 575–149, 393–263, 413–263, 350–326, 316–469, 500–469, 875–469, 907–469, 1017–469, 846–499 and 878–499 keV gamma cascades. The present results, which include measurements on six gamma cascades not studied previously, when combined with other available data establish spin and parity assignments for the majority of low-lying levels in ^{105}Rh up to about 1 MeV. The multipole mixing ratios δ(E2/M1) calculated from the measured angular correlations are: $\delta(149) = 0{\cdot}34 \pm 0{\cdot}01$, $\delta(263) = -0{\cdot}15 \pm 0{\cdot}01$, $\delta(316) = -0{\cdot}20 \pm 0{\cdot}01$, $\delta(489) = 0{\cdot}25 \pm 0{\cdot}02$, $\delta(500) = 0{\cdot}70 \pm 0{\cdot}30$, $\delta(875) = 1{\cdot}3 \pm 0{\cdot}4$, $\delta(907) = 0{\cdot}21 \pm 0{\cdot}03$ or $-21{\cdot}7^{+8}_{-31}$ and $\delta(1017) = 1{\cdot}3^{+\infty}_{-1{\cdot}4}$.

RADIOACTIVITY ^{105}Ru (from ^{104}Ru(n, γ)); measured $\gamma\gamma(\theta)$. ^{105}Rh levels; deduced J, π, δ(E2/M1). Enriched target, Ge(Li) detector.

1. Introduction

Recently there has been a considerable theoretical (Kisslinger 1966, Ikegami and Sano 1966, Sherwood and Goswami 1966, Goswami and Sherwood 1967, Goswami and Nalcioglu 1968) as well as experimental (Easterday and Meyer 1972, Todd *et al* 1973, Phelps and Sarantites 1970, Zoller *et al* 1969, Bertrand and Horen 1972, Bertrand 1974, Kocher 1972, Raman and Kim 1971) interest in the study of the low-lying energy-level structure of odd-mass nuclei with an odd number of protons ($Z = 41$–49). Such studies are quite useful since they can reveal important systematic effects resulting from the filling of $2p_{1/2}$ and $1g_{9/2}$ orbitals just below the $Z = 50$ proton shell. Apart from the low-lying $\frac{1}{2}^-$ and $\frac{9}{2}^+$ single-particle levels found in all these nuclei, the odd-A Rh and Ag isotopes are known to have negative-parity $\frac{3}{2}^-$ and $\frac{5}{2}^-$ levels at low energies just above the $\frac{1}{2}^-$ level. Such levels have usually been interpreted as resulting from a weak coupling between the 2^+ one-phonon and the $p_{1/2}$ single-particle states. The positive-parity states in these nuclei, however, are found to be even more interesting. The presence of a low-lying $\frac{7}{2}^+$ level in Tc, Rh and Ag isotopes in addition to the expected $\frac{9}{2}^+$ level and its interpretation as the three-quasiparticle intruder state is not yet quite certain (Jain *et al* 1972). Recent studies of odd-A Pd and Rh isotopes have suggested that even some of the very low-lying levels can be interpreted in terms of rotational levels of a deformed core based upon the Nilsson-model states.

The nucleus ^{105}Rh has been investigated experimentally by several techniques, including beta and gamma spectroscopy from the decay of ^{105}Ru (Aras and Walters 1975), conversion electron spectroscopy (Schreiber and Johns 1967), (^{3}He, d), (p, α) and (t, p) reactions (Dittmer and Daehnick 1970, Anderson *et al* 1977) as well as the γ-ray angular correlation measurements (Arya 1963, Neeson and Arns 1965, Begzhanov 1970, Schneider *et al* 1976, Güven *et al* 1976). The spin and parity assignments to several levels in ^{105}Rh have been proposed from these various studies. The older γ–γ angular correlation measurements were carried out with the use of NaI(Tl) detectors and are quite likely to have interferences from the unresolved gamma cascades. More recent measurements (Schneider *et al* 1976, Güven *et al* 1976) were made by the use of two Ge(Li) detectors; however, only a few of the relatively strong gamma cascades were investigated. During the course of the present study, the results of one more γ–γ angular correlation measurement have appeared (Krane and Shobaki 1977). In spite of the use of high-resolution Ge(Li) detectors by various authors there are still disagreements in the reported values of A_{kk} for some of the gamma cascades.

