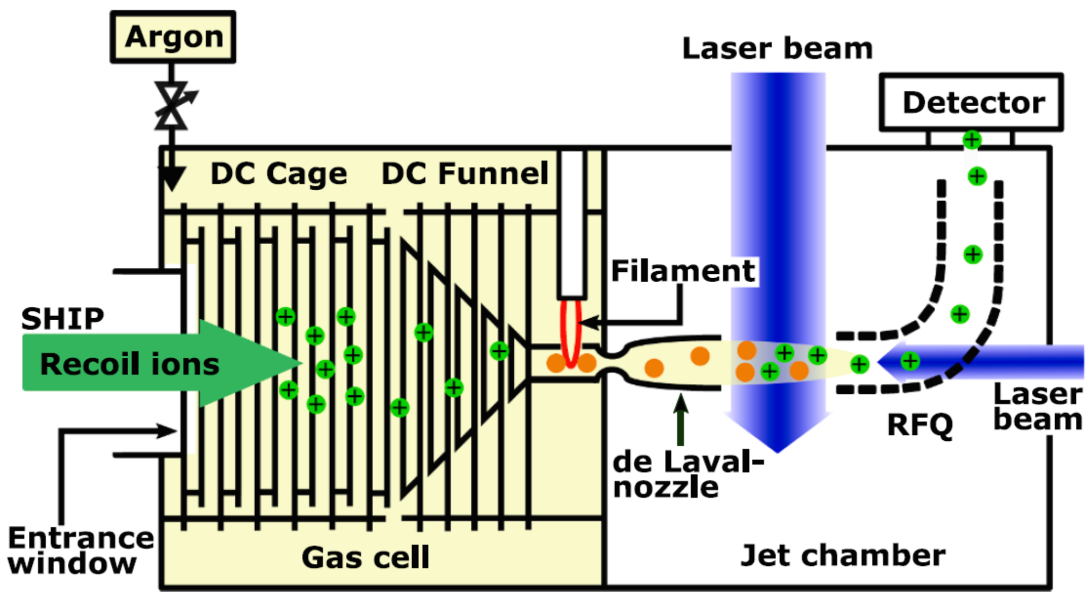
<u>LISA Gas Jet Fluorescence Measurements</u>

Summary

Laser spectroscopy is a powerful tool for studying fundamental properties of the nucleus. With sufficient resolution, information about the size and shape of the nucleus can be determined through interactions with the electron. At the edges of the chart of the nuclides, production rates fall very quickly and very sensitive techniques are required. One such technique is RAdiation Detection Resonance Ionization Spectroscopy (RADRIS), where ions are neutralized on a filament, which is then heated to produce vapor that is subsequently ionized and detected through radioactive decay. The RADRIS technique allows studies of isotopes with production rates of less than 1 per second, but has a resolution of a few GHz. We are developing a new technique incorporating a de Laval nozzle to produce a low temperature jet of atoms for high resolution spectroscopy, on the order of a few hundreds MHz. During the LISA training, we will examine properties of the de Laval nozzle.

