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.

6. Experimental Procedure

A. Transverse (normal) Zeeman effect

1) Place the rail on a solid table and adjust it to level horizontally.
2) Place the electromagnet at one end of the rail. Lock its rotary axis by using the locking screw on the side of the base. Connect the power supply to the electromagnet.
3) Place the Mercury lamp between the poles of the electromagnet by inserting the lamp base mount into the dovetail on the base of the electromagnet. Turn on the lamp.
4) Remove the polarizer from the holder of the condensing lens (the fixing screw is on the top of the holder). Refer to Figure 4, place all optical components except the polarizer on the optical rail, adjust them to the same height on a common optical axis.

   Note: place the F-P assembly onto its support stage with the metal protection strip by fixing the strip onto the top of the two posts on the stage using two M3 thumb screws.
5) The F-P etalon has been pre-adjusted at factory, so there is no need to readjust it. (If the two surfaces are not parallel, only an experienced instructor or technician is allowed to realign the F-P, as described in Appendix). Bright interference concentric rings can be observed from the eyepiece, as seen in Figure 5.

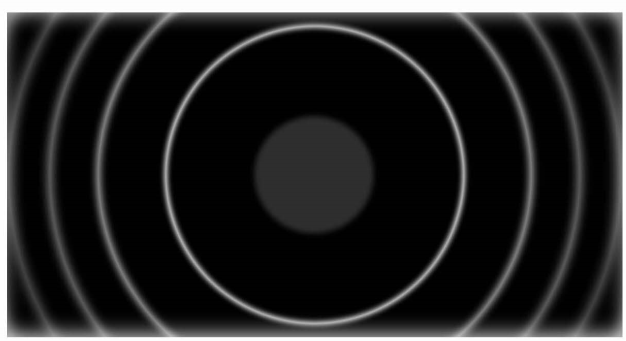


Figure 5 Interference pattern in the absence of magnetic field

6) Turn on the power supply of the electromagnet. Spectral splitting phenomenon can be seen through the eyepiece for each group of rings as shown in Figure 6. 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 *B*.

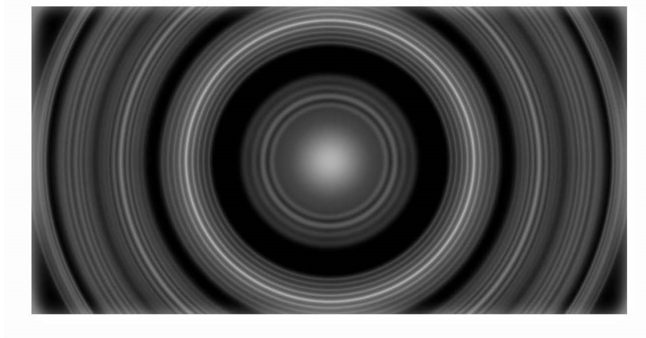
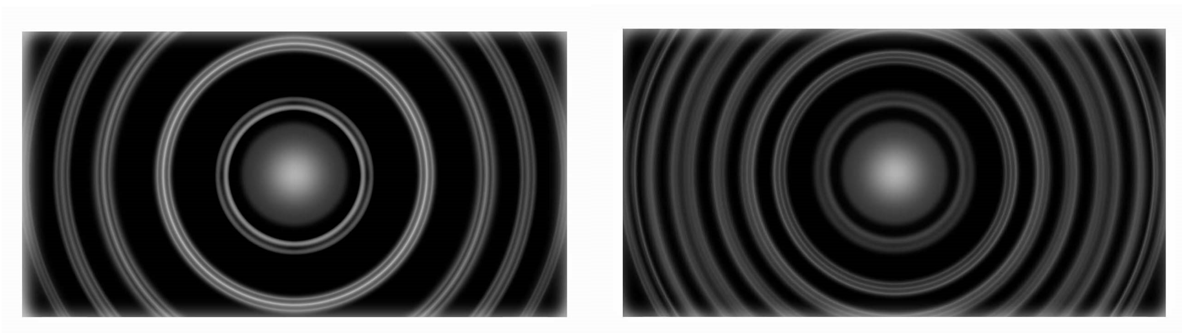


Figure 6 Interference pattern in the presence of magnetic field

7) Now mount the polarizer onto the holder of the condensing lens and rotate the polarizer, polarization states of π component and σ component can be observed (see Figure 7).



(a) (b)

Figure 7 Zeeman π component (a) and σ component (b)

8) As shown in Figure 8, use the eyepiece to measure the diameters of 3 rings of π component, 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.

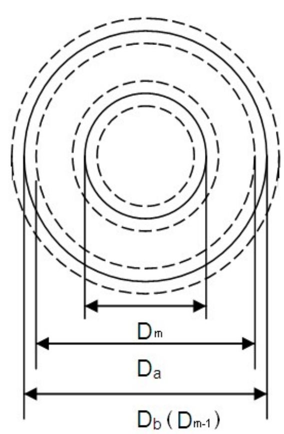


Figure 8 Split rings of Mercury green line at 546.1 nm after applying magnetic field

B. Longitudinal Zeeman effect

1) Pull the rod inserted in the pole of the electromagnet out. Rotate the magnet by 90° to let the open hole of the magnet face the optical rail.
2) Rotate the Mercury lamp to let it shine through the open hole of the magnet pole.
3) Arrange other components to build the setup same as the previous experiment.
4) Attach the λ/4 wave plate onto the open hole (the mount of the λ/4 wave plate has small magnetic disks), so that the circularly polarized light is converted to linearly polarized light. The white mark line on the mount indicates the direction of the slow axis of the wave plate.

   Note: (1) the direction of slow axis is marked using a red dot on the edge of the glass plate inside the mount. It has been aligned with the white line on the mount at factory. (2) since the hole in the magnetic pole is small, the condensing lens is not necessary, and therefore can be removed.
5) Rotate the polarizer by 45° clockwise, one group of the split spectral lines disappears; rotate the polarizer by 45° counterclockwise, the group of the disappeared spectral lines comes back but the other group of spectral lines disappears. This confirms that the split two groups of spectral lines are left and right circularly polarization beams, respectively.

Note*: The power supply for the electromagnet has automatic overheating protection. If it is automatically turned off, wait a moment to allow it to cool down before turning it on again. Do not operate it at large current for a long period of time, as otherwise the coils would overheat. Reduce current after each measurement or during idle of the experiment. Radiator at the rear should not be blocked out.* ***Do not exceed 5 A of current.***

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.

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

By applying a magnetic field, observe the transverse effects, and measure the diameters of the rings with a reading microscope. 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 the central region, B=1.201 T; with a F-P gap d=2 mm; and M_2g_2-M_1g_1=1/2; substitute the data into equation (27), we get

$e/m = 1.8333\times10^{11}$ (C/kg) while the recognized value is: $e/m = 1.7588\times10^{11}$ (C/kg).

So the measurement error is: 4.24％.