Optimization of the Supersonic Gas Jets' Parameters for in-Gas-Jet Nuclear Spectroscopy Studies

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Abstract

The in-gas-jet laser ionization and spectroscopy method (Figure 1) that has been developed at KU Leuven allows to produce and to perform laser spectroscopy of short-lived radioactive isotopes created in different types of nuclear reactions [1,2]. To realize the advantages of in-gas-jet ionization, the parameters of the gas cell (in which the isotopes under investigation should be efficiently stopped and neutralized in the argon gas) and of the de Laval nozzle (for subsequent acceleration of the argon flow with isotopes to the Mach numbers up to 12) should be carefully chosen.

Simulations in using the CFD Module of the COMSOL Multiphysics® software were applied for the optimization of the parameters of the gas cell and of the de Laval nozzle in order to increase the efficiency of the transportation of the isotopes under investigation in the gas cell, to reduce their evacuation time and to form a homogeneous supersonic gas jet after the de Laval nozzle. The Transport of Diluted Species and High Mach Number Flow physics interfaces were used for the cases of stationary and time dependent studies.

The gas cell (Figure 2) and de Laval nozzle (Figure 3) with the parameters optimized in COMSOL were produced and will be tested in our laboratory. For the visualization of the supersonic gas jet the Planar Laser-Induced Fluorescence (PLIF)-technique [3] can be applied. In the PLIF-technique the atoms coming out of the nozzle are irradiated by a planer laser beam and the emitted fluorescence light is recorded by a CCD camera (one of the first images of the supersonic gas jet obtained in our laboratory can be seen on Figure 4). The experimental setup that include the gas handling- and pump system, the laser and the detection system will be described. By scanning the frequency of the narrow band laser around the resonance transition the information about velocity, temperature and density across the gas jet can be obtained and compared later with the results from simulations in COMSOL.

In the present contribution, the results of the CFD simulations in COMSOL together with the first tests of the supersonic gas jet after the de Laval nozzle by means of the PLIF-technique in a new Heavy Element Laser Ionization Spectroscopy (HELIOS) laboratory at KU Leuven will be presented.

Reference

[1] Y. Kudryavtsev et al., “Beams of short lived nuclei produced by selective laser ionization in a gas cell”, NIM B, 114, 350-365 (1996).

[2] R. Ferrer et al., “In Gas Laser Ionization and Spectroscopy experiments at the Superconducting Separator Spectrometer (S3): Conceptual studies and preliminary design”, NIM B, 3187B, 570-581 (2014).

[3] Noel T. Clemens, Encyclopedia of Imaging Science and Technology by Joseph P. Hornak, A Wiley-Interscience Publication, p. 390 - 419, 2002.

Figures used in the abstract

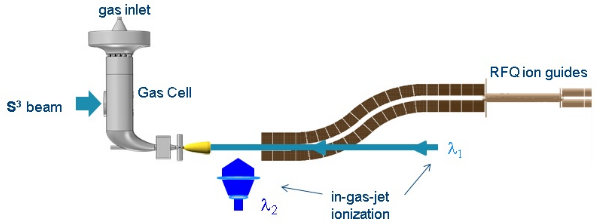

Figure 1: Experimental layout.

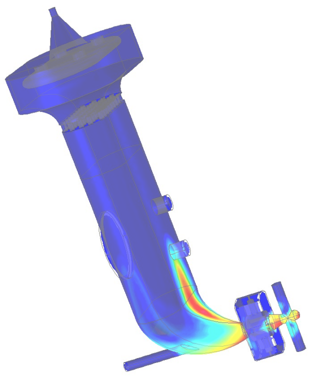

Figure 2: Optimized shape of the gas cell.

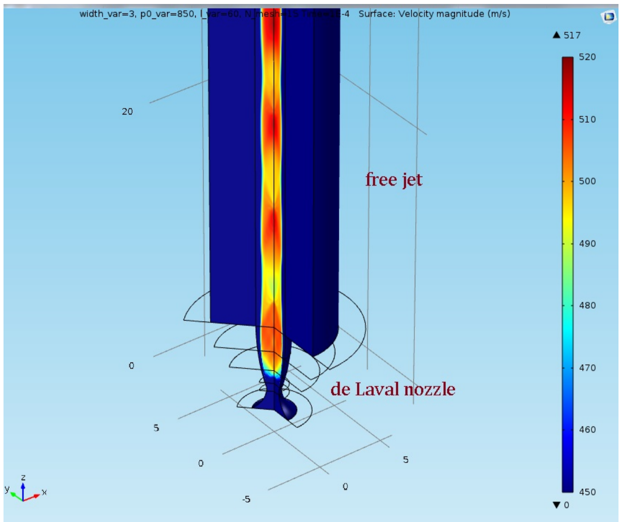

Figure 3: Velocity profile for the 'de Laval' nozzle.

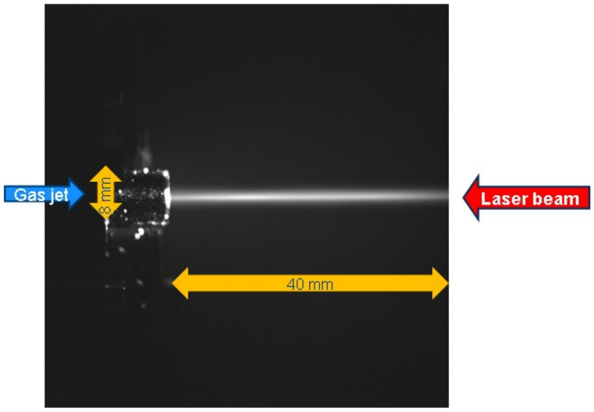

Figure 4: PLIF-image of the supersonic gas jet.