High-Performance Computing of High-Energy-Density Plasmas at LLE The scope of high-performance computing (HPC) at LLE has increased significantly over the last several years. The 3-D hydrodynamic code *ASTER* has been used to study direct-drive OMEGA cryogenic implosions and identify potential mechanisms for performance degradation, including the role of long-wavelength modes imposed by the laser or target-placement offset (Fig. 1).[1]

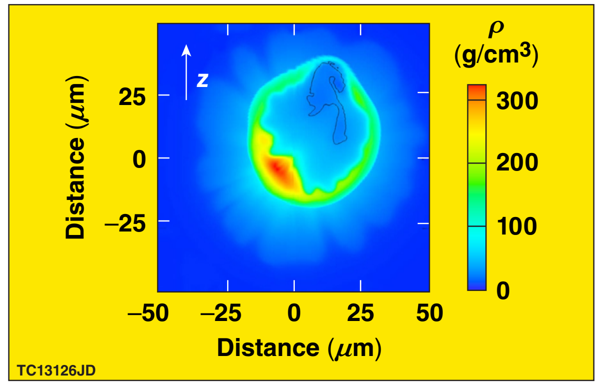

Figure 1. A vertical slice through a 3-D simulation of an OMEGA cryogenic implosion with *ASTER* showing a plausible mechanism for performance degradation, including heat and fuel loss from the hot spot, resulting from long-wavelength asymmetry on the target.

Material properties such as equations of state, opacities, and heat conductivities calculated from first-principles techniques such as path-integral and quantum molecular dynamics methods are used as inputs to radiation–hydrodynamic simulations.[2]

The laser-plasma simulation environment (*LPSE*)[3] Maxwell solver code has been used to verify laser-deposition models used in hydrodynamic codes. More recently, it has been identified that laser-frequency detuning with an amount currently achievable by laser technology can mitigate two-plasmon decay, a potential source of preheat in direct-drive implosions.[4]

Figure 2. The LLE cluster located at the University of Rochester's CIRC data center. Also shown is Dr. Carroll-Nellenbeck who has a joint appointment between LLE and CIRC.

Most of LLE's HPC occurs on a diverse set of Linux clusters totaling 8188 cores with over 250 TB of storage located within LLE. However, space, weight capacity, power, and cooling limitations have prevented expansion of computational resources. Off-site usage at the Oak Ridge National Laboratory has been used for specific projects to augment LLE-owned resources. In addition, over 3000 cores have been purchased at LLNL for the development and use of the LLNL's *HYDRA*[5] code for direct-drive inertial confinement fusion (ICF) studies. Recently, LLE has moved one computing rack comprising 1120 cores over to the University of Rochester's Center for Integrated Research Computing (CIRC) (Fig. 2). The LLE rack is part of the university Linux clusters (BlueHive) maintained by CIRC. Network connections to the main campus have been upgraded to permit faster data-transfer rates. Based on successful integration of the LLE cores with BlueHive, future purchases of cores by LLE will be physically located at the CIRC facility.

With space limitations alleviated, additional purchases of cores are now possible, and the scope of HPC will further advance more realistic, large-scale 3-D simulations of the effect of short-wavelength perturbations on cryogenic target performance will be possible. Stopping power of α particles and electron transport for heat conduction are some examples of problems that will be addressed using the material properties codes. The effect of bandwidth on laser–plasma interaction mitigation that occur in the coronal plasma of direct-drive implosions will also be studied using *LPSE*.

Omega Facility Operations Summary: The Omega Facility conducted 216 target shots in February with an average experimental effectiveness (EE) of 94.0%. The OMEGA laser had 140 shots with an EE = 91.4% and OMEGA EP had 76 shots with an EE of 98.7%. The ICF program accounted for 122 of the shots for experiments led by LLNL and LLE, while the HED program had 41 shots for experiments led by LANL, LLNL, and LLE. A total of 33 shots were taken for two MIT-led and one Princeton-led NLUF experiments and three LLNL-led LBS experiments accounted for 20 target shots.

1. I. V. Igumenshchev *et al*., Phys. Plasmas **23**, 052702 (2016); 2. S. X. Hu *et al*., Phys. Plasmas **25**, 056306 (2018); 3. J. F. Myatt *et al*., Phys. Plasmas **24**, 056308 (2017); 4. R. K. Follett *et al*., Phys. Rev. Lett. **120**, 135005 (2018); 5. M. M. Marinak *et al*., Phys. Plasmas, **8**, 2275 (2001).