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HIGH SPIN STATES IN ^{191}OS*

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Abstract – High spin states in the neutron rich nucleus ^{191}Os has been populated for the first time using the ^{82}Se+^{192}Os deep-inelastic reaction at 460 MeV beam energy using the ALPI accelerators at the Laboratory Nazionali di Legnaro, Italy. High fold γ-γ coincidences were acquired with the 4π spectrometer GASP detector array, consisting of 40 Compton-suppressed, large-volume germanium detectors with an inner ball consisting of 80 BGO crystals acting as a multiplicity filter and a total-energy spectrometer. The new discovered level scheme is extended up to spin $19/2^+$. The observed structure is interpreted as fragments of a rotational band built on single neutron configuration {$11/2^+$ [615]} according to a Nilsson deformed shell model.

Keywords – Deep-inelastic Reaction, Rotational Band, High Spin States, Deformed Shell Model, Gamma-gamma Coincidences

1. INTRODUCTION

Fusion-evaporation reactions provide a standard mechanism to populate states with high angular momentum. However, by using stable beam-target combinations, beta-stable and neutron-rich nuclei cannot be studied. Neutron-rich nuclei with mass A<150 can be studied in spontaneous and induced fission. Projectile fragmentation has proven to be an efficient method of populating nuclei far from the valley of stability. However, in the case of heavy nuclei, this method is still limited to species with isomeric states, needed to enhance the sensitivity of the technique [1]. Deep-inelastic reactions are the most general reaction mechanism that can be used to study neutron-rich nuclei, and are able to populate relatively high-spin states.

The ^{82}Se+^{192}Os deep-inelastic reaction was used to study nuclei in the vicinity of the ^{192}Os target. The structure of nuclei in the A≈180-190 region is characterized by the presence of high-angular momentum intrinsic, i.e. non-collective states. Such states compete with the collective excitations because the proton and neutron Fermi levels are among orbitals with large angular-momentum projections (Ω) on the symmetry axis, allowing states with large values of $K=\Sigma\Omega$ to be formed [2]. Some new results about even mass Osmium nuclei that were obtained in this experiment were published before [3, 4]. As part of a systematic study of odd mass Osmium nuclei, some new results on the stable ^{191}Os nucleus are presented in this paper.

2. THE EXPERIMENT

Excited states in the vicinity of both the ^{82}Se beam and the ^{192}Os target nuclei have been populated using heavy-ion multi-nucleon transfer reactions and studied through gamma-ray spectroscopy in a "thick

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target" type [5] measurement. The combination of the Tandem-XTU and the super conducting LINAC ALPI accelerators at the Laboratory Nazionali di Legnaro, Italy, was used to accelerate a beam of ^{82}Se ions to energy of 460 MeV. The ^{192}Os target, isotopically enriched to 99.0%, had a thickness of 50 mg/cm^2 on a 0.2 mm Ta backing, which is sufficient to stop all reaction fragments. High fold γ-γ coincidences were acquired with the 4π spectrometer GASP [6] consisting of 40 Compton-suppressed, large-volume germanium detectors with an inner BGO ball consisting of 80 crystals which was acting as a multiplicity filter and a total-energy spectrometer.

Events were collected on tape during five days of beam time under the condition that a minimum of three Compton-suppressed Ge detectors and two BGO elements from the multiplicity filter fired in coincidence. With a beam current of 1 particle-nA, the event rate was ≈ 4 kHz and the singles rate in the germanium detectors ≈ 12 kHz. With such a setup γ-rays from the de-exciting target-like and projectile-like fragments were detected. After gain matching for all the detectors, the coincidence data were sorted into fully symmetrized matrices and cubes for off-line analysis. Since all recoiling fragments were stopped in the target, Doppler broadening prevented the observation of transitions de-exciting short-lived states and only the γ-decay with lifetimes longer than the slowing-down time of the recoiling nuclei (≈ 1ps) could be studied. Thus, no Doppler correction was necessary when sorting the data.

3. RESULTS

Two and three-dimensional gamma-matrices were used to construct the level scheme of ^{191}Os. Typical coincidence spectra are shown in Figs. 1-3 which is gated on 177 keV, 284 keV and 302 keV lines respectively. Comparing these Figures it is evident that 358 and 369 keV lines in Fig. 1 and 205 and 654 keV lines in Fig. 2 are contamination gamma rays that come from other nuclei. Partial level scheme of ^{191}Os up to spin $19/2^+$ is presented in Fig. 4 for the first time. The properties of the gamma ray transitions belonging to ^{191}Os are summarized in Table 1.

