High-spin states in ^{190}Pt *

MA Long(马龙)[1] ZHOU Xiao-Hong(周小红)[1;1)] M.Oshima[2] Y. Toh[2] ZHANG Yu-Hu(张玉虎)[1]
GUO Ying-Xiang(郭应祥)[1] LEI Xiang-Guo(雷相国)[1] M. Koizumi[2] A. Osa[2] T. Hayakawa[2]
Y. Hatsukawa[2] T. Shizuma[2] M. Sugawara[3]

1 (Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China)
2 (Japan Atomic Energy Research Institute, Tokai, Ibaraki 319-1195, Japan)
3 (Chiba Institute of Technology, Narashino, Chiba 275-0023, Japan)

Abstract The level structure of ^{190}Pt has been studied experimentally using the ^{176}Yb (^{18}O, 4n) reaction at beam energies of 88 and 95 MeV. γ-γ-t coincidence measurements were carried out. Based on the analysis of γ-γ coincidence relationships, the level scheme of ^{190}Pt is extended to high-spin states. A new structure built on the 3413.6 keV 14^+ state has been observed, and the $\nu i_{13/2}^{-2}\ \nu h_{9/2}^{-1}\ \nu j$ ($j = p_{3/2}$ or $f_{5/2}$) configuration is tentatively assigned to it.

Key words γ-γ coincidence, γ-ray spectroscopy, DCO ratio

PACS 21.10.Re, 23.20.Lv, 27.80.+w

1 Introduction

The Pt, Au and Hg nuclei in the A≈190 region are moderately oblate deformed[1—5]. These nuclei show rotational bands built on different multi-quasiparticle excitations[6]. The excited $\nu i_{13/2}^{-2}$ band and the semi-decoupled band built on the 5^- state have been generally observed in this mass region. The intrinsic structure of the 5^- state in the even-even nuclei was proposed to be dominated by the configuration $\nu i_{13/2}\ \nu j$ (νj originating from $p_{3/2}$ or $f_{5/2}$)[7, 8]. Although these negative-parity bands in the Pt and Hg nuclei show marked similarities, there are still distinctive differences between the Pt and Hg nuclei. The differences can be well explained by the particle-rotor model[8] assuming an axially symmetric oblate core for the Hg nuclei but a triaxial one for the Pt nuclei. The level structure built on the $I^\pi=10^-$ isomer, which was interpreted to be the excitation of $\nu i_{13/2}^{-1}\ \nu h_{9/2}^{-1}$, was observed in ^{190,192}Pt[9, 10]. Previously, the high-spin level structure in ^{190}Pt was studied by the α-induced reactions[9, 10]. In the present work, the level scheme of ^{190}Pt has been revised and the high-lying level structure has been investigated.

2 Experimental and results

The excited states in ^{190}Pt were populated via the ^{176}Yb (^{18}O, 4n) reaction at bombarding energies of 95 and 88 MeV. The ^{18}O beam was provided by the tandem accelerator at the Japan Atomic Energy Agency (JAEA). The target was an isotopically enriched ^{176}Yb metallic foil of 2.1 mg/cm^2 thickness with a 7.6 mg/cm^2 Pb backing to avoid the Doppler shift of emitting γ rays. The in-beam γ rays were detected by the detector array[11] of JAEA, comprising 12 HPGe's with BGO anti-Compton shields. The detectors were calibrated with the ^{60}Co, ^{133}Ba and ^{152}Eu standard sources, and the typical energy resolution was about 2.0—2.4 keV for the 1332.5 keV line. A total of 2.4×10^8 events were accumulated, and about 1.0% of the coincidence events were found to belong to ^{190}Pt. After accurate gain matching, these coincidence events were sorted into a fully symmetric total matrix for off-line analysis. To obtain DCO (Directional Correlations of γ rays de-exciting the Oriented states) ratios, the detectors were divided into three groups positioned at 32° (148°), 58° (122°) and 90° with respect to the beam direction. A non-symmetrized matrix with detectors at θ_2=90°

