Dynamics of electrons and excited species in heliummicroplasma jets

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Non-equilibrium plasma jets inrare gases propagating in ambient air have recently attracted a lot of interest due to their unusual physical properties and their potential applications[1]. When excited by high voltage pulses operating at repetition frequencies lower than 1 MHz, the plasma jets are characterized by the propagation of a fast, 10^5 m/s, ionization wave. Modeling studies [2-4] demonstrated that microplasma jets are basically streamers propagating in an easily ionizable rare gas channel confined by ambient air. While models correctly predict the macroscopic properties of the plasma jets (propagationlength and velocity), large discrepancies between models and experiments werepreviously reportedfor the spatial distribution of electrons [5] and helium $He(2^3S_1)$ metastable atoms [6].

To get better insight on the plasma dynamics and to solve these discrepancies, various diagnostic techniques were implemented on a helium microplasma jet (2 mm in diameter) excited by nanosecond high voltage (4-7 kV) pulses operating at repetition frequencies in the range 1-50 kHz. Electron density and temperature were obtained by Thomson scattering, while the density of the helium $He(2^3S_1)$ metastable atoms was determined by tunable laser diode absorption spectroscopy for a large range of experimental parameters. Bandpass filters (FWHM 10 nm) coupled with sub-nanosecond time resolved imaging of the plasma jet allowed to get the spatio-temporal dynamics of characteristic plasma emissions, such as the 706.5 nm$He^*(2p^3P\text{-}3s^3D)$,587.5 nm $He^*(2p^3P\text{-}3s^3S)$ and 777 nm O*lines, as well as the 337 nmN_2(C-B, 0-0), 391 nmN_2^+(B-A,0-0) and 308 nm OH* bands. The temporal evolution of the different emission intensities at given positions were analyzed by nanosecond time-resolved optical emission spectroscopy.

As illustrated in Fig.1, the evolution of the radial distribution of the helium $He(2^3S_1)$ metastable atoms for different positions, z, along the propagation direction, exhibits dramatic differences depending, for example, on the pulse repetition frequency. Similar effects were observed in the spatial distribution of all the different excited species produced by the plasma jet.

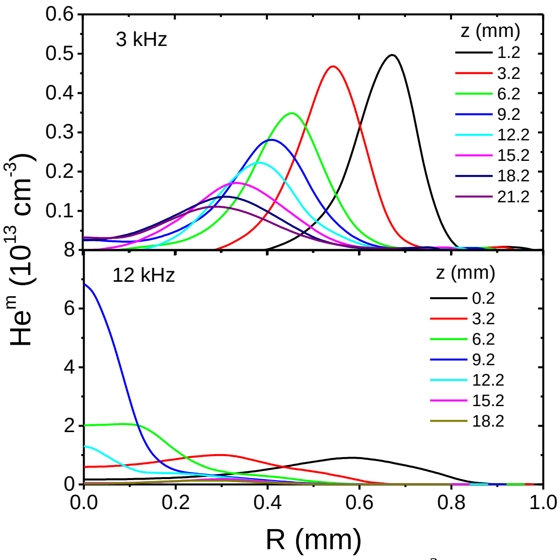

Fig.1:*Radial distribution of the peak*$He(2^3S_1)$ *metastable atomsdensity produced by the nanosecond pulsed plasma jet for different axial positions and twovalues of the repetition frequency. V=6 kV, He=4.5slm.*

In this presentation, it will be shown that these distributions are very sensitive to the values of the applied voltage, pulse repetition frequency, helium gas flow and purity, as well as on the nature of the gas surrounding the plasma jet.We will emphasize the physical processes determining the spatio-temporal dynamics of the excited species produced during the propagation of the nanosecond excited microplasma jets.

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