Revision of the K-Isomer in 190W


Published in:
Acta Physica Polonica. Series B: Elementary Particle Physics, Nuclear Physics, Statistical Physics, Theory of Relativity, Field Theory

2009

Link to publication

Citation for published version (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
REVISION OF THE K-ISOMER IN $^{190}$W$_{116}$

G.F. Farrell$^a$, Zs. Podolyá$^a$, S.J. Steer$^a$, S. Pietri$^a$, F.R. Xu$^c$
E. Werner-Malent$^{a,b}$, T. Shizuma$^{a,e}$, P.H. Regan$^a$, D. Rudolph$^d$
A.B. Garnsworthy$^a$, R. Hoischen$^b$, M. Górska$^b$, J. Gerl$^b$, H.J. Wollersheim$^b$
T. Kurtukian-Nieto$^b$, G. Benzoni$^b$, F. Becker$^b$, P. Bednarczyk$^b$
L. Cáceres$^{b,c}$, P. Doornenbal$^b$, H. Geissel$^b$, J. Grębo$^{b,c}$, A. Kelic$^b$
I. Kojouharov$^b$, N. Kurz$^b$, F. Montes$^b$, W. Prokopowicz$^b$, T. Saito$^b$
H. Schaffner$^b$, S. Tashenov$^b$, A. Hein$^b$, M. Pfëtzer$^b$, A. Jungclaus$^b$
D.L. Balabanski$^a$, C. Brandau$^a$, A.M. Bruce$^b$, W.N. Catford$^a$, I.J. Cullen$^a$
Zs. Dombrádi$^b$, E. Estevez$^m$, W. Gelletly$^a$, G. Ilie$^n$, J. Jolie$^o$, G.A. Jones$^a$
M. Kmicik$^a$, F.G. Kondev$^p$, R. Kröcken$^b$, S. Lalkovski$^b$, H.L. Liu$^c$, Z. Liu$^b$
A. Maj$^b$, S. Myalski$^o$, S. Schwertel$^o$, P.M. Walker$^a$, O. Wieland$^g$

$^a$Department of Physics, University of Surrey, Guildford GU2 7XH, UK
$^b$GSI, Planckstrasse 1, 64291 Darmstadt, Germany
$^c$Department of Technical Physics, Peking University, Beijing 100871, China
$^d$IEP, Warsaw University, Hoża 69, 00-681 Warsaw, Poland
$^e$Japan Atomic Energy Agency, 619-0215 Kyoto, Japan
$^f$Department of Physics, Lund University, 22100 Lund, Sweden
$^g$INFN, Università degli Studi di Milano, 20133 Milano, Italy
$^h$WNSL, Yale University, New Haven, CT 06520-8124, USA
$^i$Departamento de Física Teórica, UAM, 28049 Madrid, Spain
$^k$School of Environment and Technology, University of Brighton, Brighton, UK
$^l$Institute for Nuclear Research, ATOMKI, 4001 Debrecen, Hungary
$^m$Universidad de Santiago de Compostela, Santiago de Compostela, Spain
$^n$IKP, Universität zu Köln, 50937 Köln, Germany
$^o$H. Niewodniczański Institute of Nuclear Physics, Krakow, Poland
$^p$Nuclear Engineering Division, Argonne National Laboratory, Argonne, USA
$^q$Physik Department E12, Technische Universität München, Garching, Germany

(Received November 1, 2008)

Gamma rays from the decay of an isomer in $^{190}$W$_{116}$ have been observed following projectile fragmentation of a 1 GeV per nucleon $^{208}$Pb beam. An earlier experiment indicated decay from a (10$^-$) isomer to the ground state rotational band. Improved statistics have enabled gamma coincidence and time-difference measurements to be made which alter the previous interpretation. Blocked BCS calculations have also been used together with reduced hindrance factors to indicate possible values of spin-parity for the isomer.

PACS numbers: 25.70.Mn, 29.30.Kv, 23.35.+g, 23.20.Lv

* Presented at the Zakopane Conference on Nuclear Physics, September 1–7, 2008, Zakopane, Poland.
1. Introduction

The neutron-rich nucleus $^{190}$W is of some particular interest. Its experimental $E_{4+}/E_{2+}$ ratio departs from the tendency of the lighter W isotopes to change smoothly from rigid rotor (ratio $\sim 3.33$) to triaxially symmetric rotor (ratio $\sim 2.5$) as the atomic number increases [1]. In addition, isomeric states related to possible oblate-prolate shape change as well as K-isomerism have been predicted for this nuclide [2].

