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Analysis of Polarized Emission from Laser Produced Plasma

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The interaction of high-intensity laser pulses with matter leads to the formation of laser-produced plasma (LPP), a rapidly expanding and highly transient plasma, characterized by steep temperature and density gradients. These unique properties make LPP an important platform for fundamental plasma physics research and a wide range of technological applications. The extreme conditions within LPP facilitate the excitation and ionization of atomic and molecular species, enabling spectroscopic investigations of energy states that are typically difficult to be populated under normal conditions. This characteristic enables in-depth investigations through Laser-Induced Breakdown Spectroscopy (LIBS) and can be effectively utilized to analyze the atomic and molecular processes within the plasma. Moreover, LIBS has gained significant traction across various scientific and industrial disciplines, including materials analysis, environmental monitoring, and planetary exploration. Understanding the dynamics and emission mechanisms of LPP is therefore crucial for advancing both fundamental studies and applied diagnostic methodologies.

One particularly intriguing aspect of LPP is the anisotropy in emission polarization, observed in the expanding plasma plume. This anisotropy plays a crucial role in understanding electron distributions [1] and in extracting valuable information about self-generated electric [2] and magnetic fields [3]. Although this phenomenon has been studied in the past, a comprehensive spatio-temporal characterization of polarized emission from LPP has been lacking, primarily due to the limitations of localized polarization measurements.

In our recent work [4], we have sought to address this gap by investigating the spatio-temporal evolution of polarized emission using precise imaging techniques, including a Wollaston prism for polarization separation in single-shot ablation experiments. Our results indicate that the self-generated magnetic field near the target surface which can potentially effect the atomic transitions within the plasma is a likely cause of the observed polarization. Furthermore, the polarization of plasma emission has been applied to improve the signal-to-noise ratio in Laser-Induced Breakdown Spectroscopy (LIBS) through a technique known as polarization-resolved LIBS (PRLIBS). We investigated the influence of polarized emission on the parametric evaluation of plasma characteristics in PRLIBS experiments, offering new perspectives on plasma diagnostics [5]. A summary of the results on the anisotropic emission from the laser generated plasma will be covered in this presentation.

References

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