ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY OF MICHIGAN

Electrical and Computer Engineering

ECE Final PhD Defense

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Magnetic Field Dynamics and Shock Physics at the High Intensity Frontier of Laser Plasma Interactions

Monday, September 26th, 2022
2:00 PM – 4:00 PM •
Zoom: LINK Password: plasma

Chair: Professor Louise Willingale

Abstract:

The formation of shocks and the generation of magnetic fields are two of the most fundamental processes in the universe. Shocks form on many scales from the relatively low energy shock formed between the Earth's magnetic fields and the solar wind, to the extremely energetic shocks formed in pulsar wind nebulae. Similarly, magnetic fields can be found with varying strengths from nT strengths measured in the Earth's magnetosphere to predicted strengths $>10^{11}$ T around magnetars.

High power laser systems have allowed for the study of shocks and magnetic field generation in the laboratory. These studies have generally focused on shocks and fields generated in moderate intensity interactions where conditions are more relevant to the environments found in our solar system. However, lasers with intensities large enough to accelerate electrons to a significant fraction of the speed of light have been used more recently to approach the conditions of extreme astrophysical environments. The next generation of multi-petawatt lasers like ZEUS being constructed at the University of Michigan may allow us to reach these extreme conditions.

In this defense three topics will be presented: collisionless laser-driven electrostatic shock formation in plasmas with multiple ion species, experiments and supporting simulations showing the first evidence of semi-relativistic magnetized shock formation, and simulations and theory of magnetic field generation in ultra-intense laser-solid interactions. This work explores the relativistic regime of plasma physics and provides insight into the ultra-intense interactions expected from next generation lasers where quantum electrodynamic effects may become important.