ECPD 2021
European Conference on Plasma Diagnostics

Electric Field Measurements in Low Temperature Plasmas using the E-FISH Diagnostic

Tat Loon Chng [1], Svetlana M. Starikovskaia[1]

1) Laboratoire de Physique des Plasmas, (CNRS, École Polytechnique, Sorbonne Universites, Univ. Paris-Sud), Institut Polytechnique de Paris, F-91128, Palaiseau, France

E-mail : tat-loon.chng@lpp.polytechnique.fr

Electric-field induced second harmonic (or E-FISH) generation is a nonlinear optical diagnostic that has recently been redeveloped for the measurement of electric fields in plasmas [1]. This laser-based method involves probing a gas sample (viz. plasma) with laser light, and quantifying its second harmonic response to an externally applied electric field – the measured quantity. The resulting second harmonic signal (i.e. half the probe beam wavelength) varies quadratically with the applied field strength, and is otherwise absent if no field is imposed. Calibration may be performed in a known electrostatic field to obtain absolute field information in a plasma. Key advantages of the E-FISH method include its exemplary detection sensitivity and versatility, excellent time resolution, as well as relatively straightforward implementation. To date, absolute field strengths on the order of several hundred volts per cm have been demonstrated. The non-resonant nature of the method affords versatility in terms of gas composition (compatible with virtually any non-polar gas or gas mixture), and choice of probe laser wavelength. The temporal resolution of the measurement is only physically limited by the laser pulse duration since the signal generation is effectively instantaneous, with pulses as short as 50 fs being shown to yield good signals. Yet recent work has also shown that the E-FISH diagnostic possesses certain limitations with respect to the spatial origin of the signal [2]. In this tutorial, I will elaborate on the basic principles of E-FISH, its strengths and limitations, and describe a few strategies that our group has been pursuing to address existing challenges. I will conclude by summarizing our efforts at characterizing the ionization wave development of nanosecond discharges at moderate to ambient pressures [3-4].

References

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