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Perspectives on High-Energy-Density Physics[1]

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Much of 21st century plasma physics will involve work to produce, understand, control, and exploit very non-traditional plasmas. High-energy density (HED) plasmas are often examples, variously involving strong Coulomb interactions and few particles per Debeye sphere, dominant radiation effects, strongly relativistic effects, or strongly quantum-mechanical behavior. Indeed, these and other modern plasma systems often fall outside the early standard theoretical definitions of "plasma". This presentation will focus on two types of HED plasmas that exhibit non-traditional behavior. Our first example will be the plasmas produced by extremely strong shock waves. Shock waves are present across the entire realm of plasma densities, often in space or astrophysical contexts. HED shock waves (at pressures $>$ 1 Mbar) enable studies in many areas, from equations of state to hydrodynamics to radiation hydrodynamics. We will specifically consider strongly radiative shocks, in which the radiative energy fluxes are comparable to the mechanical energy fluxes that drive the shocks. Modern HED facilities can produce such shocks, which are also present in dense, energetic, astrophysical systems such as supernovae. These shocks are also excellent targets for advanced simulations due to their range of spatial scales and complex radiation transport. Our second example will be relativistic plasmas. In general, these vary from plasmas containing relativistic particle beams, produced for some decades in the laboratory, to the relativistic thermal plasmas present for example in pulsar winds. Laboratory HED relativistic plasmas to date have been those produced by laser beams of irradiance $\sim 10^{18}$ to 10^{22} W/cm^2 or by accelerator-produced HED electron beams. These have applications ranging from generation of intense x-rays to production of proton beams for radiation therapy to acceleration of electrons. Here we will focus on electron acceleration, a spectacular recent success and a rare example in which simplicity emerges from the complexity present in the plasma state.

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