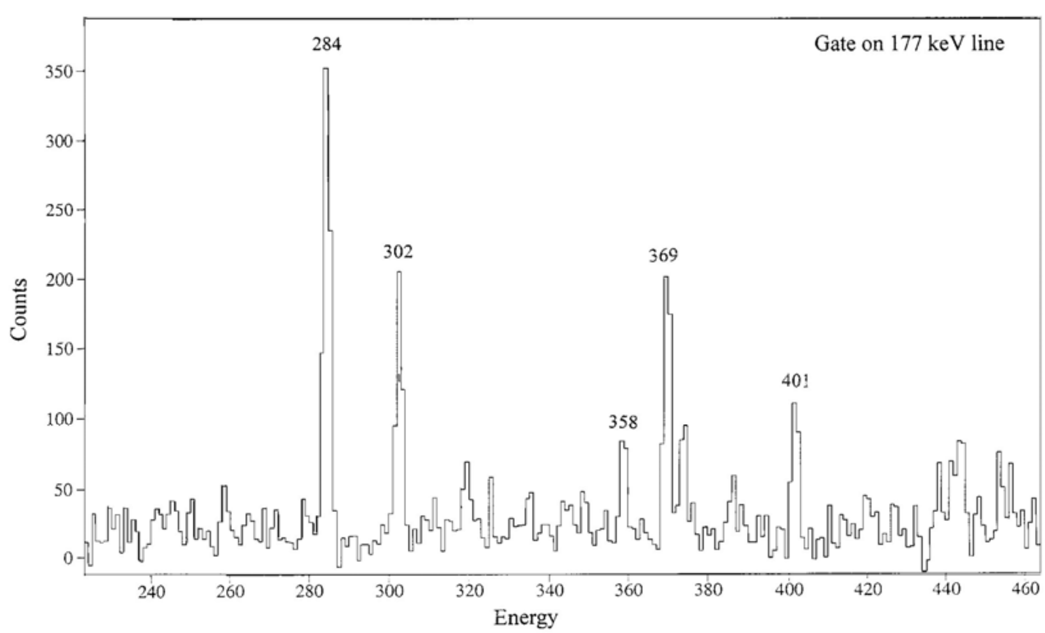

Fig. 1. Gamma-gamma coincidences in ^{191}Os gated on 177 keV line

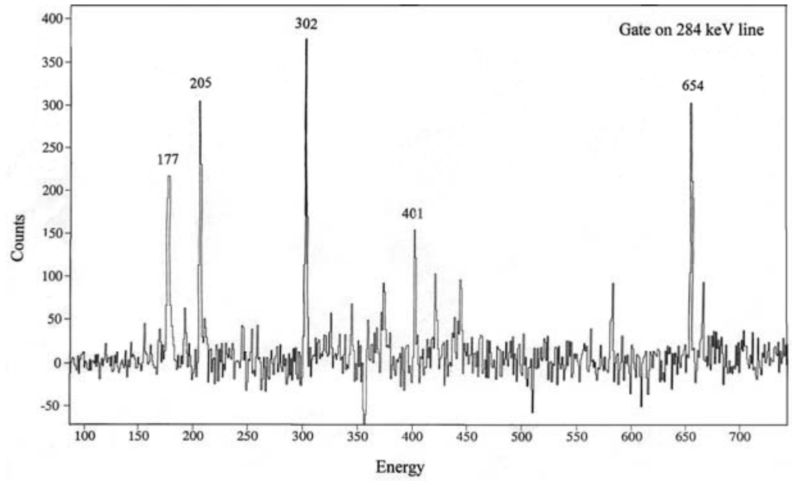

Fig. 2. Gamma-gamma coincidences in ^{191}Os gated on 284 keV line

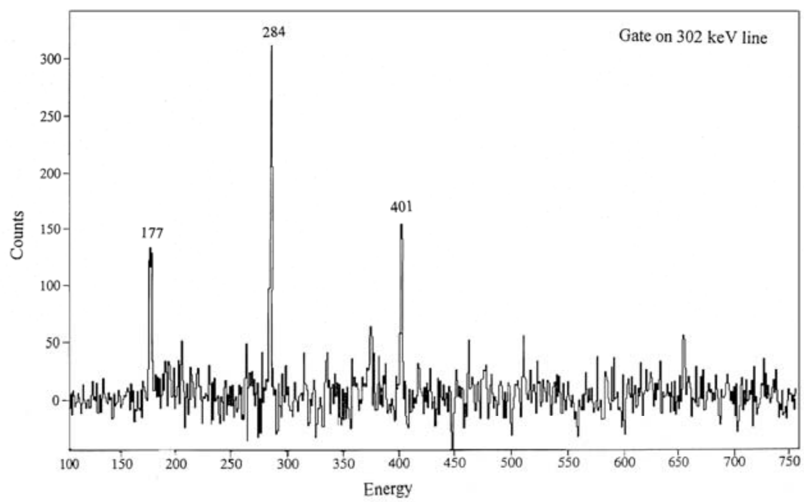

Fig. 3. Gamma-gamma coincidences in ^{191}Os gated on 302 keV line

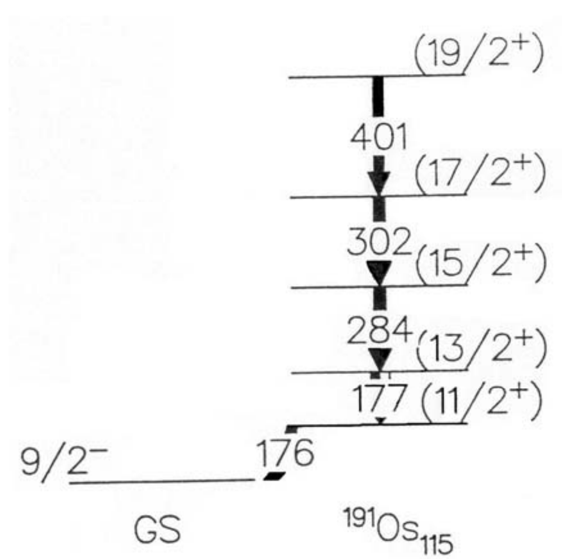

Fig. 4. Partial level scheme for $11/2^+$ band in ^{191}Os

Table 1. γ-ray transition energies, relative intensities and level assignments in ^{191}Os

E_γ (keV)	$I_\gamma^{(a)}$ (rel.)	$I_i^{\pi\,(b)}$	$I_f^{\pi\,(b)}$
177	-	$13/2^+$	$11/2^+$
284	100(13)	$15/2^+$	13/2
302	53(9)	$17/2^+$	$15/2^+$
401	29(4)	$19/2^+$	$17/2^+$

(a) Gated on 177 keV line.

(b) The spin-parity values are tentative. They are based on comparison with the lighter odd Osmium isotopes.

