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FUNDAMENTAL DIAGNOSTICS AND MODELING OF STREAMER DISCHARGE AND ITS APPLICATION FOR CANCER TREATMENT

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Streamer discharge is a representative form of cold plasma generated in ambient air. To elucidate its radical production and reaction mechanisms, we have employed various laser diagnostics. However, the random branching and filamentary nature of streamer discharges poses challenges for laser spectroscopy, as the random discharge filament does not always intersect the laser-irradiated region. To address this problem, we developed a single-filament streamer discharge system composed of a single, unbranched filament [1]. This setup enables precise laser spectroscopic measurements and allows comparison with two-dimensional simulations, as the discharge is pseudo-two-dimensional, similar to the computational model.

In this study, we present laser spectroscopic diagnostics of single-filament streamer discharges. These include measurements of the electron energy distribution function and negative charged particles (electrons and negative ions) using laser Thomson scattering [2]; electron density using a dual-wavelength Talbot interferometer system; electric field vectors via electric-field-induced second harmonic generation (E-FISH); and radical species densities using laser-induced fluorescence (LIF) and two-photon absorption LIF (TALIF). We also compare these experimental results with two-dimensional simulation data for validation [1].

Beyond fundamental studies, streamer discharge has promising applications, including cancer treatment. Previous studies have demonstrated that streamer discharge treatment of tumors in mice can induce antitumor immune responses, resulting in an *abscopal effect*—a systemic therapeutic effect at sites distant from the treated tumor [3]. Remarkably, this effect has been observed even when only normal tissue, distant from the tumor site, is treated [4]. Furthermore, applying streamer discharge to tumor-resected sites in mice suppresses tumor recurrence [5]. When combined with immune checkpoint inhibitors (ICIs), the treatment exhibits a synergistic antitumor effect in mouse models. These therapeutic applications of streamer discharge, along with experimental evidence supporting its efficacy, will also be presented.

References:

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