The present investigation was undertaken with a view to measuring the directional correlation of a number of gamma cascades, in particular several cascades of intermediate intensities not studied previously, in order to elucidate further the nature of levels and γ transitions in ^{105}Rh. The angular correlation measurements have been carried out on twelve gamma cascades (six of which have not been studied previously) in ^{105}Rh populated in the β^- decay of ^{105}Ru using an automatic spectrometer consisting of a Ge(Li) and a NaI(Tl) detector.

2. Experimental

The radioactive samples of ^{105}Ru were prepared by irradiating ^{104}Ru (> 99% enriched) in a thermal neutron flux of 2×10^{13} neutron/cm^2 s at the IEA–R1 reactor in São Paulo. Approximately 6 mg of ruthenium metal powder were sealed in a silica tube and irradiated for six minutes. Each sample was measured for up to eight hours before being replaced by a new source.

The γ–γ spectrometer employed the combination of a 35 cm^3 true coaxial Ge(Li) detector and a 7·6 cm × 7·6 cm NaI(Tl) detector. The γ–γ coincidences were recorded using a standard low-noise fast coincidence system and a 4096-channel pulse-height analyser in an automatic spectrometer. The SCA windows were selected to accept the photopeaks at 149, 263, 326, 469 and (469 + 499) keV as seen in the NaI(Tl) detector spectrum. The effects of Compton-scattered radiation from high-energy γ rays included in the window in each case were determined separately.

The γ–γ coincidences were accumulated at angular positions from 90° to 270° in steps of 30°. The intensities of the coincident γ rays were measured from the Ge(Li) detector spectra recorded at various angles and corrected for the source decay during the measurement and for chance coincidences. The angular correlation coefficients A_{kk} were obtained by a least-squares fitting procedure in the usual manner and were corrected for the solid-angle effects of the detectors (Yates 1964, Camp and Van Lehn 1969). These coefficients were subsequently analysed for the spin assignments to the levels and the γ-ray multipole mixing ratios δ(E2/M1). The convention of Becker and Steffen (1969) was used for the phase of the multipole mixing ratio.

3. Results

The angular correlation coefficients A_{kk} obtained by the least-squares fitting procedure and corrected for the solid-angle effects of the detectors are shown in table 1. In this table the A_{kk} values from some of the recent measurements have been included for comparison. The mixing ratios δ(E2/M1) for the γ transitions along with the spin sequence consistent with the observed directional correlation and the decay properties are also given in table 1.

A level scheme of ^{105}Rh showing only the γ transitions of interest in the present study is shown in figure 1. The spin and parity assignments to the levels as deduced from the available data are included in this figure. The spin and parity assignments to the individual levels and the results of directional correlation measurements are discussed below. The spin and parity of $\frac{7}{2}^+$ and $\frac{1}{2}^-$ for the ground state and the first excited state at 130 keV respectively are fairly well established, being consistent with most of the experimental results (Bertrand 1974).

3.1. The 149 keV level

An assignment of $\frac{9}{2}^+$ for the 149 keV level follows from shell-model considerations as well as from the systematics of levels in the neighbouring nuclei. Two gamma cascades, 489–149 and 575–149 keV, have been measured in the present work. The 724 keV level from which the 575 keV γ transition originates is readily assigned as $\frac{5}{2}^+$ because it is strongly fed in the β^- decay from the $\frac{3}{2}^+$ level of ^{105}Ru with log*ft* = 6·2 (Aras and Walters 1975) and also de-excites to the $\frac{9}{2}^+$ level at 149 keV with reasonable intensity. The (^{3}He, d) reaction data (Dittmer and Daehnick 1970) are in agreement with this assignment. The 575–149 keV cascade therefore has a $\frac{5}{2}^+$ (2) $\frac{9}{2}^+$ (1, 2) $\frac{7}{2}^+$ sequence. The mixing ratio δ(E2/M1) for the 149 keV transition as determined from the measured A_{kk} values is δ(149 = 0·34 ± 0·01. This value can be compared with the one obtained from the α_L measurement giving δ(149) = 0·48 ± 0·13 (Schreiber and Johns 1967) as well as with the less precise angular correlation result of δ(149) = 0·4 ± 0·1 (Schneider *et al* 1976).