Figure 5 shows a systematic comparison between a ^{191}Os new rotational band and similar rotational bands in lighter isotopes. ^{185}Os and ^{187}Os were studied by Sodan, et al [7]. Due to low statistics, we could not confirm any side level crossing in ^{191}Os, while in ^{185}Os and ^{187}Os nuclei, the rotational bands {$11/2^+$ [615]}, are built by single neutrons at energy levels 276 and 257 keV, respectively. Relative to ground state bands {$1/2^-$ [510]} [7], in ^{191}Os the rotational band {$11/2^+$ [615]} is built at lower energy level 176 keV relative to a ground state band {$9/2^-$[505]}, which shows a higher quadruple deformation parameter ε_2 , according to a Nilsson deformed shell model [8]. New experimental results (for example on angular distributions) and theoretical considerations might provide a more complete interpretation.

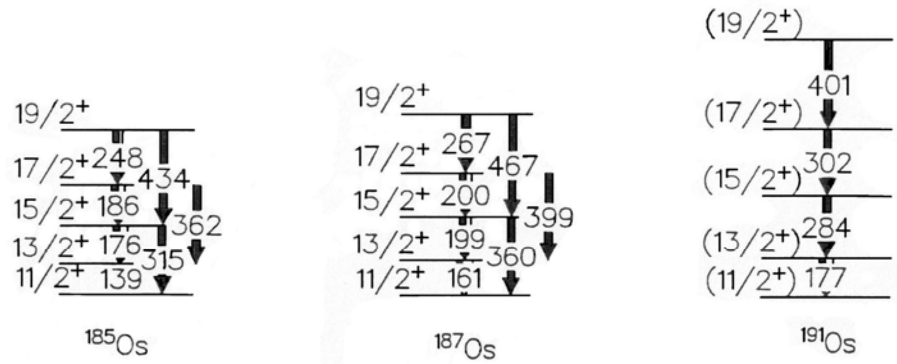

Fig. 5. Systematic comparison between 11/2+ rotational bands in $^{185\text{-}187\text{-}191}$Os (Z=76) nuclei

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