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Coupled Surface-Wave Dynamics and Acoustic Wave propagation in a Microwave Atmospheric Pressure Plasma Jet

The interaction of surface waves with atmospheric-pressure plasmas critically governs plasma stability, energy transport, and wave–matter coupling [1]. In this study, we investigate surface-wave interactions and their role in acoustic emission generation in a microwave atmospheric pressure plasma jet (MW-APPJ) operated in continuous-wave mode. Audible acoustic emissions were reproducibly observed within two microwave power regimes, 220-360 W and 570-620 W. Experiments were performed under well-controlled conditions, including different gas flow rates, mixture of gases, and an air swirl flow of 45 lpm, a water-cooling flow rate of 6 lpm, and variable sliding-short positions, to systematically analyze plasma-wave coupling. Acoustic signals were acquired using a calibrated microphone and analyzed via Fast Fourier Transform (FFT) in MATLAB to determine dominant frequency components and their dependence on operating parameters. Concurrently, plasma column fluctuations were characterized using optical emission spectroscopy to estimate variations in electron number density (ne) and electron excitation temperature (Texc). Gas temperature fluctuations were measured with a K-type thermocouple, while high-speed imaging captured the spatiotemporal dynamics of the plasma plume.

The results demonstrate a strong correlation between surface-wave interference, plasma instabilities, and acoustic wave generation. Interference between counter-propagating surface waves near the applicator induces periodic modulation of plasma parameters, producing pressure perturbations that manifest as acoustic emissions. This work provides direct experimental evidence of surface-wave-driven acoustic generation in MW-APPJs and advances the understanding of coupled wave plasma acoustic phenomena, with implications for plasma diagnostics, source optimization, and plasma-assisted applications [2].

References

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