Relazione Finale Attività Svolta dal dr. Milan Simek per la SMT 2014 % CNR IMIP Bari

The Short term mobility programme proposed for dr. Milan Simek stay at IMIP - CNR Bari was related to Advanced investigation of $N_2(A^3\Sigma_u^+, v)$ dynamics under streamer conditions.

A combined experimental and theoretical approach to elucidate absolute metastable populations in higher vibrational levels was assumed to proceed and articulated in the following steps:

1) Laser Induced Fluorescence with a narrow band laser will be performed in high pressure streamer discharges,

2) Cavity based absolute absorption measurements of Nitrogen metastable in different vibrational level will be attempted in order to calibrate the LIF measurements,

3) ICCD plasma emission spectroscopy will be performed in order to compare independent calibration procedures,

4) Time evolution of metastable vibrational levels will be modelled and compared with experimental outcomes.

During the stay the following steps were realized.

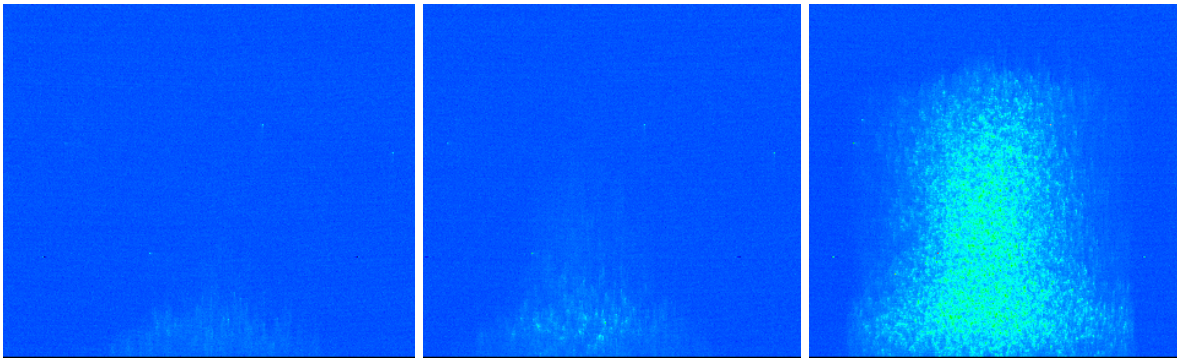
1. A high pressure Streamer discharge, the same as investigated in Prague during the proposer stays in this and past years, was set up. A picture of the discharge apparatus is displayed below.

Experimental Apparatus. Discharge chamber with CRDS mirror mounts.

The first three days of the stay were necessary to set up the discharge apparatus and related pulsed-power electronics.

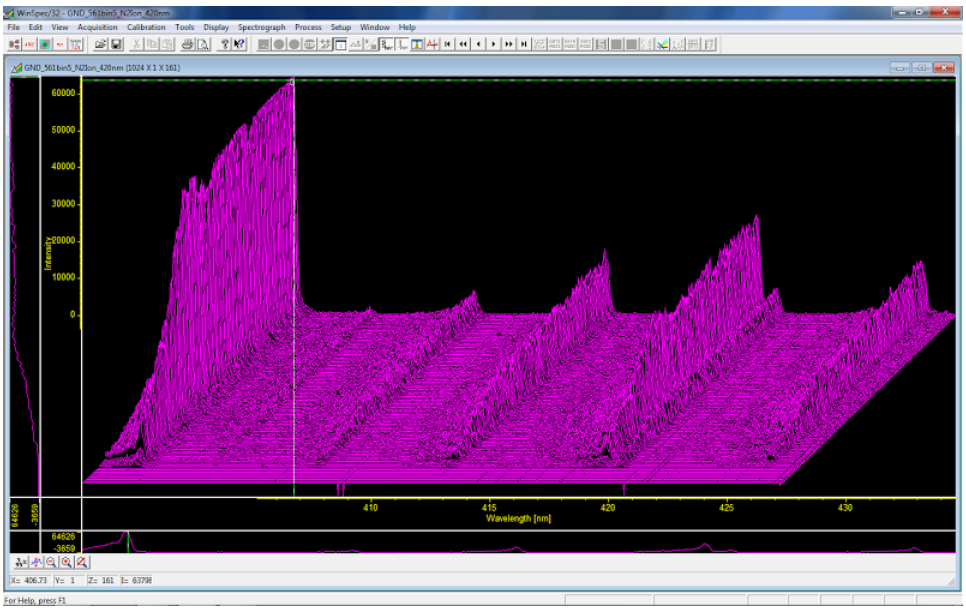
2. A nanosecond HV switch was used to ignite the discharge. Stable conditions in terms of time jitter and optical emissions were achieved with a repetition rate of 100 Hz. In order to synchronize the (sub)nanosecond streamer events with the time-resolved detection techniques (LIF and OES) the delay time of the ICCD plus external electronics were used. In this way it was possible to detect the single event and or make accumulations either for emission or LIF. Due to the imaging capabilities of the spectrometer (Acton SP2300) and the fast gating ICCD (PI MAX 4), using a proper acquisition techniques, spectra and images showing the evolution of the ionizing event in the time scale of tens of picoseconds was achieved.

