

# Time-resolved optical emission spectra of nanosecond discharge in water

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Shadowgraphic and spectroscopic analysis with 2 ns time resolution of underwater nanosecond discharges is presented. Optical emission spectra of positive streamer in water demonstrate highly broadened atomic H $\alpha$  and OI(777nm) line profiles.

## 1. Introduction

Electrical discharges in water and other dielectric liquids have been extensively studied since almost fifty years, however the mechanism of discharge initiation and propagation is still disputable. The proper measurement of plasma parameters is necessary to calibrate existing models of underwater discharge. The experimental techniques developed for measurement of electronic density (Ne) and temperature (Te) in gas phase discharges can not be easily applicable in liquids. Optical emission spectroscopy (OES) seems to be a promising tool for studying electrical discharge in liquid phase [1]. Profiles of emission Balmer lines are very sensitive to the presence of macro- and microscopic electrical fields and are extensively used for determination of Ne and Te in laboratory and interstellar plasmas[2].

## 2. Experimental setup

Experimental setup is described in detail in [3] and consists of a classical shadowgraph scheme with a Xe flash lamp as a backlight source, an objective producing the parallel beam, imaging lens, beam splitter and two iCCD cameras (ANDOR iStar 734). Time-resolved spectroscopic study is performed with a Shamrock SR-303i spectrometer equipped with a 600 l/mm grating. Discharge device has a point-to-wire geometry with nickel pin electrode of  $\sim 1 \mu\text{m}$  and interelectrode gap of 2 mm. Plasma is generated by nanosecond high voltage pulser with a 5 ns rise time, 30 ns duration (FWHM) and 10 kV amplitude (FID GmBH). Experiments are carried out in 50 ml quartz optical cell.

## 3. Results

Single streamer discharge is obtained at 6 kV of applied voltage propagating to the maximal length of 300  $\mu\text{m}$ . Expansion of the discharge channel is measured with the help of two iCCD cameras during the streamer formation phase and in the post-discharge. Analytical model of cylindrical cavity expansion in nonviscous incompressible liquid is applied to get pressure evolution inside the discharge channel. Figure 1.a demonstrates an exponential decay of discharge pressure from 1.3 GPa at 5 ns after ignition to 0,2 GPa at the end of applied voltage

pulse. Time-resolved spectrum shows a strong broadening of Balmer lines with almost continuum emission in the region 300-700 nm and weak broadened OI(777nm) line. The best fit of H $\alpha$  profiles is obtained as a sum of two lorentzian functions. Figure 1.b demonstrates temporal evolution of HFHM for each component of H $\alpha$  two-lorentzian fit. Since Stark and pressure broadening can be treated independently and both have lorentzian profile, one may suggest that complex H $\alpha$  line profile is due to the combined contribution of Van Der Waals and Stark broadening. Analysis of H $\beta$  and H $\gamma$  profiles are now in progress.

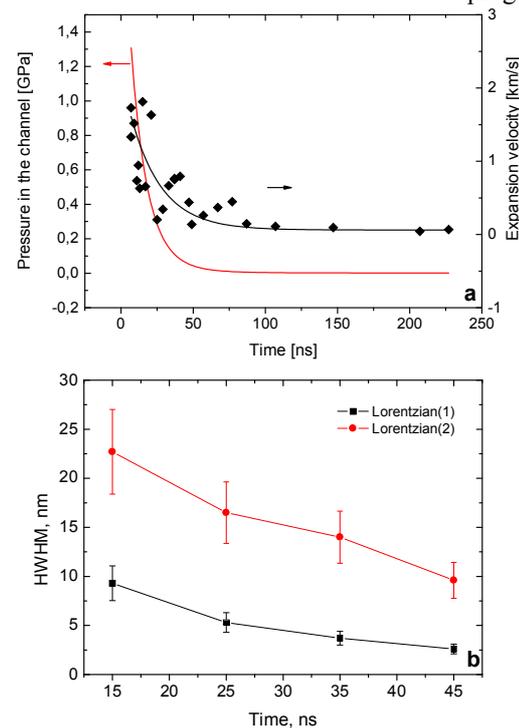


Fig. 1: a) Pressure in discharge channel b) HWHM of H $\alpha$  two-lorentzian fit

## References

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