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Short note

Low-lying isomeric states in ^{169}Ta

Y.H. Zhang, Q.Z. Zhao, S.F. Zhu, H.S. Xu, X.H. Zhou, Y.X. Guo, X.G. Lei, J. Lu, Q.B. Gou, H.J. Jin, Z. Liu, Y.X. Luo, X.F. Sun, Y.T. Zhu

Institute of Modern Physics, the Chinese Academy of Sciences, Lanzhou 730000, P. R. China

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Abstract. Two low-lying isomeric states in ^{169}Ta have been identified via ^{159}Tb(^{16}O,6nγ)^{169}Ta reaction. Their half-lives are measured to be 28 ± 5 ns for the $9/2^-$ level and 17 ± 4 ns for the $5/2^-$ level by using the delayed γ-γ coincidence method. These two isomeric states are considered to be the bandheads with $9/2^-$[514] and $1/2^-$[541] configurations respectively.

PACS. 21.10.Tg Livetimes – 21.10.Pc Single particle levels and strength functions – 23.20.Lv Gamma transitions and level energies – 27.70.+q $150 \leq A \leq 189$

Meissner et al. [1] investigated the decay of ^{169}W from which the ground state (gs) of ^{169}Ta with $5/2^+$[402] configuration and the $7/2^+$[404] excited state have been identified. The high spin states in ^{169}Ta have been well studied [2] by using the in-beam γ-spectroscopic methods; a level scheme consisting of 5 rotational bands has been established. However the connection of the rotational bands with the ground state of ^{169}Ta and the evidence of isomeric states have not been found. In this paper, we report on the identification and the half-life measurements of two low-lying isomeric states in ^{169}Ta.

The experiment has been performed at the Heavy Ion Research Facility of Lanzhou (HIRFL) by using the ^{16}O+ ^{159}Tb reaction. A 105 MeV ^{16}O beam was delivered by the Sector Focusing Cyclotron and impinged on a 2 mg/cm^2 ^{159}Tb target with a 3 mg/cm^2 Pb backing. For the in-beam γ-ray measurements, 4 BGO(AC) HPGe detectors were used and calibrated by the ^{152}Eu, ^{133}Ba and ^{60}Co standard sources and also checked by the known γ-rays of ^{169}Ta and ^{170}Hf. The energy resolutions were 2.0∼2.4 keV at FWHM for the 1332.5 keV γ-ray. The coincidence time resolution was about 24 ns for the in-beam prompt γ-γ cascade of ^{169}Ta $1/2^-$[541] band. This experiment was mainly to study the high spin states in doubly odd ^{170}Ta, however about one third of the 8×10^7 total γ_1-γ_2-$t_{\gamma_1\gamma_2}$ events can be attributed to the deexcitation of the high spin states in ^{169}Ta. Figure 1 depicts the delayed spectra gated by some intraband γ-transitions in the $9/2^-$[514] and $1/2^-$[541] bands of ^{169}Ta, respectively. It is shown that at least 3 strong γ-rays of 123.5, 153.5 and 169.5 keV together with the Ta K X-rays were clearly observed. Checking the prompt gated spectra, a strong coincidence between 123.5 and 96.5 keV lines was found, but no evidence exists for the coincidence between 153.5 and 169.5 keV lines. These results confirm the existence of two isomeric states; one is the $9/2^-$[514] bandhead depopulating by the 123.5−96.5 keV cascade, another is the $1/2^-$[541] bandhead deexciting by 153.5 and 169.5 keV γ radiations.

The time distributions have been carefully analyzed by setting separately several intraband transitions in the $9/2^-$[514] band as *START* and 123.5 keV line as *STOP*. The summed time spectrum is given in Fig. 2 from which the half-life was determined to be $T_{1/2}$=28±5 ns by using the centroid method; the error was estimated from the scatter of several individual measurements. The same

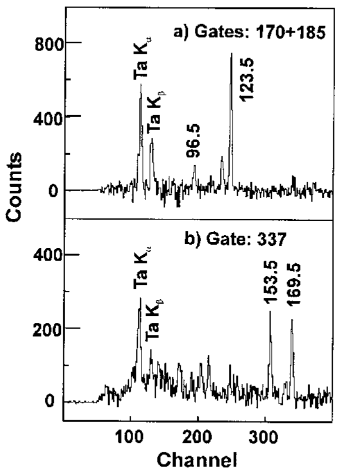

Fig. 1. Delayed coincidence spectra. **a** gated by the 170 and 185 keV $M1/E2$ transitions in the $9/2^-$[514] band; **b** gated by the 337 keV $E2$ transition in the $1/2^-$[541] band of ^{169}Ta

