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 in both transverse and longitudinal directions;
3) Calculate the electron charge-mass ratio based on Zeeman splitting amount.
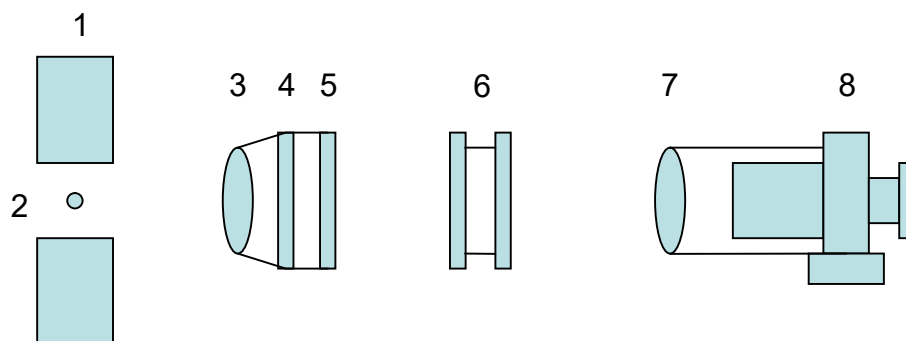
6. Experimental Procedures

Figure 5 Schematic of experiment setup for transverse Zeeman effect

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

A. Transverse (normal) Zeeman effect

1) Refer to Figure 5, place all optical components on the optical rail, adjust them to the same height on a common optical axis; turn on the mercury lamp.

2) Adjust the position of the imaging lens back and forth until a set of clear and bright concentric interference rings can be observed from the microscope eyepiece. Then use the fine adjustment screws on the two-dimensional adjustment mount to adjust the angle of the FP etalon to move the center of the concentric interference rings to the center of the field of view of the eyepiece.

3) Turn on the power supply of the electromagnet. Adjust the intensity of the magnetic field through the current applied to the electromagnet, while observing the change in spectral splitting through the microscope eyepiece.

4) Rotating the polarizer continuously, it can be seen that each interference ring is split into at most nine and at least three rings. Among them, the observed minimum three rings are the π lines for $\Delta M = 0$. At this time, further rotating the polarizer 90°, six split rings can be observed, which are the σ lines for $\Delta M = \pm 1$. The greater the magnetic field is applied, the wider the spectral line split will be.

5) Rotate the polarizer till 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 Dc, D_b (i.e. D_{K-1}), D_a and D_K. 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.
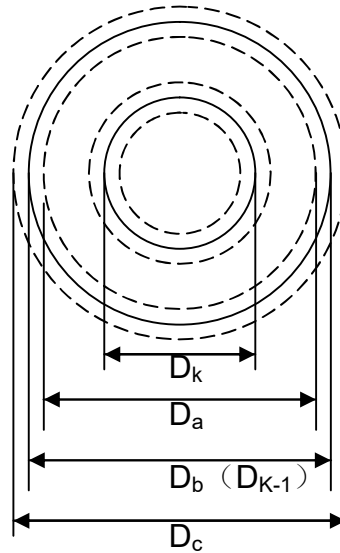

Figure 6 Split rings of Mercury green line at 546.1 nm after applying magnetic field

B. Longitudinal Zeeman effect

1) Refer to Figure 7, following the previous experiment, rotate the electromagnet by 90°, let the open hole of the magnet pole face the optical rail, and let the mercury light shine through the open hole.

2) Don't place the ¼ wave plate at this time. Arrange other components to build the setup same as the previous experiment. Observe the interference rings through the microscope eyepiece.
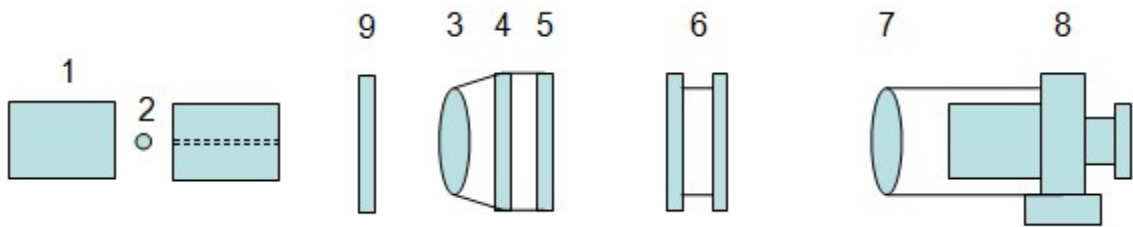

Figure 7 Schematic of experiment setup for longitudinal Zeeman effect

1. Magnet	2. Mercury lamp	3. Condensing Lens	4. Interference Filter
5. Polarizer	6. F-P etalon	7. Imaging Lens	8. Microscope
9. ¼ wave plate			

3) Turn on the power supply of the electromagnet. Adjust the intensity of the magnetic field through the current applied to the electromagnet, while observing the change in interference ring splitting. It can be seen that with the increase of the magnetic field, the split of interference rings becomes wider. Each interference ring splits into six, but

rotating the polarizer cannot change the number of interference rings, indicating that the polarization state of these spectral lines is circular polarization.

4) Place the λ/4 wave plate into the optical path as shown in Fig. 7, so that the circularly polarized light is converted to linearly polarized light.

