Improving pulsed laser induced fluorescence signal-to-noise through matched filter signal processing

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The PHAse Space MApping (PHASMA) facility was constructed to facilitate laboratory electron-only magnetic reconnection studies at kinetic scale lengths using dual plasma gun discharges. Electron velocity distribution functions (VDF) have been measured during electron-only magnetic reconnection with a Thompson scattering diagnostic [1-3]. No effect is expected on ions or neutrals in the reconnection event in PHASMA, but this has yet to be successfully measured. A discrete pulsed laser induced fluorescence (LIF) diagnostic is being developed for PHASMA to measure both ion and neutral VDFs during magnetic reconnection. LIF is a non-perturbative laser spectroscopic technique that uses the Doppler motion of a species and a narrow linewidth laser to measure the VDF of ions or neutral atoms. It has also been shown that LIF measurements of Zeeman split spectra offer a method to measure magnetic fields in laboratory plasmas [4,5]. Using neutral LIF schemes that exhibit strong Zeeman splitting, we can non-perturbatively measure the magnetic field throughout the reconnection event without the use of probes. Performing LIF during a plasma gun discharge presents unique challenges. A pulsed dye laser is necessary to produce sufficient fluorescent signal, but to avoid laser saturation, measurements must be made at relatively low laser energies at which reliable signal is only recovered by averaging over many plasma discharge events. We have implemented a matched filter signal processing technique to greatly improve the signal-to-noise ratio of our measurements. This allows us to reduce the number of discharges needed to measure a VDF or to achieve signal at lower laser energies.

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