Laboratory Astrophysics at High Energy Density

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High-energy-density (HED) physics is the study of matter having a pressure above 0.1 Mbar (10 GPa) and containing free electrons not present in the solid state. It has emerged in recent decades as an active area of research, which also includes the use of experimental systems that produce such conditions. In this talk I will provide an introduction to HED physics. HED systems play host to a wide range of quantum mechanical, many-body, electromagnetic, and relativistic effects. HED experiments often use large lasers, although several other types of device can also access this regime. Because of its unique ability to create, in the laboratory, high-pressure and high-temperature states, high-Mach number shock waves, and highly ionized matter, there are many connections between HED physics and astrophysics. I will highlight various recent work in laboratory astrophysics at high energy density.

Studies of equations of state, relevant to the structure of planets, have revealed the biggest surprises in recent years, showing that dense matter regimes long thought to be simple in fact are not. At Michigan our work in radiation hydrodynamics has emphasized radiative shocks, relevant to cataclysmic-variable binary stars, supernovae, and other systems. Our research in the dynamics of magnetized flows seeks to produce and study the impact of magnetization on jet impacts events like those in T-Tauri stars. The resulting dynamics will be relevant to disk formation, jet production, and hydrodynamic and MHD turbulence. Our research in HED hydrodynamics is focused on the long-term evolution of hydrodynamic instabilities. The talk will also briefly discuss research relevant to nuclear astrophysics, taking advantage of the high intensity of laser-based neutron sources.

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