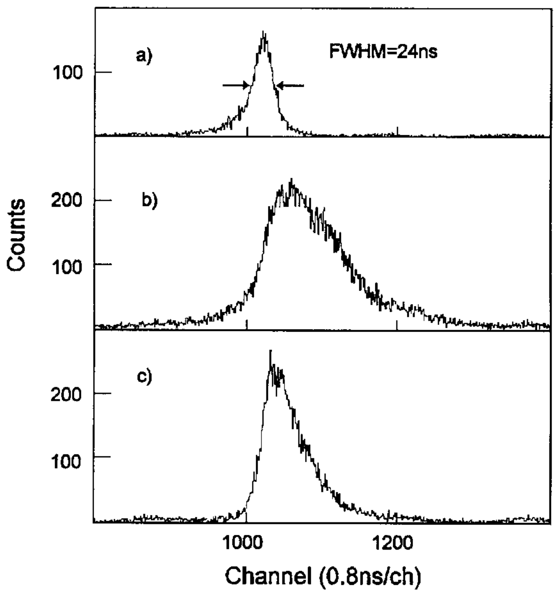

Fig. 2. Some time spectra: **a** "Start" and "Stop" by the 223 and 337 keV E2 transitions in the $1/2^-[541]$ band; **b** "Start" by the intraband transitions in the $9/2^-[514]$ band and "Stop" by the 123.5 keV line; **c** "Start" by the intraband E2 transitions in the $1/2^-[541]$ band and "Stop" by the 153.5, 169.5 keV lines of ^{169}Ta

analysis procedure was applied to the $1/2^-[541]$ bandhead, a half-life of $T_{1/2}$=17±4 ns was determined.

In the decay scheme proposed by Meissner et al., a level at $E_x = 220\ keV$ is found to feed to the $7/2^+[404]$ excited state, then to the $5/2^+[402]$ ground state of ^{169}Ta through 123.5 keV and 96.5 keV γ radiations sequentially. In our experiment the 123.5−96.5 keV prompt coincidence is also observed, furthermore these two γ-rays are clearly seen in the delayed coincidence spectrum (see Fig. 1a). Therefore it is concluded that the 220 keV level should be the intrinsic state with $9/2^-[514]$ configuration. This assignment is not in disagreement with the $E1$ multipolarity of 123.5 keV γ transition [1]. To further confirm this assignment, the hindrance factors $F_W(E1)$ have been calculated to be 2.33×10^5; this value is in the reasonable range ($10^5\sim10^6$) as those of the similar transitions in ^{173,175,177,179,181,183}Ta [3].

The 153.5 and 169.5 keV γ-rays were also observed in the β decay study of ^{169}W [1], but not placed in the decay scheme. In this work, the same half-life has been obtained from the time distributions when either the 153.5 keV line or the 169.5 keV line was used as $STOP$, indicating that the two γ-rays deexcite from the same level. The decoupling parameter a =0.43 for the $1/2^-[541]$ band has been extracted by using the first two transition energies and the equation (3.16) in reference [4]. This large decoupling parameter is consistent with the systematics for the same bands in the heavier odd-A Ta isotopes [4], most importantly it indicates that the $1/2^-$ level of this band lies a bit higher (8.5 keV higher as estimated from our calculation) than the $5/2^-$ level. Therefore, the isomeric state observed in our experiment is suggested to be the $5/2^-$ band member of $1/2^-[541]$ configuration. An additional support comes from the facts that the $5/2^-$ band member of $1/2^-[541]$ configuration have been assigned [1] to be the ground states in ^{171,173}Ta and the $1/2^-$ level lies really higher [4] than the $5/2^-$ state in ^{175,177}Ta. Referring to the results in references [1,2], the partial level scheme at low excitation energies is proposed in Fig. 3. The connnection of the $5/2^-$ isomer with gs is inconclusive probably due to undetected very low energy transitions.

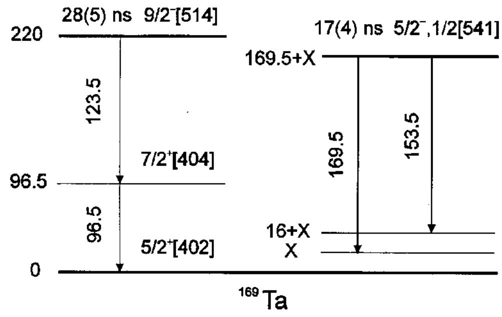

Fig. 3. Proposed partial level scheme of ^{169}Ta at low excitation energies

Finally it seems worthwhile to discuss the possible neutron configuration of the gs in ^{169}W. As discussed above, the level at E_x=220 keV is unambiguously determined to be the bandbead with $9/2^-[514]$ configuration. The three strongest γ-rays 123.5, 153.5 and 169.5 keV observed in the ^{169}W decay [1] have been assigned to the level scheme in this work as deexciting the two isomeric states (see Fig. 3). Thus it may be concluded that the $9/2^-$ state is strongly populated directly from the ^{169}W decay since the γ-rays feeding to this level are weak [1]. The strong populations to the $9/2^-$ state and the $1/2^-[541]$ band members ($5/2^-$ or $9/2^-$) should correspond normally to the allowed or at least the first forbidden β decay from the gs of ^{169}W. Among the most possible neutron configurations for the gs in ^{169}W: $5/2^-[523]$, $3/2^-[521]$ and $5/2^+[642]$, the first one could be excluded, as indicated in reference [1], by the non-observation of an allowed unhindered beta transition of ^{169}W. The second one $3/2^-[521]$ will result in a higher order forbiddeness for the beta decay to $9/2^-$ isomeric state in ^{169}Ta. Following the discussions about the ^{169}W β decay in reference [1], the best candidate for the gs of ^{169}W should be the $5/2^+[642]$ neutron configuration.

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References

1. F. Meissner et al., Z. Phys. **A337** (1990) 45
2. S.G. Li et al., Nucl. Phys. **A555** (1993) 435
3. S. Andre et al., Nucl. Phys. **A279** (1977) 347
4. A.K. Jain et al., Reviews of Modern Physics **Vol.62** (1990) 393