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(G) Coherent Homodyne Detection for Amplified Cross-Beam Electric-Field Induced Second Harmonic (ACE-FISH)

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Cold plasma technology finds diverse applications spanning from microfabrication, medicine, agriculture, and surface decontamination. Precision required in these applications usually necessitate high control over the electric field of plasma sources, allowing for tailored targeting of specific chemical pathways. To determine the electric field, high-resolution detection techniques are essential for time and spatial resolved diagnostics. We proposed to use electric field-induced second harmonic (E-FISH), a well-established nonperturbative technique for measuring the amplitude and orientations of cold atmospheric plasma electric fields. Although E-FISH allows for a good and tunable time resolution, it has been shown that it presents some issues with spatial resolution and sensitivity. While spatial resolution can be improved by the overlapping of two non-collinear optical beams, the interaction section is much more reduced and lead in a significant signal reduction. To overcome this signal reduction, coherent Amplification of Cross-beam E-FISH (ACE-FISH) signal is introduced by mixing the low E-FISH signal and a phase-locked bright local oscillator. The enhancement of the signal is demonstrated by introducing a local oscillator, and the polarity of the electric field is determined through the phase of the homodyne signal. In a groundbreaking application, we employ ACE-FISH to measure, for the first time, the magnitude and direction of the electric field in a cold atmospheric pressure plasma jet. This jet dynamically follows the profile of the applied bias current. The ACE-FISH method not only overcomes spatial resolution challenges but also enhances sensitivity, thus presenting a promising avenue for improved diagnostics and applications across various domains of cold plasma technology [1-2].

[1] J.-B. Billeau, P. Cusson, A. Dogariu, A. Morozov, D. V. Seletskiy, and S. Reuter, "Coherent homodyne detection for amplified crossed-beam electric-field induced second harmonic (ACE-FISH),"Applied Optics, (Unpublished), 2023.
[2] J. Hogue, P. Cusson, M. Meunier, D. V. Seletskiy, and S. Reuter, "Sensitive detection of electric field-induced second harmonic signals,"Optics Letters, vol. 48, no. 17, p. 4601, aug 2023.

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Cold plasma diagnostic

Keyword-2

Electric field measurements

Keyword-3

Second harmonic generation

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