Enhanced photoneutron cross sections for zirconium isotopes near threshold: evidence for an M1 strength? *

H. Utsunomiya[1], S. Goriely[2], A. Makinaga[1], S. Goko[1], T. Kaihori[1], T. Yamagata[1], H. Akimune[1], H. Toyokawa[3], T. Matsumoto[3], H. Harano[3], Y.-W. Lui[4]
[1] Department of Physics, Konan University, Japan
[2] Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelle, Belgium
[3] National Institute of Advanced Industrial Science and Technology, Japan
[4] Cyclotron Institute, Texas A & M University, USA

A systematic measurement of photoneutron cross sections was carried out for zirconium isotopes (A = 90, 91, 92, and 94) near neutron threshold with quasi-monochromatic γ rays produced from laser Compton backscattering at AIST. When compared with the threshold behavior of the E1 response, which is described by $\sigma(E_\gamma) = \sigma_0[(E_\gamma - S_n)/S_n]^{\ell+1/2}$ [1] with the neutron separation energy S_n and the orbital angular momentum of neutrons ℓ, the cross sections for ^{92,94}Zr exhibit large enhancements, whereas the cross sections for ^{90,91}Zr are rather consistent with the E1 response or much less enhanced. Note that the selection rule for neutron spin and parity allows only $\ell = 1$ for ^{91,92,94}Zr and $\ell = 0$ for ^{90}Zr.

The enhancement observed for ^{92,94}Zr amounts to about 1% of the entire cross section of GDR. The enhancement may be interpreted as (1) an extra E1 γ strength, (2) a spin-flip M1 strength, and (3) other Eλ or Mλ strength with $\lambda \geq 2$. It is noted that M1 resonance was previously reported in proton inelastic scattering for zirconium isotopes (A=90, 92, 94, and 96) in the 8 - 10 MeV region [2]. This may be attributed to a spin-flip transition from $1g_{9/2}$ to $1g_{7/2}$ over the N=50 shell gap with configuration mixing with 2p2h states [3]. The present enhancement found for ^{92,94}Zr may correspond to this type of M1 resonance. We remark that M1 resonance for ^{90}Zr reported in the proton inelastic scattering was unobservable in the present photoneutron cross-section measurement simply because it lies below the neutron threshold.

QRPA calculations are underway to study the collective nature of the enhancement observed for ^{92,94}Zr. So far we have found no extra E1 strength. We are currently exploring the second possibility, a spin-flip M1 strength. We discuss the origin of the enhancement.

* This work is supported by the Japan Private School Promotion Foundation.
[1] E.P. Wigner, Phys. Rev. **73** (1948) 1002.
[2] G.M. Crawley *et al.*, Phys. Rev. **C26** (1982) 87.
[3] M. Yabe, F. Osterfeld and D. Cha, Phys. Lett. **178B** (1986) 5.