Hf および W 同位体中の低エネルギー準位のパリティ
Parities of low-energy states in Hf and W isotopes

*Mohamed OMER[1], Toshiyuki SHIZUMA[2], Ryoichi HAJIMA[1,2] and Mitsuo KOIZUMI[2]
[1]JAEA, [2]QST

Abstract

Nuclear resonance fluorescence (NRF) experiments have been performed on Hf and W natural targets in the 2.5-3.1 MeV energy range using quasi-monochromatic γ-ray beams generated from laser Compton scattering at the HIγS facility, Duke University. The complete polarization of the incident γ-rays has provided the determination of parity of states in this energy range. Results of these experiments have revealed parity of about 15 levels in Hf and W nuclei. Such data provide knowledge about the nondestructive detection system of nuclear material by understanding the scissors mode encountered in deformed nuclei including uranium and plutonium isotopes.

Keywords: Parity, Hf, W, Nuclear resonance fluorescence target.

1. Introduction

We proposed the nuclear resonance fluorescence (NRF) as a nondestructive assay technique for nuclear materials [1]. Nuclei of nuclear materials are typical deformed nuclei which exhibit the so-called scissors mode, a collective mode of excitations involving M1 transitions around 2~3 MeV. To improve our understanding of such mode, we measured parity of transitions in deformed nuclei of Hf and W using linearly polarized γ-ray beams generated from laser Compton scattering. Parity was directly determined by detecting de-excitation photons in the direction of the initial polarization vector (M1 transitions) and perpendicular to the initial polarization vector (E1 transitions).

2. Experimental

A tungsten target of 2.5 cm in diameter and 0.4 cm in thickness was irradiated by a quasi-monochromatic linearly polarized γ-ray beam of central energies of 3.12, 3.00, 2.89, and 2.50 MeV for an average time of 5 hours per each energy at the HIγS facility, Durham, NC, USA. The polarization plane of the incident beam was horizontal. In addition, a hafnium target of thickness 0.4 cm and square cross-sectional area of 2.5×2.5 cm^2 was irradiated by the above mentioned γ-ray beam at energies of 2.60 and 2.89 MeV. De-excitation photons emitted vertically and horizontally were detected by 4 high-purity Ge detectors.

3. Results・Conclusion

Fig. 1 shows an example of the measured NRF spectra at an incident beam energy of 3.12 MeV. De-excitations from tungsten isotopes are clearly visible in the spectra. Within the beam width, two M1 transitions are observed in ^{182}W and ^{184}W. On the other hand, an M1 transition and two E1 transitions are observed in ^{186}W. The unmarked peaks are unresolved and need further investigation using enriched targets.

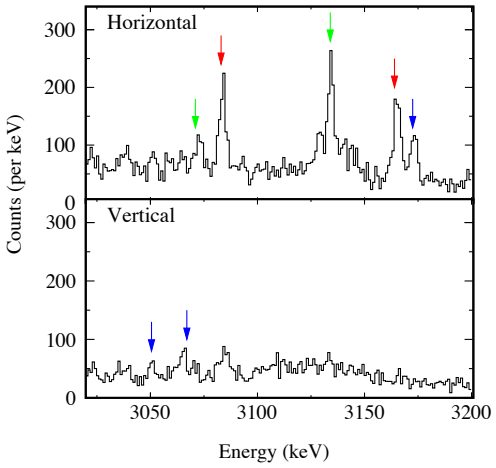

Fig. 1: NRF spectra measured by the horizontal and vertical detectors. The energy of the beam is 3.12 MeV. Arrows in red, blue, and green indicate de-excitations from ^{182}W, ^{184}W, and ^{186}W, respectively. Since the polarization of the incident photons was horizontal, states measured in the horizontal plane are M1 states while those measured vertically are E1 states.

References

[1] R. Hajima *et al.*, *J. Nucl. Sci. Technol.*, vol. 45 (5), pp. 442-451, 2008.