OMEGA Nuclear Science Experiments: An experiment to measure the neutron-induced deuterium breakup cross section has been developed on the OMEGA laser. This platform could prove to be a valuable tool for complementing accelerator-based experiments since experimental data are scarce and incomplete; for example, we can measure the energy spectra of neutrons from D(n,2n)p breakup occurring in a thermonuclear inertial confinement fusion (ICF) environment. By comparing theoretical predictions to breakup data, the present day models of two-nucleon interactions can be tested. In addition, the effects of a three-nucleon force calculations based on realistic nucleon–nucleon interactions can be studied.[1,2]

Subnanosecond impulses of 10^{13} to 10^{14} 14-MeV neutrons, produced by direct-drive laser ICF implosions, were used to irradiate deuterated samples on the OMEGA laser.[3] The implosion targets used for this experiment were 1100-μm-diam, 4-μm-thick SiO_2 shells filled with an equimolar concentration of deuterium–tritium. Neutron yields of up to 1×10^{14} are produced with 30-kJ, 1-ns-square laser pulses. High-resolution neutron time-of-flight (nTOF) spectroscopy is used to study the deuterium breakup reaction signal from a nuclear reaction vessel filled with either a deuterated or non-deuterated sample located close to the implosion target (Fig. 1). A highly collimated nTOF detector is used to record the signal from the interaction of the DT neutrons with the reaction vessels. Modeling the experimental setup using a neutron transport code (MCNP)[4] indicated that a measurable signal from the breakup process would be present in the nTOF detector. The advanced nTOF detector fielded on OMEGA has a very large dynamic range (10^6) so that the primary DT fusion yield does not overwhelm the much smaller spectral features at lower energies.

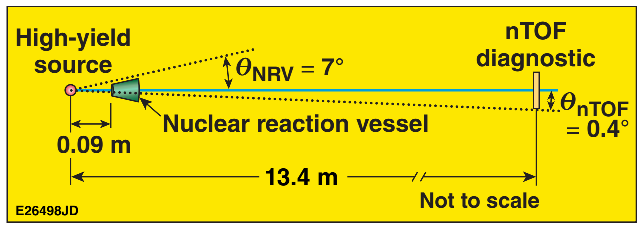

Figure 1. Schematic of a nuclear science experiment on the OMEGA laser.

The energy spectrum of the deuterium breakup reaction from 0.5 MeV to 10.5 MeV averaged over an angular region from $\theta_{lab} = 3.5° \pm 3.5°$ was measured on OMEGA.[5] Figure 2 shows that the cross sections inferred on OMEGA are in better agreement with recent theoretical cross sections[6,7] than the earlier experimental measurements[8,9] from accelerator-based platforms. These measurements demonstrate that high-energy-density plasmas can be used to measure fundamental nuclear reactions and properties with the appropriate diagnostics. Additional reaction vessels that contain other light-*Z* elements (^{7}Li and ^{9}Be) to measure the (n,2n) reactions have recently been fielded.

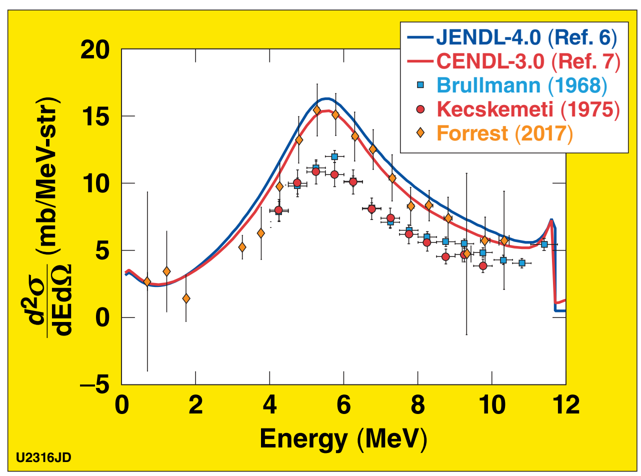

Figure 2. Comparison between published theoretical cross sections (JENDL, CENDL) and experimental measurements of the deuteron breakup. The most-recent experimental measurement (Forrest 2017) was obtained using the OMEGA laser.

Omega Facility Operations Summary: The Omega Facility conducted 212 target shots in November 2017, with an average experimental effectiveness of 95.0%. The OMEGA and OMEGA EP lasers conducted 123 and 89 of these shots, with an experimental effectiveness of 93.9% and 96.6%, respectively. The ICF program accounted for 109 target shots for experiments led by LLNL and LLE, while the HED program had 45 shots for experiments led by LANL, LLNL, and LLE. Eight shots were taken for an ARPA-E funded experiment; 38 shots were taken for NLUF experiments led by the University of Michigan, MIT, and Princeton University; and one LLNL LBS experiment accounted for 12 shots.

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