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Short-Pulse Laser-Driven Moderated Neutron Source

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Los Alamos National Laboratory (LANL) and collaborators have pioneered a novel short duration yet extremely intense neutron source using the short-pulse laser at LANL's Trident laser facility [1-5]. The Trident laser facility was until it's closure in 2016 one of the most intense and powerful short-pulse lasers in the world, providing a very high contrast laser pulse of ~600 fs in duration, ~80 J energy with a wavelength of 1053 nm. The laser beam can be concentrated to a peak intensity up to 1021 W/cm2, that, when interacting with a sub-micron ultrathin CD (or CD2) foil target, drives a high-energy deuteron beam. That intense beam converts into a neutron flux in a beryllium target that acts as catcher of deuterons and converter of deuterons to neutrons. The Trident laser-driven neutron source featured high intensity and directionality, ~1010 fast neutrons per shot in a ~1 sr cone and with an extremely short neutron pulse of <1 ns in time. The source has been already used effectively towards the development of a new generation of active interrogation concepts to detect clandestine nuclear material [6]. In order to enable other applications, such as nuclear resonance spectroscopy for isotopic identification of (irradiated) nuclear fuel [7], temperature measurement in shock–driven dynamic material experiments [8], and pulsed neutron diffraction and scattering, we have developed a bright moderated short-pulse laser-driven neutron source. Beryllium and high density polyethylene were used to realize this aim. The single pulse moderated neutron source was fully characterized in its energy spectral components by a set of neutron time-of-flight detectors, including the fast neutron component (~1 MeV--~50 MeV) coming from the neutron production, as well as the epithermal, thermal, and cold (few meV) components subsequent to the moderation of the neutrons. The presentation reports and discusses the measured features of the moderated single-pulse neutron source that we have just demonstrated and preliminary results in the detection of nuclear resonances with a view towards spectroscopy.

Moreover, the presentation compares the laser-driven short pulse neutron source with the spallation neutron source at the LANSCE facility, and the prospects of such novel laser-driven compact neutron sources based on available or proposed laser systems for medium and large scale neutron user facilities. The precedence of high-powered lasers in rugged environments for military or industrial (e.g. welding) applications may even provide a pathway to mobile compact short-pulse neutron sources.

References

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