Beta-gamma-gamma directional correlation in $^{103}$Rh

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Abstract. $\beta$-$\gamma$-$\gamma$ directional correlation studies for the cascades (i) $\beta$-rays of $E_{\text{max}} = 0.12$ MeV, $\gamma$-rays of 557 keV and $\gamma$-rays of 53 keV and (ii) $\beta$-rays of $E_{\text{max}} = 0.21$ MeV, $\gamma$-rays of 444 keV and $\gamma$-rays of 53 keV have been made. The triple correlation functions $W(\theta)$ were obtained to be

$$W(\theta) = 1 + (-0.153 \pm 0.031)P_2(\cos \theta) + (0.004 \pm 0.035)P_4(\cos \theta)$$

for $\beta$-rays of $E_{\text{max}} = 0.12$ MeV $\rightarrow$ 53 keV cascade and

$$W(\theta) = 1 + (0.163 \pm 0.042)P_2(\cos \theta) + (-0.035 \pm 0.058)P_4(\cos \theta)$$

for $\beta$-rays of $E_{\text{max}} = 0.21$ MeV $\rightarrow$ 444 keV $\rightarrow$ 53 keV cascade.

Spins and parities of the 650, 537 and 93 keV levels of $^{103}$Rh are deduced by triple angular correlation and the internal conversion coefficient studies. Multipolarities of the transitions are also determined.

Keywords. Decay $^{103}$Ru; $\beta\gamma\gamma$ ($\theta$) in $^{103}$Rh; deduced spin and parity; determined multipolarities of the transitions.

1. Introduction

The excited energy levels in $^{103}$Rh from the decay of $^{106}$Ru have been well established as given in figure 1 by many previous investigators (Lederer et al 1967). The spins and parities of excited states in $^{103}$Rh are assigned by the directional correlation and internal conversion coefficients (ICC) have been studied by many workers (Flack and Mason 1958, Singh 1960, Manthuruthil et al 1968, Zoller et al 1969, George and Mukherji 1970, Petterson et al 1970, and Avignone III and Frey 1971). Recently Avignone III and Frey (1971) claimed to have conclusively assigned the parities and spins of the 93, 537 and 650 keV levels by $\gamma-\gamma$ angular correlation and ICC studies. One of the serious difficulties pointed out by Avignone III and Frey (1971) was due to interference of the cascades from the decay of $^{106}$Ru resulting from use of fission product sources. $^{106}$Ru decay to $^{106}$Pd via $^{106}$Rh. Coincidence counting rate due to $\gamma$-radiations from $^{106}$Rh cannot be eliminated if it is present as impurity in the coincidences of $\gamma$-rays of the interest from the decay of $^{106}$Ru. But one can eliminate it (or reduce it to the extent of elimination) by $\beta-\gamma\gamma$ coincidences selecting $\beta$-radiations in a fixed energy interval. Therefore an attempt has been made to reinvestigate it by the method of $\beta-\gamma\gamma$ angular correlation, so as to either eliminate or reduce the $\gamma$ cascades of $^{106}$Pd.
2. Experimental set-up and results

Two NaI(Tl) detectors and one plastic scintillator are used. NaI(Tl) detectors are 3.8 cm in dia and 3.8 cm in length and the plastic scintillator was 3.0 cm in dia and 0.4 cm in length. These detectors are optically coupled with RCA 6810A photomultiplier tubes. Conventional slow-fast coincidence circuits have been used for making a gate of coincidences of $\beta$- and $\gamma$-rays. This gate is used as one of the inputs of the mixture type coincidence unit of the resolving time of the order of $5 \times 10^{-6}$ sec. The second input to this unit is from the third $\gamma$-ray spectrometer which is movable.

The detectors are mounted in the plane of the table such that two of the detectors, the plastic scintillator in vacuum and one NaI(Tl) detector are perpendicular to each other and placed at distances 3.5 cm and 6 cm respectively from the source (also in vacuum) while the third movable detector NaI(Tl) is placed 6 cm from the source. The source in the form of RuCl$_3$ in HCl was obtained from BARC, Bombay. Few drops of the source were dried on cellotape mounted on perspex stand. The source on cellotape along with the stand is kept in vacuum chamber.

The $\beta$ ray spectrometer is used as an integral spectrometer for selecting $\beta$-rays between 50 keV and 1 MeV energies and the $\gamma$ ray spectrometer (fixed) is used as differential spectrometer for scanning the spectrum in the region of $\gamma$-ray photopeaks of 444 keV and 557 keV in one volt channel width (1 volt = 14.2 keV). These two spectrometers are used for coincidences of $\beta\gamma$ rays using slow-fast coincidence set-up and the output of this forms a gate of $\beta\gamma$ coincidences for one of the inputs of second coincidence unit (mixture type) and the second input of this is from the other $\gamma$-ray spectrometer selecting the $\gamma$-rays in the photopeaks of