Received 26 March 2007
* Supported by National Natural Science Foundation of China (10505025, 10475097) and Chinese Academy of Sciences
1) E-mail: zxh@impcas.ac.cn

against those at θ_1=32° (148°) was constructed. The DCO ratios were extracted from the measured γ ray intensities according to the prescription[12] $R_{\rm DCO}=\frac{I_{32^\circ}^{\gamma_1}(\text{gate}_{90^\circ}^{\gamma_2})}{I_{90^\circ}^{\gamma_1}(\text{gate}_{32^\circ}^{\gamma_2})}$, where $I_{32^\circ}^{\gamma_1}(\text{gate}_{90^\circ}^{\gamma_2})$ is the intensity of γ_1 at 32° in a spectrum gated by γ_2 detected at 90°, and $I_{90^\circ}^{\gamma_1}(\text{gate}_{32^\circ}^{\gamma_2})$ is the γ_1 intensity from a γ_2 gated projection on the 90° axis. If the gating transition has an E2 character, the measured DCO ratio is around $R_{\rm DCO}\approx 1.0$ for a stretched quadrupole transition and $R_{\rm DCO}\approx 0.6$ for a stretched dipole transition.

Assignments of the observed new γ rays to ^{190}Pt were based on the coincidences with the known γ rays[9, 10]. The level scheme of ^{190}Pt, proposed from the present work, is shown in Fig. 1. The construction of the level scheme was based on the comprehensive γ-γ coincidence relationships, the transition intensities, and the transition energy sums. The character of transition has been deduced from the measured DCO ratios. Typical coincidence spectra are shown in Fig. 2. The properties of the transitions newly observed in the present work are listed in Table 1. The level scheme shown in Fig. 1 is consistent with those given in Ref. [9] and [10]. The present work has significantly extended the level scheme of ^{190}Pt to high-spin states. Particularly, cascades above the 3413.6 keV 14$^+$ state were established. The cascade of 250.8, 386.8, 795.0, 732.5, 422.0, 417.0 and 173.0 keV transitions was observed to feed the 14$^+$ state directly. The parallel cascade of 141.3, 508.0, 795.0 and 890.3 keV transitions is in coincidence with the 250.8 keV transition. The 141.3 keV transition has a DCO ratio of 0.53, indicating it to be a pure dipole transition. The DCO ratios for the other transitions above the 14$^+$ state are consistent with $\Delta I=2$ character. Spins and parities are therefore assigned to the concerned levels. The 14$^+$ state was observed to decay to the semi-decoupled band via the 202.0 and 451.8 keV transitions. However, DCO ratios could not be extracted for these two γ rays.

Table 1. γ ray transition energies, γ intensities, multipolarity and DCO ratios in ^{190}Pt. The γ intensities are normalized to 100 for the 441.0 keV transition.

energy/keV$^{a)}$	placement/keV	intensity$^{b)}$	multipolarity	$R_{\rm DCO}$
441.0	736.3→295.3	100	E2	1.12(13)
250.8	3364.4→3413.6	28	E2	1.10(15)
386.8	4051.2→3664.4	21	E2	1.01(20)
795.0	4846.2→4051.2	12.5	E2	1.13(25)
732.5	5578.7→4846.2	4	E2	1.03(40)
422.0	6000.7→5578.7	2.3		
417.0	6417.7→6000.7	1.2		
173.0	6590.7→6417.7	1		
508.0	4313.7→3805.7	2.1		
795.0	5108.7→4313.7	1.7		
890.3	5999.0→5108.7	1.1		
451.8	3211.7→2759.9	4		
202.0	3413.6→3211.7	1.5		
743.0	4864.9→4121.9	1.2		
596.0	3664.4→3067.8			
507.1	4081.9→3574.8			
141.3	3805.7→3664.4	6	M1?	0.53(30)

a) Uncertainties between 0.1 and 0.5 keV. b) Uncertainties between 5% and 30%.

