Title: Predicting hot electrons for inertial confinement fusion

Principal Investigator: Chuang Ren, University of Rochester

Co-investigators: Riccardo Betti (University of Rochester)

ALCC allocation: Site: National Energy Research Scientific Computing Center (NERSC)  
Allocation: 800,000 node-hours on Cori

Research Summary:

Inertial confinement fusion aims to realize fusion, which powers the Sun and stars, as a clean and sustainable energy source for humankind. One major approach is direct drive, which uses high energy laser to compress a tiny target to achieve fusion ignition condition of high density (100’s grams per cubic centimeter) and high temperature (100’s million degrees). Compressing the target to high density requires fusion fuel to be kept at low temperatures before the compression starts. However, the laser can generate plasma waves through a process called laser-plasma instabilities. Electrons can be accelerated by the plasma waves to high energy, much like a surfer gaining speed riding a wave. These hot electrons can preheat the fuel to impede the compression. A predictive capability of hot electron generation is thus required to find successful experiment designs where the hot electrons are kept at a tolerable level. Such a capability is currently lacking and is identified as a critical need by the inertial confinement fusion community. This project uses a series of particle-in-cell simulations, combined with a hot electron database from experiments performed at the Laboratory for Laser Energetics, University of Rochester, to obtain a scaling law for hot electron generation. The simulations, limited by available computer resources, can provide a scaling law that includes only the most relevant physics. It will then be improved by comparing with the experimental data to account for any missing physics. Such a scaling law can be implemented inline in codes modeling target performance and help find a path to ignition, a scientific and engineering grand challenge.

If successful this work will significantly improve the fidelity of direct-drive implosion modeling, especially on the areal density and ignition likelihood. It will also explore the high-gain shock ignition scheme and potentially open new paths to ignition. It will expand an active knowledge base in laser plasma instabilities and have broad impact on indirect-drive inertial confinement fusion as well. It will also train new workforce in academia, national laboratory, and industry.