**A08. Optical Spectroscopy ­– Experimental Plan**

**Team:** Student1, Student2, Student3

**Experimental goals:** In this experiment, we will use a grating spectrometer to perform basic optical spectroscopy on solid and gaseous samples. More specifically, we plan to:

1. Determine thickness and index of refraction of an unknown sample by resolving the etalon fringes as function of the relative angle between light propagation direction and sample surface.
2. Measure the fluorescence spectrum of a ruby sample and characterize its radiative decay lifetime by illuminating it with a chopped laser beam.
3. Measure the Raman spectra of gaseous H2 at standard pressure and variable temperature to determine a change in the relative concentration of ortho and parahydrogen states.

**Best experimental practices:**

1. Health safety: This experiment makes use of lasers and cryogenic liquids. Hence, we need to always wear appropriate goggles, rated for our laser intensity, and never look into the laser path. Special care must be used when aligning, as the path of the laser can be unknown and susceptible to sudden changes. Always keep the laser path on a well-defined plane on the table. When using cryogenic liquids, always wear appropriate protective gloves and face shields to guard again splashes. Make sure that the liquids have ways to safely expand in gaseous form, and that there is no pressure buildup. Check that the room is spacious enough to avoid suffocation due to the displacement of breathable air by the cryogenic gas volume.
2. Instrument damage: Never point the unattenuated laser beam into the CCD at zero order, as it might burn the CCD pixels. Do not touch optical components with bare hands to avoid surface contamination.

**Tentative experimental plan:**

1. Understand how the spectrometer and the data acquisition software works.
2. Characterize the noise sources of the experiment (dark noise, readout noise, Poisson noise). How to reduce them? What is a typical integration time for a publication-quality spectrum?
3. Verify that the grating spectrometer is calibrated. What is the calibration procedure? Is there a standard sample which I can use as a reference to verify that the instrument is properly calibrated?

**Etalon Fringes**

1. Let light into the spectrometer and acquire a reference spectrum. Verify that there are no fringes.
2. Place the unknown sample into the light path and verify that fringes can be resolved by the spectrometer.
3. Rotate the angle of incidence in increments of 5-10 degrees and record the spectrum.
4. Fourier-Transform the spectrum and extract the oscillation period. From this determine the thickness and refractive index.

**Ruby Lines**

1. Check the spectrometer calibration.
2. Place a ruby in the optical path
3. Align the argon ion laser so that it hits the crystal.
4. Insert a mechanical chopper with a frequency of 14 Hz between the laser and the ruby
5. Align the laser so that light scattered at 90 degrees goes into the spectrometer and directly transmitted light goes into a notch filter and a photodiode.
6. Acquire a high-quality ruby fluorescence spectrum.
7. Acquire the ruby fluorescence (frequency-integrated) with the photodiode as function of time and fit the decay.

**Hydrogen spectroscopy**

1. Check the spectrometer calibration.
2. Align a high power laser to excite the hydrogen gas.
3. Position the hydrogen sample in the beam at room temperature.
4. Acquire the Raman spectrum at room temperature. Is the signal-to-noise good enough? If not, acquire more!
5. After acquiring the RT spectrum, let’s move to low temperature. Wear appropriate PPE.
6. Expose the H2 gas to Apachi silica gel and submerge it into a canister filled with LN.
7. Acquire the Raman spectrum off the sample and compare to the RT one. Are there any differences?