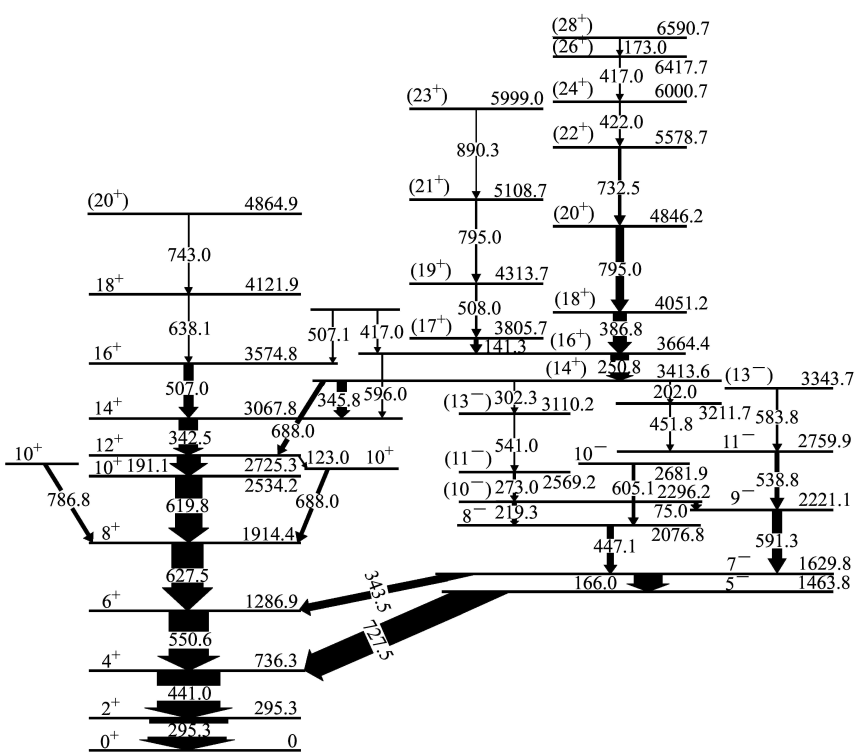

Fig. 1. Level scheme of ^{190}Pt proposed in the present work.

