PHYSICS COLLOQUIUM:

Mapping the Microphysics of Opacity to the Macrophysics of Inertial Confinement Fusion

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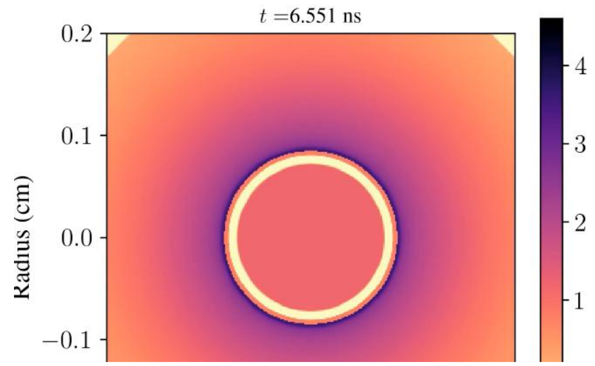
__Date:__
4/17/2026

__Time:__
10:30 AM – 11:50 AM

__Location:__
GRAN 135

About The Speaker:

Paul Grabowski is the deputy director of the High Energy Density Science Center and a staff physicist in the Theory and Modeling Group of the Physics Division, where he models and calculates opacity in high energy density systems. He is the team project leader of the opacity uncertainty quantification project, which aims to provide reasonable model variations, including in line shapes, mixing, inverse Bremsstrahlung, and embedding atoms in plasmas. He is interested in extending current models to go beyond single scattering approximations. Before coming to Lawrence Livermore National Laboratory in 2016, he completed a bachelor's degree at Vassar College in physics and mathematics, a doctoral degree at Cornell University in astrophysics, and a postdoctoral position at Los Alamos National Laboratory, working on wave packet molecular dynamics and stopping power. He also held an appointment as a research scientist at the University of California, Irvine, to work on density functional theory with Prof. Kieron Burke.



Abstract:

A recent inertial-confinement fusion (ICF) experiment at the National Ignition Facility (NIF) achieved fusion ignition, obtaining a greater fusion-energy yield than the input-laser energy. Since then, ignition has been repeated several times, and it is expected that this result will soon become routine, allowing regular experiments to understand the physics of a self-heating high-energy-density plasma and to improve the energy gain. Optimizing the fusion yield requires detailed knowledge of energy transfer and transport processes to ensure maximal heating and compression of the fuel. One key step is the absorption of x-rays by the fuel pellet,which depends on the opacity of the material. To better understand our models and uncertainties in experimental predictions, we have developed a mapping from opacity model variations to ICF observables. We vary the electron collision model, the definition of mean ionization, the gaunt factor, and pressure ionization model for pure carbon. We show that errors are correlated in density-temperature-energy space and quantify the effects of each variation. In addition to the above data-driven approach, we also develop a rigorous ab initio formalism to efficiently account for the effect of quantum fluctuations associated with core ionizations at high temperatures.

This work was performed in part under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

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