Flash Center releases new version of FLASH code

FLASH v4.7 expands the range of laboratory experiments the code can model in fields including high-energy-density physics and fusion energy.

The Flash Center for Computational Science at the University of Rochester recently announced an exciting milestone: researchers have developed a new version of the FLASH code, the first official update of the code since the Flash Center moved to Rochester from the University of Chicago last year.

FLASH is a publicly available, high-performance computing, multi-physics code that allows researchers to model and simulate many scientific phenomena, from plasma physics and astrophysics to computational fluid dynamics, high-energy-density physics (HEDP), and fusion energy research. The new version of the code, FLASH v4.7, increases the accuracy of simulations of magnetized plasmas and significantly expands the range of laboratory experiments the code can model.

The FLASH code is developed at the Flash Center, which is part of Rochester's Department of Physics and Astronomy and the Laboratory for Laser Energetics (LLE), under the auspices of the U.S. Department of Energy (DOE) National Nuclear Security Administration (NNSA) Advanced Simulation and Computing (ASC) and Inertial Confinement Fusion (ICF) Programs. Petros Tzeferacos, an associate professor of physics and astronomy at Rochester and a senior scientist at the LLE, serves as the center's director.

Researchers have validated the FLASH code for more than a decade by modeling laser-driven plasma experiments at the Omega Laser Facility at LLE and the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory (LLNL) in California.

"NNSA's commitment to a vibrant high-energy-density physics community is demonstrated by their support of the LLE's Omega facilities and their funding for FLASH," says Christopher Deeney, Director of the LLE. "The University of Rochester is delighted to host FLASH, and this new release is a wonderful example of the cutting-edge science from FLASH we can expect based on the excellent collaborative team Petros has assembled."

'A game changer' milestone

The newest FLASH code release is the culmination of nearly two and a half years of code development, spearheaded by Adam Reyes, the Flash Center code group leader in the Department of Physics and Astronomy, and other Flash Center personnel.

"We are very excited for this FLASH code release," Reyes says. "It represents the dedication, as well as countless hours of work, of a fantastic team of UR scientists that went above and beyond to provide our users with powerful new tools to push scientific boundaries."

The new version of the FLASH code for the first time incorporates the full Braginskii extended magneto-hydrodynamics terms in the code's generalized Ohm's Law. This includes full anisotropic magnetic resistivity; the Hall, Nernst, Seebeck, and cross-field terms; and the Biermann battery mechanism. The new physics terms are coupled with state-of-the-art transport coefficients that govern how heat, magnetic fields, and momentum are transported in magnetized plasmas. FLASH v4.7 also includes support for materials tables developed by Los Alamos National Laboratory (LANL) in New Mexico, extending the code's applicability into new plasma regimes.

FLASH v4.7 includes several novel code units that enable, for the first time, simulations of pulsed-power experiments such as Z-pinches. The Z-pinch is a plasma confinement system that utilizes strong currents to magnetically compress plasmas to extreme conditions and is a prime candidate for conducting fusion energy experiments in facilities like the Z Pulsed Power Facility at Sandia National Laboratories in New Mexico.

"FLASH can now be used to model pulsed-power experiments," Tzeferacos says. "This development provides the pulsed-power HEDP community for the first time with an open and validated tool to model Z-pinch experiments. It's a game changer."

FLASH v4.7 also includes enhancements in the code's laser package, expanded support for diffusion processes, and a novel interface-capturing algorithm that mitigates numerical mixing.

"This expansion fuels discovery science for thousands of researchers around the world, across application domains, while concurrently enabling the Flash Center to pursue a rich portfolio of research topics at the frontiers of plasma astrophysics, HEDP, and fusion," Tzeferacos says.

Robust support

The Flash Center's continued expansion, verification, and validation of the FLASH code's physics and algorithmic capabilities is supported primarily by the NNSA, LANL, LLNL, and the LLE.

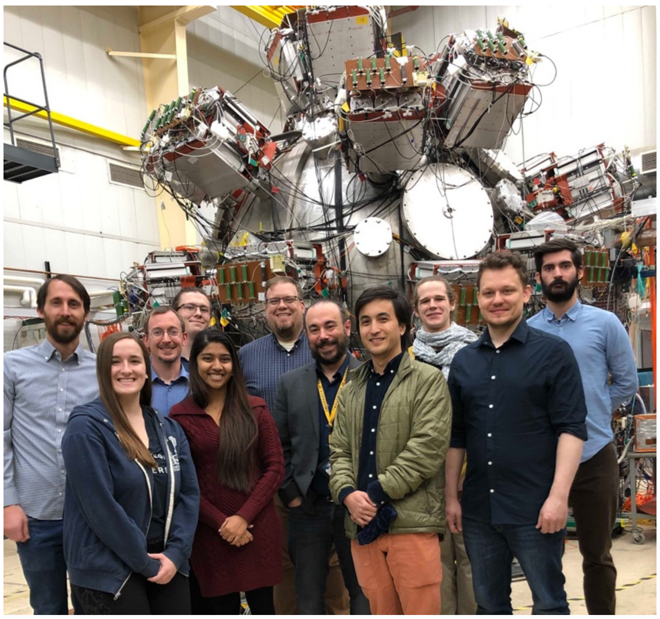
Joint research projects involving the FLASH code include collaborators from academic groups, industry partners, and national laboratories and are supported through federal grants from the NNSA, the DOE's Advanced Research Projects Agency-Energy (ARPA-E), the DOE's Office of Science Fusion Energy Sciences (FES), the National Science Foundation (NSF), and the Department of Defense (DOD).

According to Tzeferacos, the development of FLASH also draws heavily from the Flash Center's robust education program that engages Rochester graduate and undergraduate students.

"A key aspect of what we do at the Flash Center is to train the next generation of computational physicists and astrophysicists to develop multi-physics codes like FLASH and perform validated simulations," Tzeferacos says. "Several of the items in the new FLASH release were developed and verified by our graduate students, who will ultimately use the new capabilities in their graduate research."

Tzeferacos and Reyes are enthusiastic about the future of the FLASH code.

"We are now turning our attention to the next FLASH release and our most recent code development efforts to leverage accelerators, which can efficiently solve the bulk of our computationally-expensive operators," Reyes says. "FLASH users can expect a return to annual code releases and significant enhancements in FLASH's physics and numerics, with an eye toward future technologies."



Flash Center visits LANL: In November, the Advanced Simulation and Computing (ASC) and Inertial Confinement Fusion (ICF) programs at Los Alamos National Laboratory in New Mexico hosted visitors from the University of Rochester's Flash Center for Computational Science. Flash Center scientists, postdocs, and graduate students presented aspects of their FLASH code research and learned about LANL's radiation-hydrodynamics codes and LANL's experimental and computational work in HEDP and ICF. Pictured above, Flash Center members and their hosts stand in front of LANL's Plasma Liner Experiment (PLX), which the Flash Center is simulating using FLASH in the context of a project funded by the DOE's Advanced Research Projects Agency-Energy. (Image credit: Samuel Langendorf, Los Alamos National Laboratory)