Electric field measurement of positive single channel streamers in air by E-FISH

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Streamers are fast developing ionized channels that occur when a high voltage is quickly applied to a gas gap [1]. The space charge layer formed at the head of a streamer channel can enhance the electric field ahead of it and help its development. The electric field also determines the energy transfer, gas temperature, and chemical activity, *etc.*, in the discharges. Therefore, determining the electric field of streamer discharges is of great significance. Dijcks *et al.* [2] determined the electric field of streamers in pure nitrogen and synthetic air at pressures from 33 to 266 mbar by using optical emission spectroscopy (OES). However, this method has the disadvantages that it depends on optical emission and has a rather low spatial and temporal resolution.

Recently, a new technique called electric field induced second harmonic generation (E-FISH) has been introduced to the plasma community to measure the electric field of various kinds of plasmas [3, 4]. Initially, this method was considered as easy to implement and the measured signals straightforward to interpret. However, it has been shown that the measured signals are strongly related to the laser beam profile and to the electric field profile [5]. Recent advances on the interpretation of E-FISH signals provide us the possibility to restore the electric field distribution if cylindrical symmetry is assumed.

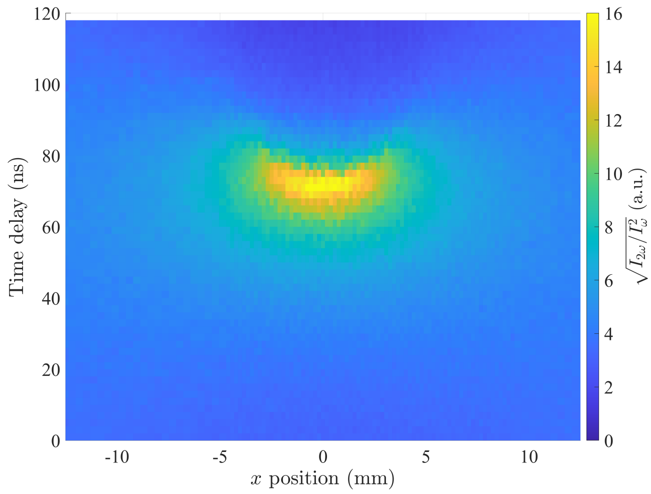

Fig. 1: A 2D map of E_y signals of a streamer in 70 mbar air with an applied voltage of 8 kV. The streamer propagates in the y-direction.

In this work, we built an E-FISH setup that mainly consists of a laser, optics, and streamer generation vessel. A Nd:YAG laser (EKSPLA SL234) with a pulse width of 120 ps is used for a high temporal resolution and a high signal intensity. The laser has a Gaussian beam profile and is focused to the discharge region inside the vessel by a lens with focal length of 500 mm. The second harmonic that is generated from the interaction between the laser and the electric field of the streamer is separated from the fundamental by a prism and a series of dichroic mirrors and is then directed to a photomultiplier tube (PMT). The orientation of the electric field vector is determined by implementing a polarizer in front of the PMT. The streamers are generated by repetitive high voltage pulses that are applied to a protrusion-to-plate gap (12 mm pin protrusion, 100 mm plates separation). Simultaneously to the E-FISH measurements, discharge images are captured by an ICCD camera (Andor iStar DH334T) to show the stability and cylindrical symmetry of the streamers. Figure 1 shows the E-FISH signals of E_y of a streamer in 70 mbar air with an applied voltage of 8 kV at different position and time delays. The space charge layer with a crescent shape, where the electric field is the most intense, is clearly visible in the figure. Furthermore, a dimmer screened channel that follows the space charge layer can also be seen.

In this work, we measure the E-FISH signals of single channel positive streamers in air and air-like mixtures at pressures around 100 mbar. The line-of-sight integrated signals are then restored into electric field distributions by a deconvolution method. The absolute electric field is determined by measuring a known field from calibration electrodes. These results are also compared with existing simulation results and previous OES measurement under the same conditions. More details and the fully processed experimental results will be presented at the conference.

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