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Plasma afterglow light dynamics and measurement technics of a plasma accelerator plasma source

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We present an experimental and simulated investigation of helium plasma glow light dynamics and its application to the physical measurements of a plasma wakefield accelerator (PWFA) plasma source. We model the plasma formation with a split-step Fourier optical propagation code and a particle-in-cell (PIC) code. We then simulate the plasma expansion dynamics using a plasma fluid code. Using a combination of analytical reasoning and simulations, we develop a simple model to estimate the photon emission density from the plasma based on the initial plasma density and temperature. Our findings indicate that electron-induced collisional excitations dominate the light emission process over electron-ion recombination. We also introduce an innovative experimental technique that enables a machine vision gigabit Ethernet (GigE) camera to resolve nanosecond-scale temporal dynamics of the plasma source. This is cost-effective method is well suited high-radiation settings like PWFA experimental environments. We find good agreement between experimental data and simulations. Further, we demonstrate that a PWFA-like plasma source's integrated peak plasma light density, a common measurement in PWFA experiments, can be written in an analytical form dominated by the electron-neutral collisional excitation in the light emission process.

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