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Measurement of prompt γ-rays from the neutron capture reaction of Pd isotopes in the eV energy range

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In the compound process of neutron-induced nuclear reactions, the parity symmetry (P-violation) is violated due to the effect of the weak interaction. It has been experimentally found that the helicity dependence of the reaction cross section due to the P-violating nucleon-nucleon interaction is enhanced by up to six orders of magnitude compared to the bare effect observed in few-nucleon reactions[1]. This amplification effect has been explained by using a statistical model based on the Random Matrix Theory. In this model, transition matrix element is expected to be inversely proportional to the square-root of the level density N. The accuracy of the existing experimental data of W, however, are not sufficient to verify the model, and thus more accurate data are demanded. W is related to the asymmety A_{L} of the helicity-dependent reaction cross section as the following equation;

$$A_L \approx -\frac{2xW}{E_{\mathrm{p}}-E_{\mathrm{s}}}\sqrt{\frac{\Gamma^{\mathrm{n}}_{\mathrm{s}}}{\Gamma^{\mathrm{n}}_{\mathrm{p}}}} \qquad \left(x \equiv \sqrt{\frac{\Gamma^{\mathrm{n}}_{\mathrm{p,j=1/2}}}{\Gamma^{\mathrm{n}}_{\mathrm{p}}}}\right), \qquad (1)$$

where E_{s} and E_{p} are the resonance energies of the s-wave and the p-wave resonances, respectively. $\Gamma^{\mathrm{n}}_{\mathrm{s}}$ and $\Gamma^{\mathrm{n}}_{\mathrm{p}}$ are the corresponding neutron widths, respectively. x is the ratio of the partial p-wave neutron width to the total neutron width, it can be determined by measuring the angular dependence of the emitted γ-rays of the (n,γ) reaction [2]. Therefore, by measuring A_{L} and x, one can determine W experimentally from Eq. (1).

In this study, we focus on Pd isotopes which have relatively small values of N, and consequently N dependences of W are rather significant. To obtain x, the angular distributions of the prompt γ-rays from the p-wave resonance of the Pd isotopes were measured at the J-PARC MLF BL04 in February 2021. As a preliminary result, the following values of x were obtained for ^{108}Pd;

$$x = 0.9986^{+0.0003}_{-0.0099} \qquad \text{or} \qquad x = -0.9986^{+0.0099}_{-0.0003}. \qquad (2)$$

In this contribution, the experimental procedure and the result will be presented.

[1] G. E. Mitchell et al., Phys. Rep. 354, 157 (2001).

[2] V. V. Flambaum et al., Nucl. Phys. A 435, 352 (1985).

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