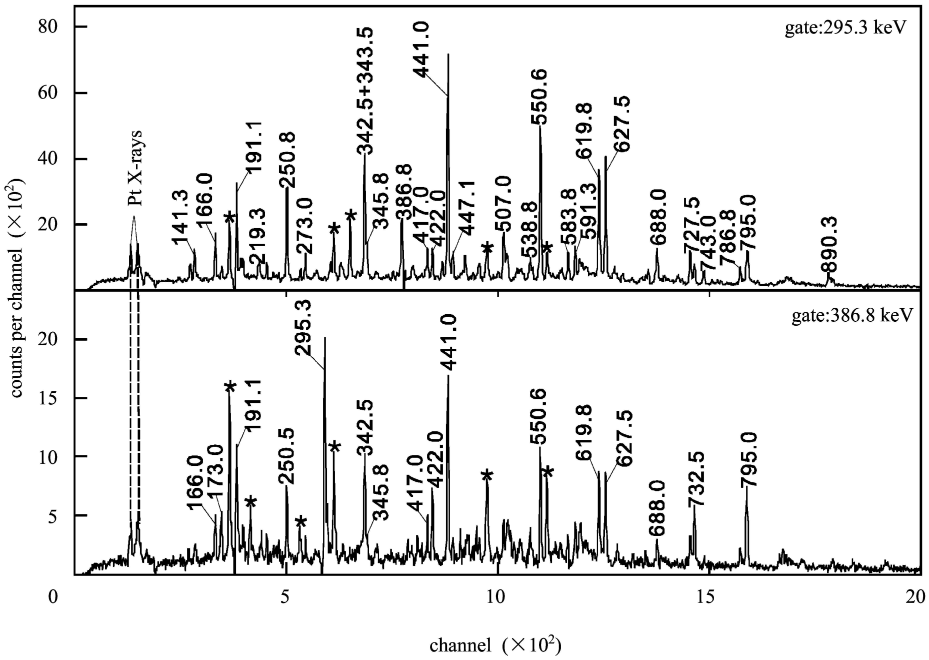

Fig. 2. Coincidence spectra gated on the 295.3 and 386.8 keV γ rays. The $*$ symbols indicate contaminations (mainly from ^{189}Pt).

3 Discussion

The low-lying level structure has been well explained[9, 10]. The decay pattern of the 3413.6 keV 14^+ state suggests that it has close relationships with the $\nu i_{13/2}$ and $\nu h_{9/2}$ configurations. Note that the excitation energy of the 14^+ state is close to the sum of the energy of the 5^- semi-decoupled band head and the excitation energy of the 10^- isomer. The intrinsic structure of the 5^- state was proposed to be dominated by the configuration $\nu i_{13/2}\nu j$ (νj originating from $p_{3/2}$ or $f_{5/2}$). The 10^- isomer[9, 10] at 2296.2 keV was formed by the excitation of $\nu i^{-1}_{13/2}\ \nu h^{-1}_{9/2}$. Therefore, it is reasonable to propose the $\nu i^{-2}_{13/2}\ \nu h^{-1}_{9/2}\ \nu j$ ($j=p_{3/2}$ or $f_{5/2}$) configuration to the 3413.6 keV 14^+ state. A similar structure with the configuration of $\pi h^{-1}_{11/2}\otimes\nu i^{-2}_{13/2}\ \nu h^{-1}_{9/2}\nu j$ was identified in ^{191}Au[13]. The branch built on the 3805.7 keV state may be the other signature of the $\nu i^{-2}_{13/2}\ \nu h^{-1}_{9/2}\nu j$ configuration.

In summary, the level scheme of ^{190}Pt was extended up to high spins using the ^{176}Yb (^{18}O, 4n) reaction. A new level structure built on the 14^+ (3413.6 keV) state was observed and the $\nu i^{-2}_{13/2}\ \nu h^{-1}_{9/2}\nu j$ configuration was tentatively proposed.

References

1 Bengtsson R, Bengtsson T, Dudek J et al. Phys. Lett., 1987, **B183**: 1

2 Nazareuicz W, Riley M A, Garett J D. Nucl. Phys., 1990, **A522**: 61

3 Hilberath Th, Becker St, Bollen G et al. Zur. Phys., 1992, **A342**: 1

4 Rikovska J, Wyss R, Semmes P B et al. Hyperfin. Interact., 1992, **75**: 59

5 Esser L, Nevneyer U, Casten R F et al. Phys. Rev., 1997, **C55**: 206

6 Firestone R B, Shirley V S. Table of Isotopes. 8th ed. Wiley, New York, 1996

7 Neergard K, Vogel P, Radomski R. Nucl. Phys., 1975, **A238**: 799

8 Toki H, Neergard K, Vogel P et al. Nucl. Phys., 1977, **A229**: 1

9 Cunnane J C, Piiparinen M, Daly P J et al. Phys. Rev., 1976, **C13**: 2197

10 Hjorth S A, Johnson A, Lindblad Th et al. Nucl. Phys., 1976, **A262**: 328

11 Furuno K, Oshima M, Komatsubara T et al. Nucl. Instrum. Methods, 1999, **A421**: 211

12 Kramer-Flecken A, Morek T, Lieder R M et al. Nucl. Instrum. Methods in Phys. Research, 1989, **A275**: 333

13 Gueorguieva E, Schuck C, Minkova A et al. Phys. Rev., 2003, **C68**: 054308