Development of a New Method to Infer the Total Kinetic Energy of Non-Thermal Electron Beams in Z-pinch Experiments

Benjamin D. Hammel

Abstract:
Axially directed beams of electrons, with kinetic energies much greater than those found in the surrounding high-temperature bulk plasma, are a common feature in pulsed power pinch-driven plasma experiments. The existence of these electron beams is evident through the observation of non-thermal spectral signatures however the properties of the described beam are not well known. At the Nevada Terawatt Facility's 1 MA pulsed-power generator, a new method of estimating the total kinetic energy of the non-thermal electron population in experiments of this type has been developed.

Experiments utilizing x-pinch wire arrays generate energetic electron beams with electron energies upwards of 1 MeV. The beam impinges on a thick copper anode target depositing its energy over a range of depths, rapidly heating the target material and generating high-energy bremsstrahlung photons. The ablatively-driven shock response is measured using a line-imaging velocity interferometer system for any reflector (VISAR) on the back side of the anode. Using a magnetohydrodynamics code (HYDRA) we model the shock response (shock strength, and time-resolved free back surface velocity). These simulations enable us to estimate the total beam energy by scaling the intensity of the electron beam drive, with a time-profile inferred from the measured hard X-ray emission, until the simulated shock breakout matches the measured shock breakout.

Knowledge of the total kinetic energy of electron beam provides a better understanding of plasma pinch dynamics and energy partitioning. Moreover, the electron-drive configuration shows promise as a potential platform for performing research on the dynamic compression of materials and supporting research in fast ignition concepts.

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