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ION-BEAM-DRIVEN WARM DENSE MATTER EXPERIMENTS*

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As a technique for heating volumetric samples of matter to high energy density, intense beams of heavy ions are capable of delivering precise and uniform beam energy deposition dE/dx , in a relatively large sample size, and with the ability to heat any solid-phase target material. The US heavy ion fusion science program has developed techniques for heating and diagnosing warm dense matter (WDM) targets. The WDM conditions are achieved by combined longitudinal and transverse space-charge neutralized drift compression of the ion beam to provide a hot spot on the target with a beam spot size of about 1 mm, and compressed pulse length about 2 ns. Initial experiments use a 0.3 MeV, 30-mA K^+ beam (below the Bragg peak) from the NDCX-I accelerator to heat foil targets such as Au, Al and Si. The NDCX-I beam contains an uncompressed pulse up to $>10 \mu s$ of fluence $\geq 200 \text{ kW/cm}^2$, and a compressed pulse of fluence $\sim 10 \text{ mJ/cm}^2$. This beam heats 150-nm Au targets to above 3000 K.

Future plans include target experiments using the NDCX-II accelerator, which is designed to heat targets at the Bragg peak using a 3-4 MeV lithium ion beam. The range of the beams in solid matter targets is about 1 micron, which can be lengthened by using porous targets at reduced density.

We have developed a WDM target chamber and a suite of target diagnostics including a fast multi-channel optical pyrometer, optical streak camera, VISAR, and high-speed gated cameras. The optical target emission spectrum is measured by a high dynamic range Hamamatsu streak camera coupled with a spectrometer. Initial WDM experiments heat targets by both the compressed and uncompressed parts of the NDCX-I beam, and explore measurement of temperature, droplet formation and other target parameters. Continued improvements in beam tuning, bunch compression, and other upgrades are expected to yield higher temperature and pressure in the WDM targets. Future experiments are planned in areas such as dense electronegative targets, porous target homogenization and two-phase equation of state.

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