# Spectra emitted by Cryoplasma in Helium

Hai Van Nguyen[1], N. Bonifaci[1], F Aitken[1], V. M. Atrazhev[2], K. Von Haeften[3], J. Eloranta[4]

[1] *Laboratoire G2Elab CNRS & Joseph Fourier University, 25 rue des Martyrs, 38042 Grenoble, France*
[2] *Joint Institute for High Temperatures, RAS, Moscow, 125412*
[3]*Departement of physics and Astronomy, University of Leicester, UK*
[4]*Department of Chemistry,University of California, USA*
mél: nelly.bonifaci@grenoble.cnrs.fr

Emission spectroscopy is a powerful tool to obtain information about the important parameters that characterize non-equilibrium discharge plasma at both low and high pressures. Spectroscopic observations of the light emitted by ionization gases can be used to determine conditions surrounding the emitted atoms or molecules. An ionization zone near a tip electrode is a source of a light emitted by the corona. Excited atoms interacting with environment and features of their spectra give information about density and temperature of a gas in the ionization zone.

Spectroscopic studies of the excitations in liquid helium have a long history. Experimental techniques, such as high energy electron bombardment, α-particle bombardment, corona discharge, strong field ionization by femtosecond laser pulses, vacuum UV excitation and synchrotron radiation, have been employed. In liquid helium the excited He* and $He_2$* species have been established to reside inside voids with a radius ranging from (7 – 15) Å ("bubble states"), which are slightly smaller than for a solvated electron in the liquid (18.5 Å). Such structures are the result of the Pauli repulsive exchange interaction between the Rydberg electron and the surrounding closed helium atoms shell.

In a gas, the "impact" interaction of radiator with surrounding atoms determines the symmetric Lorentzian profile of spectral lines with shift and width are proportional to the gas density. The shift sign ("red shift" for the shift toward longer wavelengths and "blue shift" for the shift toward shorter wavelengths) depends on character of radiator-perturbator interaction. The blue shift corresponds to significant repulsion. Well known measurements showed the blue shift of the line 706 nm ($3^3S$-$2^3P$ transition) in low density He gas. The measurements were made using discharge in low pressure gas (< 10 Torr) and gave the symmetric Lorentzian profile of the line.

The cryoplasma in helium under pressures (0.1 -0.2) MPa allows us to observe lines of He I in conditions where liquid and dense gas were realized. Experiments have been carried out in gaseous and liquid He at the fixed temperature 4.2 and 5.1K and different pressures in the cell from 0.1 MPa up to 0.5 MPa.. The light emitted from the cryoplasma was collected and spectra in the range 500 - 1080 nm were recorded. Most of atomic lines and molecular bands were identified. These lines correspond to radiative transitions between excited states of He* atoms and $He_2$* excimer molecules.