

# ATM - Atomic Physics

## Signature Sheet

Student's Name \_\_\_\_\_ Partner's Name \_\_\_\_\_

### Suggested reading to start with:

1. Griffith, "[Introduction to Quantum Mechanics](#)":
  - 1) Chapter 4.2: Hydrogen Atom
  - 2) Chapter 5.1 & 5.2: Two Partical System (Helium)
  - 3) Chapter 7.4: Zeeman Effect
2. Thorlabs, "[Diffraction Gratings Tutorial](#)"
3. Thorlabs, "[Fabry-Perot Interferometer Tutorial](#)"

### Pre-Lab Discussion Questions

It is your responsibility to discuss this lab with an instructor before your first day of your scheduled lab period. This signed sheet must be included as the first page of your report. Without it you will lose grade points. You should be prepared to discuss at least the following before you come to lab:

1. Draw five diagrams before you answer your Pre-Lab Discussion Questions: (1) Energy level of hydrogen and the transition of Balmer Series. (2) Energy level of Singlet and Triplet Helium energy level. (3) Zeeman Effect from the Red line of Helium. (4) Setup of monochromator and the grating with some rays show how to select wavelength. (5) A Fabry-Perot inteferometer and the path of a light beam. Answer following questions based on your diagrams and correct/polish your diagram through preparing these questions.
2. What is the formula that gives the wavelengths of these lines for the simple Bohr hydrogen atom? What is the definition of Rydberg constant in this expression? How does the derivation of the energy levels in the Bohr model differ from the quantum mechanical methods and how quantum mechanics express **Rydberg constant** in Hydrogen model?
3. Write the following atomic state's abbreviation in "full spectroscopic notation" (the notation for states written in the  $n, l, j, m_j$  basis, described in the first instructional video). A hydrogen atom is in the  $n=3, l=2$  state. Note that there are 2 possible values for J. What do these quantum numbers mean?
4. Show the transitions that produce the red and yellow lines in the Helium diagram and explain what is singlet and triplet. What is the main difference of Helium model comparing to Hydrogen model?
5. When a 1 Tesla magnetic field is applied to helium, what happens to the energy levels and transitions that produce the red line of helium? Now give the physical meaning of **Bohr magneton**.
6. Explain how the grating works. Can we use zeroth diffraction order to separate lights of different colors? Would higher order diffraction orders affect the measurements? Calculate a representative value for the resolving power of the grating with given period/grating constant.
7. What gives a spectral line a non-zero width? Estimate the line width for the first Balmer series. Assume that the pressure inside the tube is 5 torr and the temperature 600K, and that the lifetimes of the states are about 10ns. (hint: consider the resolution of the spectrum, Doppler broadening and the time uncertainty principle, which one is the main factor?)

- Briefly explain how FB interferometer works. Calculate the resolving power of the interferometer. Why is it necessary to use the interferometer instead of the grating for observing the Zeeman Effect. Can we observe Zeeman effect through our monochromator?

Staff Signature \_\_\_\_\_ Date \_\_\_\_\_

Completed before the first day of lab? (Circle one) Yes / No

### Mid-Lab Discussion Questions

- On day 3 of this lab, you should have successfully produced a plot of the Balmer-series lines, and made an estimate of the Rydberg constant. Show them to an instructor, briefly explain how you corrected the result and ask for a signature.

Staff Signature \_\_\_\_\_ Date \_\_\_\_\_

Completed by day 3 of lab? (Circle one) Yes / No

- On day 5 of this lab, you should have successfully observed the Zeeman splitting of the helium lines and estimated a value for the Bohr magneton. Demonstrate this to an instructor, explain the strategy you are using to measure the Bohr magneton and ask for a signature.

Staff Signature \_\_\_\_\_ Date \_\_\_\_\_

Completed by day 5 of lab? (Circle one) Yes / No

### Checkpoint Signatures

- Preparation

Staff Signature \_\_\_\_\_

2. Peak Finding

Staff Signature \_\_\_\_\_

3. Additional Questions

Staff Signature \_\_\_\_\_

4. Zeeman Picture

Staff Signature \_\_\_\_\_

5. Zeeman Splitting

Staff Signature \_\_\_\_\_