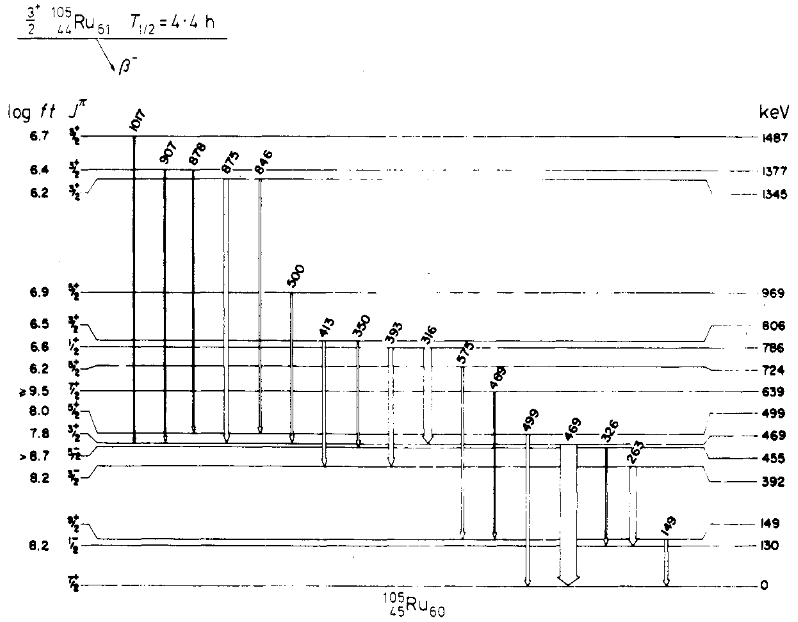

Figure 1. Partial decay scheme of ^{105}Ru to levels in ^{105}Rh.

Table 1. Results of directional correlation measurements on transitions in ^{105}Rh.

Gamma cascades (keV)	A_{22}	A_{44}	Spin sequence	Mixed transition	Mixing ratio δ(E2/M1)
Gate (469 + 499)					
(316–469)	−0·016 ± 0·003	−0·006 ± 0·006	$\frac{1}{2}(1,2)\frac{3}{2}(2)\frac{7}{2}$	316	−0·20 ± 0·01
	−0·03 ± 0·02[a]	0·0			or 3·0 ± 0·06
	−0·02 ± 0·01[b]	−0·03 ± 0·03			
	−0·018 ± 0·004[c]	0·001 ± 0·005			
(846–499)	0·057 ± 0·028	−0·045 ± 0·045	$\frac{3}{2}(1,2)\frac{5}{2}(1,2)\frac{7}{2}$	846, 499	
(875–469) + (878–499)	−0·141 ± 0·013	0·038 ± 0·022			
(907–469)	0·011 ± 0·026	−0·025 ± 0·040	$\frac{3}{2}(1,2)\frac{3}{2}(2)\frac{7}{2}$	907	0·21 ± 0·03
					or $21{\cdot}7^{+8{\cdot}0}_{-31}$
(1017–469)	−0·010 ± 0·034	−0·065 ± 0·054	$\frac{3}{2}(1,2)\frac{3}{2}(2)\frac{7}{2}$	1017	$1{\cdot}3^{+\text{[illegible]}}_{-1{\cdot}4}$
Gate 469					
(875–469)	−0·096 ± 0·018	0·009 ± 0·028	$\frac{3}{2}(1,2)\frac{3}{2}(2)\frac{7}{2}$	875	1·3 ± 0·5
	−0·090 ± 0·014[c]	0·009 ± 0·027			
(500–469)	0·067 ± 0·020	−0·055 ± 0·030	$\frac{5}{2}(1,2)\frac{3}{2}(2)\frac{7}{2}$	500	0·70 ± 0·30
Gate 326					
(350–326)	−0·199 ± 0·016	−0·008 ± 0·026	$\frac{3}{2}(1)\frac{5}{2}(2)\frac{1}{2}$		
	−0·18 ± 0·06[a]	−0·031 ± 0·08			
Gate 263					
(393–263)	0·370 ± 0·006	0·021 ± 0·010	$\frac{1}{2}(1)\frac{3}{2}(1,2)\frac{1}{2}$	263	−0·16 ± 0·01
	0·42 ± 0·03[a]	0·0			or −1·2 ± 0·02
	0·42 ± 0·02[b]	0·0			
	0·386 ± 0·014[c]	0·003 ± 0·017			
(413–263)	−0·293 ± 0·009	0·018 ± 0·012	$\frac{3}{2}(1)\frac{3}{2}(1,2)\frac{1}{2}$	263	−0·14 ± 0·01
	−0·31 ± 0·03[a]	0·0			or −1·3 ± 0·02
	−0·37 ± 0·02[b]	0·0			
	−0·348 ± 0·016[c]	0·012 ± 0·019			
Gate 149					
(575–149)	0·122 ± 0·019	−0·030 ± 0·033	$\frac{5}{2}(2)\frac{9}{2}(1,2)\frac{7}{2}$	149	0·34 ± 0·01
	0·18 ± 0·08[a]	0·11 ± 0·14			
(489–149)	0·220 ± 0·022	0·085 ± 0·036	$\frac{7}{2}(1,2)\frac{9}{2}(1,2)\frac{7}{2}$	489	0·25 ± 0·02