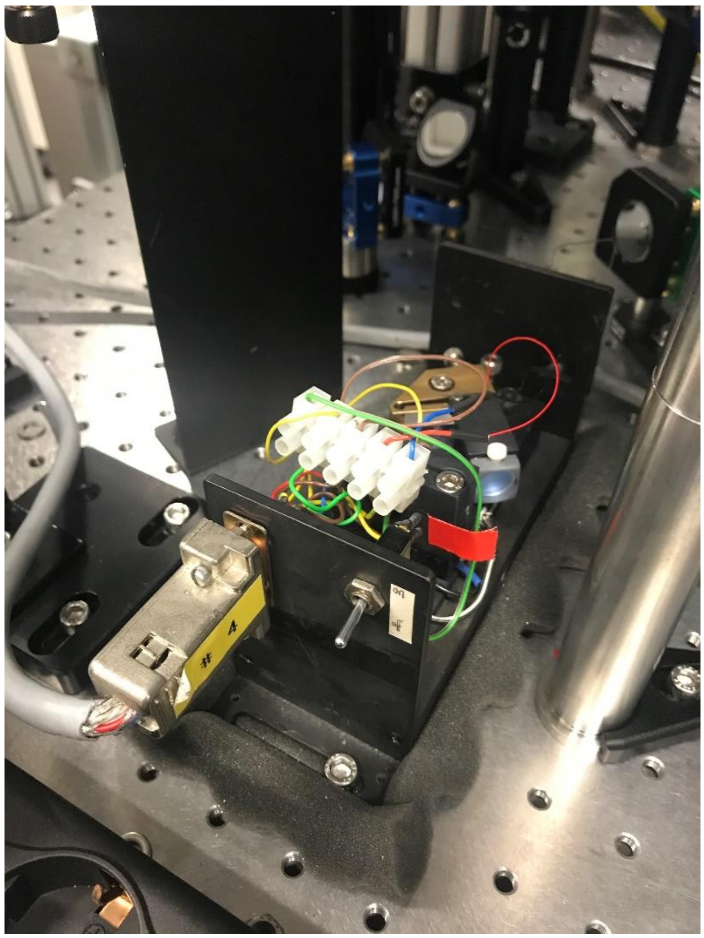


1. Schematic of the gas jet system

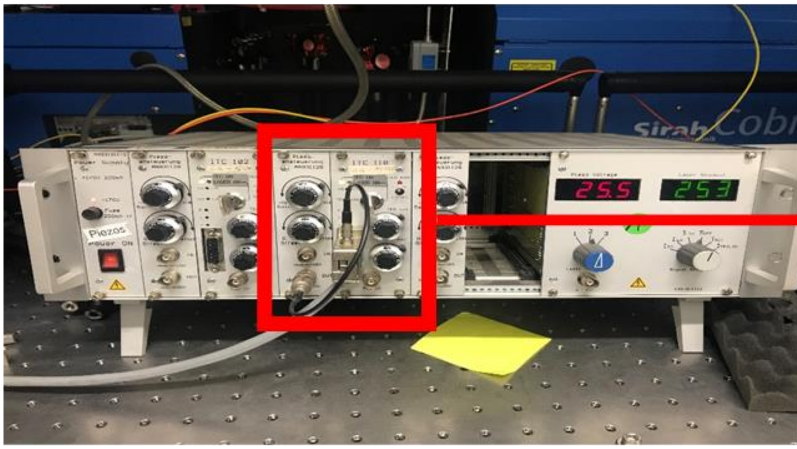
I. Effect of Stagnation Pressure on Spectroscopic Resolution

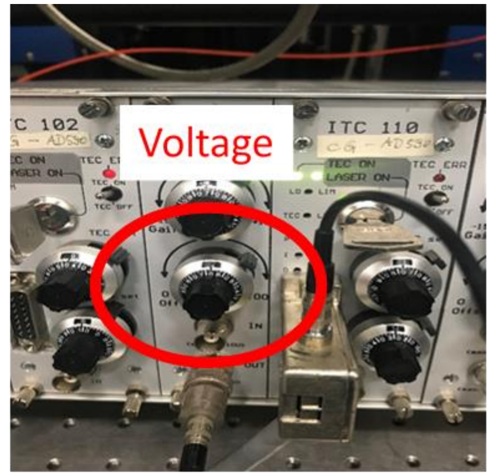
The participants will use a small diode laser and a camera to perform fluorescence spectroscopy of the 24708.971 cm^{-1} transition in Dy I. The frequency of the diode laser will be scanned across the resonance and the effect of the stagnation pressure on the linewidth of the transition.

A. Required Tools
    a. Diode Laser
    b. Wavemeter
    c. Gas Flow Controller
    d. Thorlabs Camera
    e. Laser Optics
B. Basic Procedure
    a. The on-site participants will turn on the diode laser, checking that the frequency of the laser is roughly correct with a wavemeter, and checking that the light is roughly aligned to the center of the window, perpendicular to the path of the gas jet.

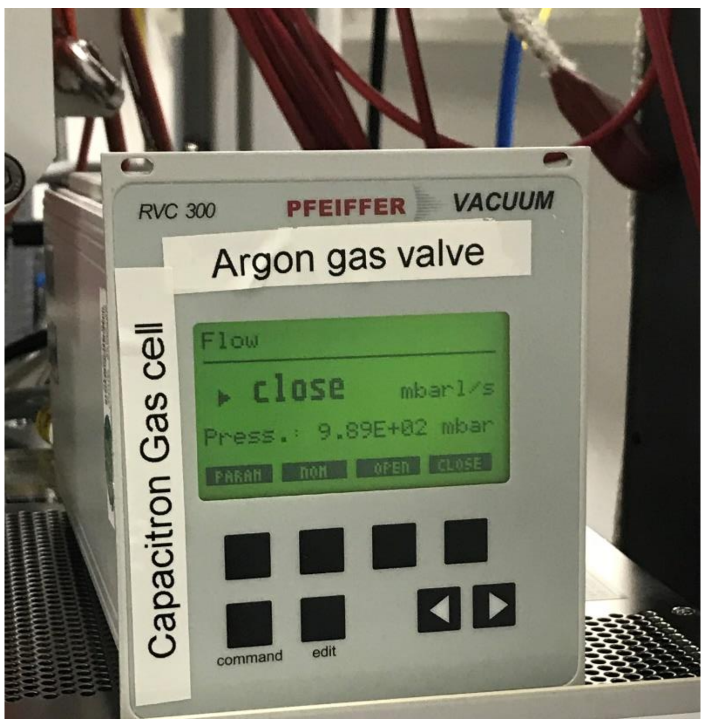


        i. The diode frequency can be changed by adjusting the applied voltage, circled in the figure below





b. Ar gas will flow into the gas jet chamber until a stagnation pressure of approximately 80 mbar is reached, using the controller shown below. The flow rate should not go above 7 mbar l/s until the stagnation pressure has stabilized.



