Dynamic ultrafast X-ray imaging of shocks in water

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laser wakefield acceleration (LWFA) has emerged as a table-top source of ultrafast [1], bright, and spatially-coherent X-ray pulses with a small source size [2, 3] that allows for high spatial resolution imaging [4]. This has been demonstrated in recent work imaging bubbles, capsules, and insects [5, 6], 3D reconstruction of bone structure [7], and imaging of laser-driven shocks in solid targets [8]. In combination with a high-repetition-rate scheme, the radiation bursts permit recording submicron scale time-dependent systems such as hydrodynamic instabilities. In this work, we utilized the betatron X-rays from the BELLA HTW system to dynamically capture the interaction of a long laser pulse with a liquid target, thus observing the evolution of a shock wave in water with unprecedented spatio-temporal resolution. CRASH radiation hydrodynamic simulations complement the experimental results, which agree qualitatively well at earlier times but do not fully capture all the physics observed experimentally. Moreover, the LWFA relativistic beam was used to perform innovative electron-beam radiography of the laser-water interplay finding evidence of bilateral heating of the plasma followed by ablation of the target and multi-directional shock generation. These measurements help explain some of the discrepancies observed between simulation and experiment and pave the way to better plasma diagnostic systems in HED physics experiments.

Acknowledgments

Work supported by LaserNetUS and US DOE Office of Fusion Energy Sciences under grant # DE-SC0020237, as well as U.S. Department of Energy NNSA Center of Excellence under co-operative agreement number DE-NA0003869 and the Lawrence Livermore National Laboratory under subcontract B645096.

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