[a] Schneider *et al* (1976); [b] Güven *et al* (1976); [c] Krane and Shobaki (1977).

Beta- and gamma-decay studies limit the spin and parity for the 639 keV level to $\frac{9}{2}^+$ or $\frac{7}{2}^+$. The $\frac{9}{2}^+$ was eliminated (Aras and Walters 1975) from the observed γ-transition to this level from a $\frac{3}{2}^+$ level at 1377 keV. The 489 keV transition is therefore of mixed (M1 + E2) multipolarity. Using $\delta(149) = 0{\cdot}34 \pm 0{\cdot}01$ and the A_{kk} values for the 489–149 keV cascade we determine $\delta(489) = 0{\cdot}25 \pm 0{\cdot}02$.

3.2. The 392 keV level

The spin and parity assignment of $\frac{3}{2}^-$ for the 392 keV level is suggested by most of the previous workers and is found to be consistent both with the decay studies and the reaction work. The A_{kk} values for the 393–263 and 413–263 keV cascades measured in the present work represent better statistical accuracy and they are compared with the recent Ge(Li)–Ge(Li) data in table 1.

Spin and parity $\frac{3}{2}^+$ are assigned to the 806 keV level based upon the beta-decay studies, the (^{3}He, d) reaction work and the conversion electron measurements. With the spin and parities of $\frac{3}{2}^+$ and $\frac{3}{2}^-$ assumed for the 806 and 392 keV levels respectively one has a $\frac{3}{2}^+(1)\frac{3}{2}^-(1,2)\frac{1}{2}^-$ sequence for the (413–263) keV cascade. The experimental A_{kk} values give $\delta(263) = -0{\cdot}14 \pm 0{\cdot}01$ or $-1{\cdot}30 \pm 0{\cdot}02$. The experimental α_k value for the 263 keV transition cannot distinguish between the two possibilities; however, a comparison with the similar transitions in the neighbouring nuclei (Krane 1977, Sayers *et al* 1972, Robinson *et al* 1970) suggests the smaller value for the mixing ratio.

