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## Fusion plasmas and neutron production from the interaction of D2 and CD4 clusters with contrast upgraded Texas Petawatt laser

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Nuclear fusion from the interaction of very high intensity laser pulses and nm-scale deuterium clusters has been studied since 1999 [1]. These van der Waals bonded clusters can be easily produced in the expansion of a gas jet into vacuum. They absorb the laser pulse energy very efficiently (approaching 100% under certain conditions) and the process by which the ions attain high kinetic energies has been well explained by the Coulomb explosion model. Using these energetic exploding clusters, it is possible to create fusion plasmas with ion temperatures of many keV at densities of up to  $10^{19} \text{ cm}^{-3}$ . DD fusion events occur between ions or when energetic ions collide with cold atoms in the background gas jet. As a result of both of these fusion reactions, quasi-monoenergetic 2.45 MeV neutrons are produced from the localized fusion plasma in a sub-nanosecond burst becoming an attractive bright, short, and localized neutron source potentially useful for material damage. These plasmas have been exploited to measure the astrophysical S factor for the  $3\text{He}(d,p)^4\text{He}$  fusion reaction at temperatures of few keV by irradiating a D2-3He mixture [2].

In this talk, I will review several experiments performed using the Texas Petawatt laser to measure astrophysical S-factors [3] and to optimize the neutron yield using D2 and CD4 clusters where  $2 \cdot 10^7 \text{ n/shot}$  were achieved [4]. Previous experiments showed a drop in the ion temperature with high laser intensities suggesting laser pre-pulses could be breaking the clusters before arrival of the main pulse [5]. In 2015, the Texas Petawatt laser underwent a major upgrade to its pulse contrast to reduce the intensity of pre-pulses [6]. I will present our recent results in neutron yield with the contrast upgraded Texas Petawatt laser and discuss measurements of the ion range in cluster media that we found differs considerably from that of homogeneous gases [7].

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