Four quasi-particle level at 2256 keV in $^{182}$Re

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Abstract. In-beam nuclear spectroscopic studies of $^{182}$Re, following the reaction $^{181}$Ta(α, 3n)$^{182}$Re have been made using gamma-ray and internal conversion electron techniques. K-conversion coefficients for several transitions have been measured and the multipoles of the various transitions assigned. In particular, the spin and parity of the four-quasi-particle isomeric level at 2256 keV were determined to be $1^\pm$. The $g$-factor of this level has been measured to be $g = 0.32 \pm 0.05$. On the basis of the $g$-factor and the decay pattern of this level, a configuration $\{v9/2^+ [624^+] v7/2^- [514^+] v7/2^- [503^+] n9/2^- [514^+] \}^{a^+}_{\alpha = 1^\pm}$ has been assigned to this level. The nature of the retardation of the gamma transitions deexciting this level is discussed. It is argued that the measured retardation factors can be explained if the nucleus has a triaxial shape.

Keywords. Nuclear reactions: $^{181}$Ta(α, 3n)$^{182}$Re; gamma-ray; internal conversion electron spectroscopy; internal conversion coefficients; $g$-factor; triaxial deformation.

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1. Introduction

Extensive investigations have been made on even-even and odd-mass deformed nuclei up to high spins; however, relatively little work has been reported on odd-odd deformed nuclei. The high level density and the consequent complexity of the spectra are some of the reasons for the paucity of data on these nuclei. Recently, Slaughter et al. (1984) investigated the odd-odd deformed nucleus $^{182}$Re through gamma-ray spectroscopy following the $^{181}$Ta(α, 3n)$^{182}$Re reaction. Earlier, this nucleus was studied through the radioactive decay of $^{182}$Os (Burson et al. 1973; Svahn et al. 1973; Lederer and Shirley 1978) and through in-beam gamma-ray studies (Hjorth et al. 1968; Medsker et al. 1971). Slaughter et al. (1984) identified four rotational bands, built on two quasi-particle states; with $K^*$-values of $7^+, 9^-, 2^+$ and $4^-$. The level sequence proposed by them is shown in figure 1. They also assigned the band heads on the basis of Nilsson states available near the Fermi level. In addition, they identified an isomeric level at 2256 keV with a half-life of $(88 \pm 8)$nsec (in the text and the figures, the energies of the transitions and the levels have been rounded off to the nearest keV. The exact energies of the transitions with the estimated uncertainties are quoted in table 1). This level was identified as a 3-proton-1-neutron four-quasi-particle state. Probable assignments on the basis of Nilsson orbitals were made and it was concluded that the state is most probably the band head of a $K^* = 15^+$ band with the configuration
Figure 1. Level scheme of $^{182}$Re populated in the $^{181}$Ta($\alpha$, 3$n$)$^{182}$Re reaction as proposed by Slaughter et al (1984). The energies of the levels are given in keV. The exact energies of the transitions in the $K^* = 9^-$ and $7^+$ bands are given in Table I. The spins and parities of the 2256, 2524 and 2614 keV levels are deduced from the present work. The location of the $2^+$ band-head is not known and is denoted by $\delta$. The energies of all the levels in the $2^+$ and $4^-$ bands thus have to be increased by $\delta$ with respect to the energies shown in the figure.

$\pi 9/2^- [514\uparrow] \pi 7/2^- [523\uparrow] \pi 5/2^+ [402\uparrow] \pi 9/2^+ [624\uparrow]$. The transition probabilities of the electromagnetic transitions from this level to the excited levels of the $K^* = 9^-$ band were invoked in arriving at this assignment. While angular distribution was studied by Slaughter et al (1984) to infer the multipolarities and mixing ratios of the transitions, no data exist on the internal conversion coefficients for these transitions.

In the present work, the levels in $^{182}$Re have been studied through in-beam gamma-ray and internal conversion electron spectroscopy following the $^{181}$Ta($\alpha$, 3$n$)$^{182}$Re reaction. Attention was directed only at the $7^+$ and $9^-$ bands and on the isomeric level. Internal conversion coefficients of the transitions between these levels were measured. Further, the magnetic moment of the isomeric level at 2256 keV was measured in order to elucidate its nature. A preliminary report of the $g$-factor measurement was presented earlier (Agarwal et al 1985).

2. Experimental details

2.1 Target and the beam

A natural Ta foil of high purity ( > 99.9%) was rolled to a thickness of 1.7 mg/cm$^2$. This self-supporting target, of dimensions 2 x 2 cm, was used in the gamma-ray and conversion-electron spectroscopic studies. A 0.075 mm thick Ta foil backed by a $^{208}$Pb foil thick enough to stop an $\alpha$-beam of 45 MeV was used in the $g$-factor studies.