The spin and parity of the 786 keV level are limited to $\frac{1}{2}^+, \frac{3}{2}^\pm$ or $\frac{5}{2}^-$ from the spectroscopic data. The $\frac{3}{2}^+$ possibility is readily eliminated from the measured A_{22} value for the 393–263 keV cascade, which is positive. Of the remaining possibilities, only the $\frac{1}{2}^+$ and $\frac{5}{2}^-$ assignments are consistent with the angular correlation data for the 393–263 and 316–469 keV cascades provided one assumes a $\frac{3}{2}^+$ spin value for the 469 keV level (this, in fact, is the most probable value for the level, as will be shown later). A recent study of the ^{103}Rh(t, p)^{105}Rh reaction (Anderson *et al* 1977) shows that the 786 keV level is not populated in this reaction whereas the other low-lying $\frac{5}{2}^-$ and $\frac{3}{2}^-$ levels already known from the decay study are populated. This suggests that the 786 keV level has positive parity. The most probable spin and parity for the level therefore may be assumed to be $\frac{1}{2}^+$. The sequence for the 393–263 keV cascade is therefore $\frac{1}{2}^+(1)\frac{3}{2}^-(1,2)\frac{1}{2}^-$. The calculated E2/M1 mixing ratio for the 263 keV transition is $\delta(263) = -0{\cdot}16 \pm 0{\cdot}01$ or $-1{\cdot}20 \pm 0{\cdot}02$, in very good agreement with the one obtained from the 413–263 keV cascade.

3.3. The 455 keV level

A negative parity is indicated by Aras and Walters (1975) for the level at 455 keV considering the large log *ft* value ($\geqslant 8{\cdot}5$) for the beta decay from the ^{105}Ru $\frac{3}{2}^+$ state and also considering the strong γ transitions between this level and other observed negative-parity states $\frac{1}{2}^-$ and $\frac{3}{2}^-$. A gamma transition from the $\frac{5}{2}^+$ level at 969 keV to this level limits the spins to $\frac{3}{2}^-$ or $\frac{5}{2}^-$. The $\frac{5}{2}^-$ is favoured from the existence of similar levels in ^{103}Rh (Zoller *et al* 1969) and ^{107}Ag (Bertrand and Horen 1972). The present angular correlation results for the 350–326 keV cascade are in agreement with the measurements of Schneider *et al* (1976). Accepting a $\frac{3}{2}^+(1)\frac{5}{2}^-(2)\frac{1}{2}^-$ sequence, both 350 and 326 keV transitions are pure multipole E1 and E2, respectively, with an excellent agreement between the experimental $A_{22} = -0{\cdot}20 \pm 0{\cdot}02$ and the theoretical $A_{22} = -0{\cdot}20$ values. This result lends further support for the $\frac{3}{2}^+$ assignment to the 806 keV level. It may be noted, however, that from the results of angular correlation data alone one cannot rule out the $\frac{3}{2}^-$ assignment for the 455 keV level.

3.4. The 469 keV level

Beta-decay studies (Aras and Walters 1975) suggest the spin and parity of the 469 keV level to be $\frac{5}{2}^-$ or $\frac{3}{2}^+$ with the latter favoured. No definite information is available from either the (^{3}He, d) or (p, α) reactions. Positive parity, however, is indicated for the level from the α_k measurements (Schreiber and Johns 1967), which indicate a E2 or (M1 + E2) character for the 469 keV γ transition. The angular correlation data of Begzhanov (1970) for the 316–469 and 875–469 keV cascades earlier indicated a $\frac{5}{2}^+$ assignment for the 469 keV level; however the A_{22} values from this work are not reproduced by any one of the more recent measurements including the present measurement. It has been argued by Krane and Shobaki (1977) that $\frac{5}{2}^+$, in fact, is not compatible with the combined results of the 316–469 and 875–469 keV cascades. The A_{22} values for the 875–469 and 316–469 keV cascades from the present measurement are in good agreement with that of Krane and Shobaki (1977). Our results further show that the A_{22} value obtained by Begzhanov (1970) for this cascade includes the contribution from the unresolved 878–499 keV cascade, as will be discussed later. A simple calculation of the orientation coefficient $B_2(875)$ using the experimental A_{22} values for the 316–469 and 875–469 keV cascades (for details see the paper by Krane and Shobaki (1977)) shows that a $\frac{5}{2}^+$ value for the 469 keV level is not supported by the data, even when the presently adopted $\frac{1}{2}^+$ spin and parity is assigned to the 786 keV level (Krane and Shobaki (1977) assumed $\frac{5}{2}^-$ for this state). We therefore concur with Krane and Shobaki that the spin and parity for the 469 keV level is $\frac{3}{2}^+$ and the transition to the ground state is E2. The same conclusion is reached when one considers the result of the combination of 316–469 and 500–469 keV cascades. With this assignment the multipole mixing ratio for the 316 keV transition is calculated to be $\delta(316) = -0{\cdot}20 \pm 0{\cdot}0$ or $3{\cdot}0 \pm 0{\cdot}06$. The conversion coefficient data of Schreiber and Johns (1967) indicate a dipole character for the 316 keV transition, favouring the smaller value for the mixing ratio.

