Contribution ID: **40** Type: **Workshop 2025/2026**

Glint Model for New Diagnostic for the National Ignition Facility

Thursday 29 January 2026 14:45 (15 minutes)

Understanding the X-ray drive deficit in inertial confinement fusion is crucial to realizing fusion as a viable energy source. To this end, the National Ignition Facility (NIF) has performed proof-of-concept experiments for a new post-shot transmitted-beam diagnostic, which requires improved understanding of laser glint and thermal filamentation. In this work, we develop a theoretical model of laser glint from oblique reflection off an expanding plasma and compare it to two NIF proof-of-concept experiments. We describe laser propagation and reflection in a collisional plasma, as well as the inverse Bremsstrahlung absorption mechanism. We model the plasma using a self-similar isothermal expansion. Ionization scaling laws are derived from simulations performed at Lawrence Livermore National Laboratory, and corrections to the electron-ion collision rate due to the Langdon effect are included. The Coulomb logarithm is adapted to accurately describe inverse Bremsstrahlung absorption in the relevant regime. The model reproduces the observed qualitative behavior of glint decay while highlighting discrepancies that point to missing physics, such as radiative losses and thermal filamentation. Finally, we outline a numerical pathway for studying glint and thermal filamentation from first principles using particle-in-cell simulations, and present preliminary results on inverse Bremsstrahlung absorption.

Field of Research/Work

Plasma and Solar Physics, Accelerators and Beams

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