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Rapid and uniform heating of matter using laser-accelerated ion beams

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Abstract

We have used a beam of laser-accelerated ions [1] to heat solid density targets uniformly and rapidly above 10,000 K [2]. Although matter at such an extreme state, known as warm dense matter, is commonly found in astrophysics (e.g., in planetary cores) as well as in high energy density physics experiments, its properties are difficult to predict theoretically and are not well known. A sufficiently large warm dense plasma sample that is uniformly heated would be ideal for these studies, but has been unavailable to date. We present a theoretical study regarding the heating uniformity of the heated sample using an energetic ion beam with a finite energy spread.

We visualized directly the expanding warm dense gold and diamond with an optical streak camera [3]. We developed a new technique to determine the initial temperature of these heated samples from the measured expansion speeds of gold and diamond into vacuum [4]. Figure 1 shows the schematic layout of the experimental setup. The expanding warm dense gold and diamond plasmas are observed using an optical streak camera [3]. We show that we can determine the initial temperature of these heated samples from the measured expansion speeds of gold and diamond into vacuum [4].

We anticipate the uniformly heated solid density target will allow for direct quantitative measurements of equation-of-state, conductivity, opacity, and stopping power of warm dense matter, benefiting plasma physics, astrophysics, and nuclear physics [5]. This presentation was supported by NRF-2018R1C1B6001580.

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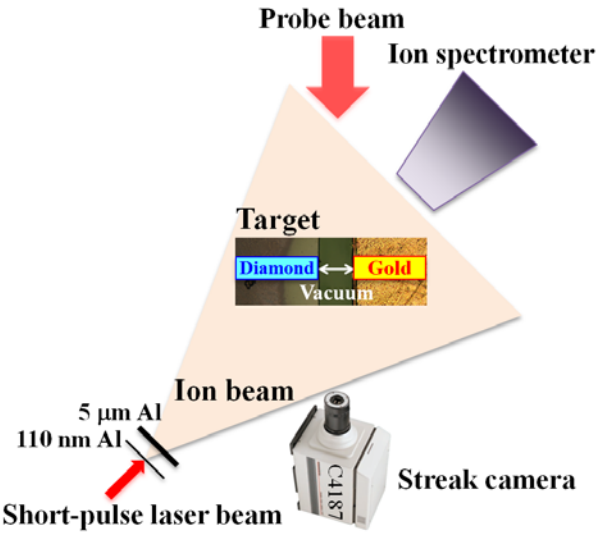

Figure 1. Schematic layout of the experimental setup (not to scale).