3.5. The 499 keV and 969 keV levels

The spin and parity for the 499 keV level are restricted to $\frac{5}{2}^+$ from the decay studies as well as from the reaction work. A gamma cascade 846–499 has been measured in the present work. The 846 keV transition originates from the 1345 keV level which has an assigned value of $\frac{3}{2}^-$ for its spin and parity (Aras and Walters 1975). Present angular correlation data are not inconsistent with these spin assignments; however, they cannot limit the spin to $\frac{5}{2}$ for the 499 keV level. A $\frac{5}{2}^+$ assignment for the 969 keV level is also argued strongly from the decay studies. There is no clear evidence for the spin and parity of this level from the (^{3}He, d) reaction data. The present angular correlation measurements for the 500–469 cascade are consistent with the $\frac{5}{2}^+$ assignment but cannot exclude $\frac{3}{2}^+$.

3.6. The 1345 keV level

The 875–469 cascade measured from the 469 keV gate is likely to have interference from the unresolved 878–499 cascade if special care is not exercised to exclude the 499 keV photopeak from the gate. We have measured the 875–469 keV angular correlation with and without the inclusion of the 499 keV photopeak in the gate setting. From the results presented in table 1, it can be seen that the A_{22} value for the 875–469 keV cascade in cases where only the 469 keV photopeak is present in the gate agrees reasonably well with that obtained by Krane and Shobaki (1977), using two Ge(Li) detectors. The A_{22} value from the 469 + 499 keV combined gate is to be compared with the one obtained by Begzhanov (1970), who used two NaI(Tl) detectors. From the known relative intensities of γ rays involved we estimate the A_{22} value for the 878–499 cascade to be $-0{\cdot}36 \pm 0{\cdot}02$. The results for the 875–469 keV cascade are consistent with any of the assignments $\frac{1}{2}^+, \frac{3}{2}^+$ or $\frac{5}{2}^+$ for the 1345 keV level. The beta- and gamma-decay studies, however, indicate $\frac{3}{2}^+$ for this level.

3.7. The 1377 keV and 1487 keV levels

The combined results of beta decay and reaction work restrict the spin and parity of the 1486 keV level to $\frac{5}{2}^-$ or $\frac{3}{2}^+$ with the latter strongly favoured. The decay studies also suggest a $\frac{3}{2}^+$ assignment for the 1377 keV level. The present angular correlation measurements of the 907–469 and 1017–469 keV cascades do not permit unique spin assignments for these levels, but they are consistent with spin $\frac{3}{2}$ for both levels.

4. Discussion

According to the shell model the expected proton configuration for ^{105}Rh is $(2p_{1/2})^2$ $(1g_{9/2})^5$ beyond the closure of the shell at 38 protons. Such a configuration implies the ground state to be $\frac{9}{2}^+$ rather than the experimentally observed $\frac{7}{2}^+$. However, such anomalous ($j - 1 = \frac{7}{2}$) states are commonly found in nuclei with $N = 43$, 45 and 47 and $Z = 45$ and 47, although not necessarily as the states of lowest energy in all cases. These states have often been attributed to the $(g_{9/2})^n$ configuration. Experimentally one finds the $\frac{7}{2}^+$ states quite close to the $\frac{9}{2}^+$ and in many cases below it. According to an interpretation given by Kisslinger (1966), the $\frac{7}{2}^+$ level in Rh and Ag nuclei may be considered as the $j - 1$ member of the $g_{9/2}$ three-quasiparticle configuration. According to this calculation the $\frac{9}{2}^+ \to \frac{7}{2}^+$ M1 transition is forbidden.

