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Generation and Characterization of States of Matter at Solar Core Conditions[1]

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The equation-of-state (EOS) of matter at solar core conditions is important to stellar evolution models and understanding the origin of high Z elements. Temperatures, densities and pressures of stellar cores are, however, orders of magnitude greater than those obtained in state-of-the-art laboratory EOS experiments [1] and therefore such conditions have been limited to observational astronomy and theoretical models. Here we present a method to generate and diagnose these conditions in the laboratory, which is the first step towards characterizing the EOS of such extreme states of matter. By launching a converging shock wave into a deuterated plastic sphere (CD_2) we produce solar core conditions ($R/R_{Sun} < 0.2$) which are initiated when the shock reaches the center of the CD_2 sphere and extends during transit of the reflected wave until the temperature drops to a level where the neutron production and x-ray self emission drop below threshold levels of the detectors. These conditions are diagnosed by both, the neutron spectral data from D-D nuclear reactions, and temporal, spatial [2,3], and spectral [4] x-ray emission data. We will discuss how these observables can be measured and used to help our understanding of dense plasma states that reach well into the thermonuclear regime of stellar cores.

[1] R. F. Smith *et al.*, Ramp compression of diamond to five terapascals, Nature 511, 330-333 (2014)
[2] B. Bachmann *et al.*, Using penumbral imaging to measure micrometer size plasma hot spots in Gbar equation of state experiments, Rev. Sci. Instrum. 85, 11D606 (2014)
[3] B. Bachmann *et al.*, Resolving hot spot microstructure using x-ray penumbral imaging (invited), Rev. Sci. Instrum. 87, accepted for publication (2016)
[4] B. Bachmann *et al.*, High-speed three-dimensional plasma temperature determination of axially symmetric free-burning arcs, J. Phys. D: Appl. Phys. 46, 125203 (2013)

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