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Neutron production in the interaction of 200-MeV deuterons with Li, Be, C, Al, Cu, Nb, In, Ta, and Au

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Intensive fast neutron sources using deuteron accelerators have been proposed for the study of medical RI production, radiation damage for fusion reactor materials, nuclear transmutation of radioactive waste, and so on. Neutron production data from various materials bombarded by deuterons are required for the design of such neutron sources. However, the experimental data, e.g. double-differential neutron production cross sections (DDXs), are not sufficient. In the present work, therefore, we have conducted a systematic measurement of DDXs for a wide atomic number range of targets (Li, Be, C, Al, Cu, Nb, In, Ta, and Au) at an incident energy of 200 MeV in the Research Center for Nuclear Physics (RCNP), Osaka University.

The experiment was carried out at the N0 course in RCNP. A deuteron beam accelerated to 200 MeV was transported to the neutron experimental hall and focused on a thin target foil placed in the beam swinger magnet. Emitted neutrons from the target were detected by two different-size EJ301 liquid organic scintillators (2" in dia. x 2" thick and 5" in dia. x 5" thick) located at two distances of 7 m and 20 m, respectively. The neutron DDXs were measured at six forward angles (0°, 5°, 10°, 15°, 20°, and 25°) by moving the target along the beam trajectory in the swinger magnet. The two-gate integration method was adopted to eliminate gamma-ray background. The neutron energy was determined by a conventional time-of-flight (TOF) method.

Each measured neutron spectrum showed a characteristic broad peak around half the incident deuteron energy, which is formed via the breakup of incident deuterons. The peak yield was found to increase monotonically with an increase in target mass number. The measured DDXs were compared with theoretical model calculations by the DEUteron-induced Reaction Analysis Code System (DEURACS) [1,2] and PHITS [3]. The result indicated that the DEURACS calculation provides better agreement with the measured DDXs than the PHITS calculation. In addition, two deuteron nuclear libraries, JENDL Deuteron Reaction Data File 2020 (JENDL/DEU-2020) [4] and TENDL-2017 [5], were benchmarked using the experimental DDX data of Li, Be, and C.

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