c. The filament will be heated by increasing the current to approximately 8 A. The filament is controlled with the "Delta SM800 Main.vi" Labview program.

d. A Thorlabs camera will be used to capture the fluorescence, controlled on the local computer by the ThorCam program.

e. Slowly increase the filament current until fluorescence is observed.

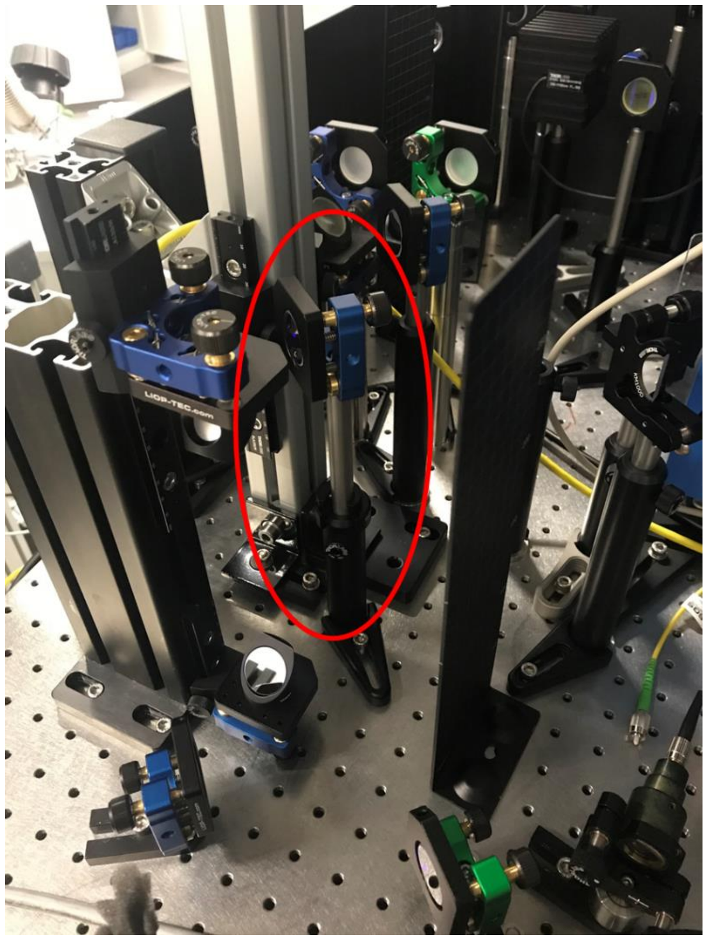
f. Perform measurements across the resonance by scanning the frequency to determine the linewidth of the laser.

g. Increase the pressure of the Ar gas to approximately 120 mbar and repeat the linewidth measurement.

II. Anticollinear Spectroscopy

The participants will perform in-gas jet spectroscopy with a different light path, where the laser light propagates anticollinearly with respect to the gas jet. The Doppler shift will be used to determine the speed of the gas jet, and if there is a difference in the observed linewidth compared to the previous measurements.

1. Basic Procedure
   a. The participants will remove a mirror from the optical layout, shown in the image below. The laser light should now enter the gas jet chamber from the end. Check that it is roughly aligned and that light can be seen on the camera.



   b. Based on the provided information about the nozzle, estimate how the Doppler shift should impact the observed resonance, searching for the fluorescence.
   c. After finding the resonance, perform a frequency scan

III. Analysis

The images captured by the Thorlabs camera can be analyzed using Python scripts provided in Anaconda. One script will extract the intensity of the light along specific regions of the image. A second script will be used to fit the resulting intensity as a function of frequency.

1. Basic Procedure
    a. The participants will use the provided Python scripts to extract the intensity of the fluorescence from the image.
    b. The participants can compare the data with and without a cut on the gas jet to examine how increased background light impacts the measurements
    c. The participants will determine what function to fit the linewidth data to, eventually determining if the stagnation pressure has a significant difference on the resolution of spectroscopy in the gas jet, as well as the speed of the gas jet.