5. Experimental Objectives

1) Observe Zeeman effect to understand atomic magnetic moment and spatial quantization in atomic physics;
2) Observe the splitting and polarization of a Mercury atomic spectrum at 546.1 nm;
3) Calculate the charge-mass ratio of an electron from Zeeman splitting amount;
4) Learn how to adjust an F-P etalon and apply a CCD device and image analysis software in spectroscopy.

6. Experimental Procedures

1) Mount the pencil Hg lamp into the magnet: refer to Figure 5, first insert the lamp holder into the mounting hole on the top of the magnet and use the nut to lock it from inside; then remove the protection tube of the Hg lamp and insert the lamp into the holder; finally set a proper height of lamp in the magnet and use the screw to fix it in place.

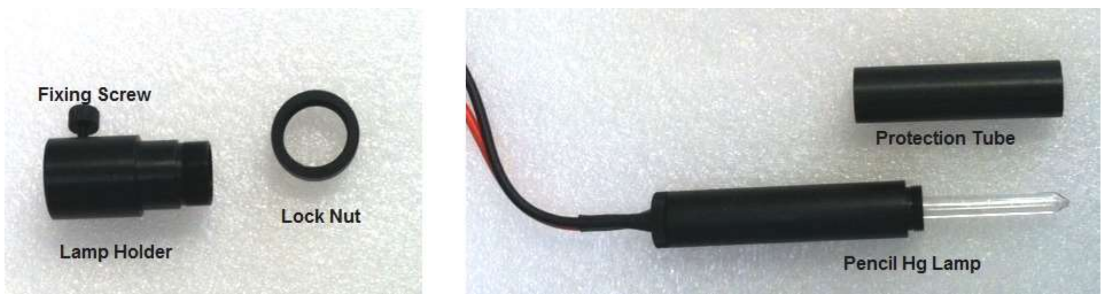
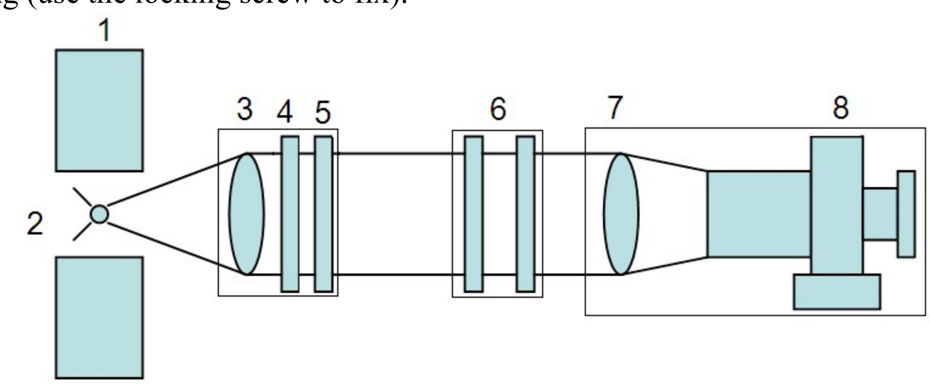


Figure 5 Photos of Hg lamp and holder

2) Refer to Figure 6, place all optical components, adjust them to the same height on a common optical axis (the reference point of the overall height is the center of the magnetic pole); turn on the Hg lamp. **Note**: Condensing lens, 546 nm filter, and polarizer are mounted together in one holder. The imaging lens and the microscope eyepiece are mounted together and the imaging lens can be shifted along the tube for focusing (use the locking screw to fix).



1. Magnet	2. Hg Lamp	3. Condensing Lens	4. Filter
5. Polarizer	6. F-P Etalon	7. Imaging Lens	8. Microscope eyepiece

Figure 6 Schematic of experimental setup

3) The F-P etalon was pre-adjusted at factory. In need of re-adjustment, only instructors or technicians are allowed to adjust the three screws with great care.

4) The spectral line splitting phenomenon can be seen through the microscope for each group rings. By rotating the polarizer to 0°, 45° and 90°, different polarization states of π component and σ component can be observed.

5) By setting the polarizer to a proper angle, three splitting rings of each interference order can be clearly seen through the microscope, as shown in Figure 7. Use the reading microscope to measure the diameters of the four rings, as D_c, D_b (i.e. D_{K-1}), D_a and D_K. Use the Teslameter to measure the magnetic induction B in the central area of the magnet. Substitute these data into (27) and (28), the wave number difference and the charge/mass ratio of an electron can be calculated accordingly. Measurement error can also be calculated.

6) If the apparatus is equipped with a CCD camera with an image grabber and analysis software, replace the microscope and the imaging lens (seen in Figure 6) with the CCD camera (with camera lens), interference pattern can be acquired and analyzed with the software. Please read software instruction in Appendix.

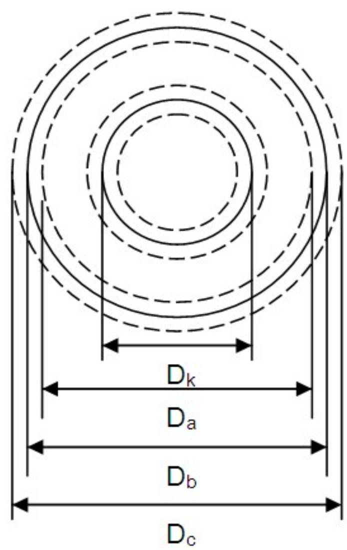


Figure 7 Splitting rings and diameter measurement

Note: Ideally, the lamp should be at the focal point of the condensing lens to form a collimated beam for the F-P etalon. However, this arrangement will produce an interference pattern of non-uniform brightness, i.e. a narrow vertical strip of the lamp tube. So, in practice, it is better to place the condensing lens either closer to or farther from the lamp, and then find proper positions as well as proper orientations of other components to achieve uniform, sharp, bright, and symmetrical interference pattern.

There are many factors that may have influences on the interference image quality. Careful alignment of the optical path is needed. Be patient and thoughtful to observe the changes of the interference image during adjustment of the optical path. Also, a good parallelism of the F-P etalon is very important. However, only an instructor is allowed to do the adjustment to restore the parallelism of the F-P etalon.

Sample experimental data (for reference purpose, not the criteria of apparatus performance)

Sample Data (unit: mm)

	D_c	D_b （D_{K-1}）	D_a	D_K
Left side	1.292	1.410	1.546	2.936
Right side	7.422	7.284	7.146	5.688
diameter	6.130	5.874	5.600	2.752

Use a Teslameter to measure the magnetic field at central region, $B = 1.301$ T, while F-P gap $d = 2$ mm, so we have $M_2g_2\text{-}M_1g_1 = 1/2$;

Substitute the data into equation (28): $\frac{e}{m} = \frac{\pi \cdot c}{(M_2g_2 - M_1g_1)Bd}(\frac{D^2{}_c - D^2{}_a}{D^2{}_{K-1} - D^2{}_K})$, we got

$e/m = 1.6923 \times 10^{11}$ C/kg.

The recognized value is: $e/m = 1.7588 \times 10^{11}$ C/kg.

So the measurement error is: 3.8%.