2. Experimental setup

Heavy nuclear species around $^{192}$W were populated in a relativistic projectile fragmentation reaction with a 2.5 g/cm$^2$ thick Be target bombarded by a 1 GeV/u $^{208}$Pb beam at GSI, Germany. The typical on-target beam intensity was $1 \times 10^9$ Pb ions per 10 s spill, with 10–30 s between spills. The nuclei of interest were separated and identified using the FRagment Separator (FRS), operated in the standard achromatic mode with a wedge-shaped degrader of total thickness of 5420 mg/cm$^2$ Al equivalent in the intermediate focal plane. The nuclei were then slowed down in a variable thickness Al degrader and finally stopped in a 9 mm thick perspex stopper. The $\gamma$ rays emitted by the stopped nuclei were detected by the high-efficiency RISING $\gamma$-ray spectrometer, consisting of 15 cluster Ge detectors of 7 crystals each, in a $4\pi$ arrangement, with a photopeak efficiency of 15% at 662 keV [3]. The delayed $\gamma$ rays were recorded, allowing clean identification of isomeric decays. The time difference was measured between fragment implantation in the stopper and a subsequent $\gamma$ ray, over a maximum range of 390 $\mu$s.

3. Experimental results

The FRS setting was optimised for maximum transmission of $^{192}$W. Around 20 000 fully stripped $^{190}$W ions were implanted in the passive stopper at a rate of approximately 8 per minute. The delayed $\gamma$-ray spectrum associated with $^{190}$W from the current work is presented in Fig. 1. The four gamma transitions of energies 206, 357, 483 and 693 keV, when corrected for detector efficiency and internal conversion, assuming an E2 character, have the same intensities within experimental error. All four $\gamma$ rays and the characteristic tungsten $K_\alpha$ X-ray are in mutual and prompt ($\Delta t < 300$ ns) coincidence, as shown in Fig. 2. An additional 591 keV transition, with an intensity close to the observation limit, was observed in a previous fragmentation experiment [1, 4] and more recently using deep-inelastic reactions at Gammasphere [5]. The present experiment indicates a maximum possible branching ratio of: $I(591 \text{ keV})/I(693 \text{ keV}) < 10\%$. The most likely reason for the absence of the 591 keV transition in the present experiment is the ex-
Revision of the K-Isomer in $^{190}W$

Fig. 1. (a) Delayed gamma-ray spectrum associated with $^{190}W$. (b) Decay curve for the sum of the gamma transitions with line of best fit for 100–380 $\mu$s.

Fig. 2. Prompt ($\Delta t < 300$ ns) coincidence spectra obtained by gating on individual transitions.

istence of more than one isomeric state in $^{190}W$. It is likely that the relative populations of these isomers depend on the reaction mechanisms employed. The decay curve in Fig. 1(b) indicates a rise during the first 100 $\mu$s; the half-life, 105(22) $\mu$s, has been obtained by considering the 100–380 $\mu$s time range only. The half-life is consistent with that obtained in the previous fragmentation experiment, but with improved precision. The systematics of this mass region suggest that the 206, 357 and 483 keV transitions form a quasi-rotational cascade. The 206 and 357 keV transitions have been recently observed in the $\beta$-decay of $^{190}Ta$ [6] with intensities which confirm
that the 357–206 sequence corresponds to the $4^+ \rightarrow 2^+ \rightarrow 0^+$ cascade. If the 693 keV transition is interpreted as originating from the direct decay out of the isomeric state, the isomer would have an energy of 1739 keV.

Blocked BCS calculations, without residual interaction [7], were performed using deformation parameters $\epsilon_2 = 0.145$ and $\epsilon_4 = 0.056$, and pairing strengths $G_{\pi} = 22.50/\text{A MeV}$ and $G_{\nu} = 21.50/\text{A MeV}$. The calculations indicate a number of possible candidates for the isomeric state, including states at $8^-$ and $8^+$ with configurations of $\pi 9/2[514] \otimes \pi 7/2[404]$ and $\nu 9/2[505] \otimes \nu 7/2[503]$ at energies of 2006 and 1812 keV respectively.

4. Summary and conclusions

In conclusion, we present an improved, high-statistics measurement of the isomeric decay of $^{190}\text{W}$ produced in projectile fragmentation. The data show no evidence for the previously reported 591 keV transition. The previous $(10^-)$ spin-parity assignment for this isomer [8] is now disregarded in the light of improved data.

REFERENCES