5) Rotate the λ/4 wave plate to different angles, the two groups (i.e. inner side and outer side) of 3 interference rings will emerge and disappear alternatively. 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.*

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_c	D_b （D_{K-1}）	D_a	D_K
Left side reading	6.311	6.204	6.091	4.945
Right side reading	0.062	0.171	0.277	1.418
diameter	6.249	6.033	5.814	3.527

Use the Teslameter to measure the magnetic field at central region, B=1.105 T; with F-P thickness d=1.40 mm and refractive index n=1.46; and M_2g_2-M_1g_1=1/2; substitute the data into equation (27), we get e/m=1.8280×10^{11} (C/kg) while the recognized value is: e/m=1.7588×10^{11} (C/kg).

The measurement error is: 3.9％.

7. Appendix: LEAI-21A Software User Instruction

In Figure 5, replace the imaging lens and the reading microscope with the CCD and camera lens. The interference pattern is acquired by PC through the CCD camera via a USB frame grabber. For initial use, the USB driver of the frame grabber needs to be installed as follows (USB2.0 port is required):

For Windows-7/32-bit PC:

(1) Connect the USB plug of the frame grabber to one USB port of the PC.
(2) Installation of device driver will be automatic, or manually locate the driver software to folder "Driver32" on the CD.
(3) Copy "devwdm.ax" and "devwdm.dll" from folder "ZEEMAN EFFECT VCH7.0" on the CD to folder C://WINDOWS/SYSTEM32.
(4) Click the Start Button, type "CMD" in the "Search" box, but DO NOT hit "Enter" yet.
(5) Under "Programs" right-click on "CMD" and choose "Run as Administrator", then

click "Continue".

(6) In the black command line window, enter "Regsvr32 devwdm.ax" to complete registration.

For Windows-7/64-bit PC:

(1) Connect the USB plug of the frame grabber to one USB port of the PC.

(2) Installation of device driver will be manual by locating the driver software to folder "Driver64" of the provided CD (refer to the "**Installation Note of Frame Grabber**").

(3) Copy "devwdm.ax" and "devwdm.dll" from folder "ZEEMAN EFFECT VCH7.0" on the CD to folder C://WINDOWS/ Syswow64.

(4) Click the Start Button, type "CMD" in the "Search" box, but DO NOT hit "Enter" yet.

(5) Under "Programs" right-click on "CMD" and choose "Run as Administrator", then click "Continue".

(6) In the black command window, enter "Regsvr32 c:/windows/sysWOW64/devwdm.ax" to complete registration.

Now the interference pattern can be acquired by the Zeeman program.

1) Run the program

Open the file folder where the software is stored. Double click the executable file "ZEEMAN EFFECT VCH7.0" to run the program. Program window will pop up.

2) Menu functions

A Demo video "Demo" can be found on the CD provided.

The menu bar consists of these sub-menus: File, Edit, Option, Set up, Calculate, and About.

(1) "File" menu: to open/save/export file, or exit program

(2) "Option" menu: select command from this menu to select working mode "Preview" or "Capture". There are also two tabs under the menu bar, i.e. "Preview" and "Capture." After executing command "Preview" by selecting it from the menu, click tab "Preview" to display the window of real time image. After executing command "Capture," the collected image will be displayed in current window (under tab "Capture"), and then this image can be further operated by executing relevant commands from the menu bar.

(3) "Setup" menu: to modify image brightness, contrast, etc.

(4) "Edit" menu: only effective for the captured image, includes these commands:

a) Zoom in, Zoom out and Pristine size: for image size operations.

b) Move: move the image position on the panel

c) Mark: determine the centers and positions of required interference rings as seen in Fig. 7. First, mark three points on the central ring of the mth order, the track and the center of the ring are determined automatically; second, mark one point on each ring of the three rings of the $(m-1)^{th}$ order. The diameters of the selected rings, i.e. D_b (D_{m-1}), D_a and D_m, are calculated and displayed on the panel (left-lower portion).
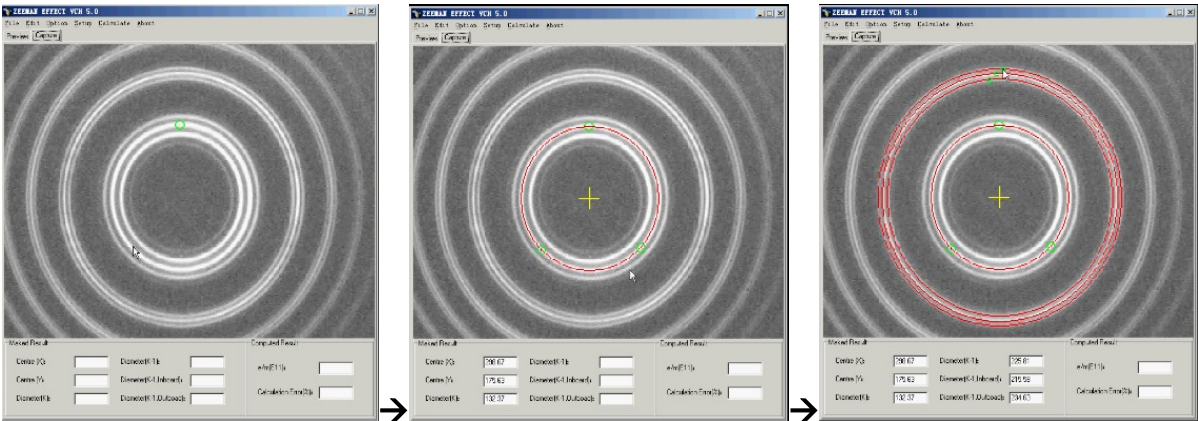
Figure 7 Fringes acquired by CCD camera

(5) "Calculate" menu: input parameters such as F-P spacing and magnetic field to calculate *e/m* and display results on panel (right-lower portion).