5. Objectives of Experiment

1) Observe Zeeman effect, 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 electron charge-mass ratio based on Zeeman splitting amount;
4) Learn how to use a Fabry-Perot etalon;
5) Measure the magnetic field in the central region of an electromagnet with a Tesla meter, analyze its linear range.

6. Experimental Procedure

1) Refer to Figure 5, place all optical components except the polarizer on the optical rail, adjust them to the same height (i.e. the central height of the magnet poles) on a common optical axis; turn on the mercury lamp.
2) Moving the microscope to the back focal plane of the imaging lens, interference fringes should be observed through the eyepiece. Finely adjust the F-P direction or tilt as well as the positions and heights of other relevant components to achieve optimal fringe pattern. Note: though the F-P etalon was pre-adjusted at factory, its parallelism may be altered during transportation. Prior to experiment, the instructor needs to confirm or adjust the F-P device to be in good parallelism. Without the instructor's permission, students should not re-adjust the parallelism of the F-P device.

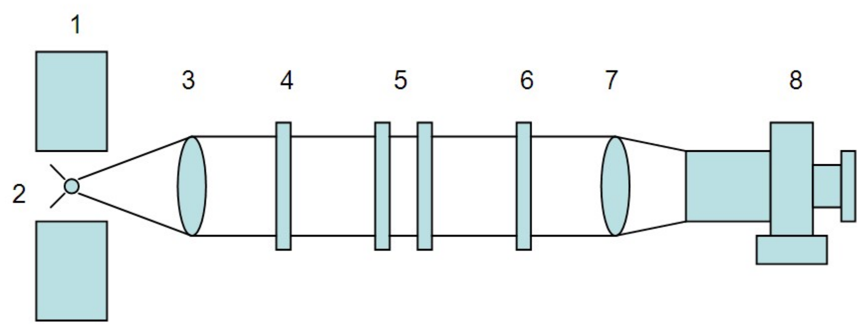

Figure 5 Schematic of Zeeman experiment setup

1. Magnet	2. Mercury lamp	3. Condensing Lens	4. Filter
5. F-P etalon	6. Polarizer	7. Imaging Lens	8. Microscope

3) Turn on the power supply of the electromagnet, set current at a mediate value (e.g. 3A). Spectral splitting phenomenon can be seen through the microscope for each group of interference rings. By adjusting the intensity of the magnetic field through the current applied to the electromagnet, spectral splitting gets wider with an increase in the magnetic field. Now place the polarizer into the optical path and rotate it to different angles respectively, polarization states of π and σ components can be observed with relative angle differences 0°, 45°, or 90°.

   Note: the small aperture may be attached to the polarizer to achieve optimal contrast of the fringes. If the fringe pattern is too dim, either adjust the optical path to improve fringe brightness or remove the small aperture.

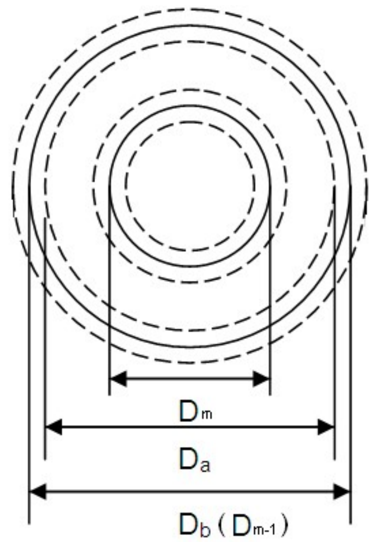

Figure 6 Split rings of Mercury green line at 546.1 nm after applying magnetic field

4) By rotating the polarizer, three split rings of each order of the interference pattern can be clearly seen through the microscope, as seen in Figure 6. Use the reading microscope to measure the diameter of the three rings, written as D_b (i.e. D_{m-1}), D_a and D_m. Use the magnetic field meter (Teslameter) to measure the magnetic induction B in the central area of the magnet. Substitute the data into (26) and (27), the wave number difference and electron charge/mass ratio can be calculated.

5) If CCD camera, USB frame grabber, and analysis software are ordered, the microscope and the imaging lens as seen in Figure 5 should be replaced with the CCD (with lens) to acquire the image that is then analyzed using the analysis software. Again, if CCD gets saturation or want to improve fringe contrast, please reduce lens aperture or attach the small aperture to the polarizer. Please read software instruction in Appendix with a demo video provided from the CD.

   Note: for first time use, one needs to install the USB driver for the frame grabber (blue box), please refer to "Installation Note of USB Driver for MV-U2000 Frame Grabber" on the provided CD.

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 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 may have influences on the interference image quality. Careful alignment of the optical path is needed. Be patient and thoughtful to observe the change of the interference image during adjustment of the optical path.

Reference data (information purpose only; not the performance criteria of apparatus)

A set of reference data is recorded in the table below (unit: mm):

	D_b（D_{m-1}）	D_a	D_m
Left side reading	1.410	1.546	2.936
Right side reading	7.284	7.146	5.688
diameter	5.874	5.600	2.752

Use the Teslameter to measure the magnetic field at central region, B=1.301 T; with F-P gap d＝2 mm; and M_2g_2-M_1g_1=1/2; substitute the data into equation (27), we get e/m=1.6923×10^{11} (C/kg) while the recognized value is: e/m=1.7588×10^{11} (C/kg).

The measurement error is: 3.8％.