Jain *et al* (1972) have measured the lifetimes of the $\frac{7}{2}^+$ or $\frac{9}{2}^+$ states in ^{103,105}Rh and ^{107,109,111}Ag isotopes. These results are used by them along with the E2/M1 mixing ratios for the $\frac{9}{2}^+ \to \frac{7}{2}^+$ γ transitions to compute the hindrance factors for the M1 and enhancement factors for the E2 transitions. It has been shown that the E2 enhancement factor as predicted by the Kisslinger model for Rh isotopes is much smaller than the experimental values. In fact the E2 enhancement is of the same order of magnitude as the corresponding E2 enhancement for the $2^+ \to 0^+$ transitions in the neighbouring even–even nuclei. At the same time, the M1 retardation factor is too small whereas the model forbids such transitions. The three-quasiparticle interpretation of the $\frac{7}{2}^+$ state thus does not seem to fit the experimental results of the lifetimes. On the other hand, recent measurements of the nuclear g factors for the $\frac{7}{2}^+$ ground state in ^{105}Rh (Wittkemper *et al* 1977) and the 40 keV first excited state in ^{103}Rh (Scholtz *et al* 1974) fit quite well into the systematics of the $1g_{9/2}$ proton g factors, as they should according to the three-quasiparticle description of the $\frac{7}{2}^+$ state. The quasiparticle–phonon coupling theory of Sherwood and Goswami (1966, 1967) is able to explain some properties of the $\frac{7}{2}^+$ states, e.g. the energy and B(E2) values. The non-zero M1 transition probabilities in this model are explained by assuming a phonon admixture of the $\frac{9}{2}^+$ state as well as the single-particle $g_{7/2}$ admixture of the $\frac{7}{2}^+$ state.

As might be expected from the anomalous $\frac{7}{2}^+$ ground state of ^{105}Rh, there is no simple model to explain the low-lying energy levels. It appears that certain aspects of a weak coupling model apply to this nucleus but a detailed description of the observed level scheme in terms of a collective model is difficult. In the case of ^{107}Ag, Ford *et al* (1967) were able to describe the low excitations as the coupling of the odd $p_{1/2}$ proton to the one- and two-phonon vibrations of the ^{106}Pd core with some success. Similar calculations, however, are not available in the case of ^{105}Rh.

A recent study of the odd-A Pd isotopes (Kim *et al* 1975) has suggested that some of the very low-lying levels can be interpreted in terms of rotational levels of a deformed core based upon the Nilsson model. In one such modified Nilsson-model calculation (Pierson 1965) an energy level diagram results for protons in which the $\frac{7}{2}^+$ ^{105}Rh ground state as well as the first two excited states $\frac{1}{2}^-$ and $\frac{9}{2}^+$ appear naturally if one assumes a prolate shape for ^{105}Rh with the deformation parameter $\beta = +0{\cdot}105$. On the other hand, since some recent studies have revealed that the level structure of isobaric ^{105}Ag (Anderson and Kraushaar 1975, Jackson *et al* 1976) is much more vibrational in nature, the suggestion of deformation in ^{105}Rh does not seem quite reasonable.

The present results confirm and establish more conclusively the spin and parity assignments for more than ten levels up to 1·3 MeV in ^{105}Rh. In addition, our results support a $\frac{1}{2}^+$ value for the 786 keV level and $\frac{3}{2}^+$ for both the 1377 and 1487 keV levels. The γ-ray mixing ratios for eight transitions have been determined, some of them confirming previous studies. Despite the fact that presently there is a considerable amount of experimental information for the Rh nuclei, so far there has been no satisfactory theoretical interpretation of the observed properties. It is our hope that the results of the present investigation on the spins, parities and γ-ray mixing ratios might be helpful in future theoretical calculations. Further measurements of transition probabilities and of nuclear moments of excited states in Rh nuclides, although they may be difficult, will be extremely valuable for a better understanding of the structure of these nuclei.

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