3. OES at picosecond time steps (10 ps) was performed both in imaging and spectral modes. In the following figure an example of the propagation of the ionization wave in the discharge gap of 5 mm is reported. From these images the propagation velocity of the ionization wave will be deduced after proper data treatment.



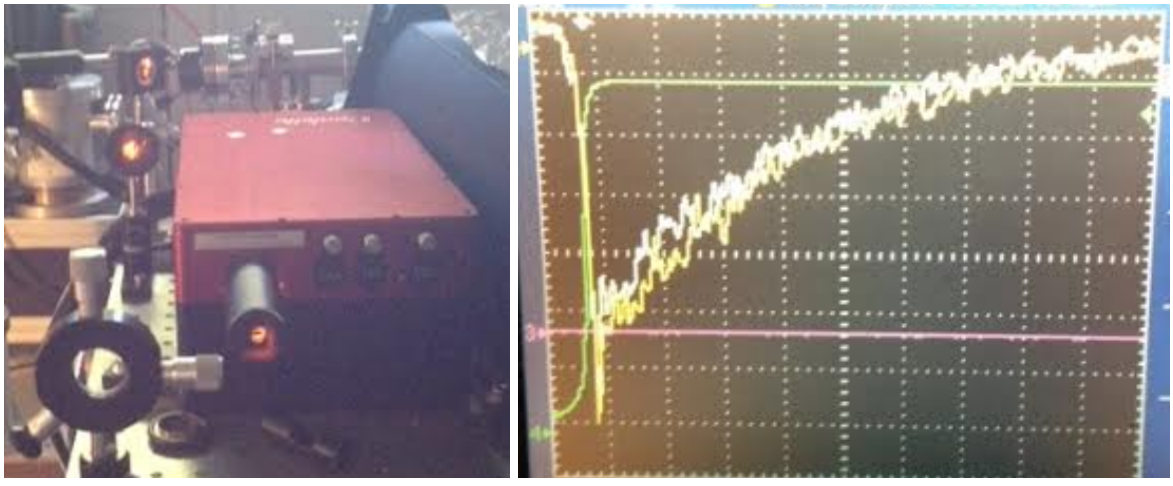
Streamer Propagation images registrered with 10 picosecond steps.

The same time evolution was studied for the optical emission by applying technique of kinetics spectral series acquisition, focussing on the Second Positive System (SPS), First Negative System (FNS) and Herman Infrared (HIR) emission bands of N_2/N_2^+. In the following figure, as an example, the dynamics of SPS and FNS emission in the 420 nm region (as acquired) in the tens of picosecond time scale is shown. The spectroscopic measurements based on the SPS and HIR emission systems are important for the subsequent validation of laser-based calibration techniques.



Kinetic Series of SPS and FNS in the 420 nm spectral window.

4. After the Time Resolved OES measurements the setup was modified in order to implement the LIF and CRDS diagnostics. In this case, an OPO laser was used either for the LIF or CRDS experiments. In the following pictures the OPO used for both the LIF and CRDS experiments together with a typical ringdown signals for laser wavelength tuned for $N_2(A,v=2)$ absorption (yellow discharge off/white discharge on, alignment acquisition low accumulations) are shown. The difference between white and yellow curves is due to the absoprtion caused by $N_2(A,v=2)$ species produced by single streamer filament.



OPO laser and Ring Down Signals for $N_2(A,v=2)$ with discharge off (yellow) and on (white)

5. A simple kinetic modeling to explain experimental data obtained on $N_2(A^3\Sigma_u^+, v=2)$ under streamer conditions was prepared.

Summary

As reported all the tasks proposed in the STM program were fulfilled. The acquired data are under analysis and obtained results will be submitted for publishing in peer reviewed journals as soon as possible with the appropriate acknowledgment for CNR STM programme.