LDS Experiments

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Third Lab Report for PHYS403

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Abstract

This document reports one laser diode spectroscopy (LDS) experiment.

Introduction

Laser Diode Spectroscopy

Spectroscopy is an analytical technique used to identify and measure the characteristics of materials, such as the composition, structure and properties of molecules, atoms, or ions. It is usually used to study the interaction of light with matter. Laser diodes are special types of semiconductor diodes that produce light due to stimulated emission of radiation. Laser diode spectroscopy is the application of laser diodes in the field of spectroscopy. It is used to measure the optical properties of materials, such as the wavelength and angular distribution of light emitted from the material.

Population Inversion

Population inversion is a key concept in laser diode spectroscopy. It is a state in which the number of excited atoms or molecules is more than the number of unexcited atoms or molecules. This is achieved by pumping energy into the material to increase the number of excited atoms or molecules. Once the population inversion is achieved, stimulated emission of radiation occurs, resulting in the emission of laser light. Thus, population inversion is essential for the operation of laser diodes.

Piezo Modulation

Piezo modulation in laser diode spectroscopy is a technique used to measure the optical properties of materials. In this technique, a laser diode is modulated with a voltage applied to a piezoelectric transducer, which causes the diode to produce a beam of light with a changing frequency. This changing frequency is then used to measure the optical properties of the material that the laser is focused on. The optical properties of the material can then be used to determine the composition of the material, its optical bandgap, and other important characteristics. This technique is useful for research in the fields of physics, chemistry, and materials science. It is especially useful for the study of nanostructured materials, as the changing frequency can be used to study the properties of individual nanostructures. Additionally, this technique can be used to measure the optical properties of materials under different environmental conditions, such as temperature, pressure, and irradiance.

Resonance Fluorescence Spectroscopy

One type of laser spectroscopy is resonance fluorescence spectroscopy. In this technique, a laser is used to excite the atoms or molecules in the sample, causing them to emit light. The energy of the emitted light is measured, and this can be used to determine the energy levels and other properties of the atoms or molecules.

Rubidium is a chemical element with the symbol Rb and atomic number 37. It is a soft, silvery-white alkali metal that is highly reactive and is often used in laser spectroscopy experiments. When excited by a laser, rubidium atoms can emit light in the form of fluorescence. By measuring the energy of the emitted light, it is possible to study the energy levels and other properties of rubidium atoms.

1 Part I: Direct Detection

In this part of the experiment, we will emit a laser through a Rubidium cell, and will detect the Rb fluorescence. This method will allow some error in our measurement, and we shall address it in the next part of this report.

1.1 Experimental Setup

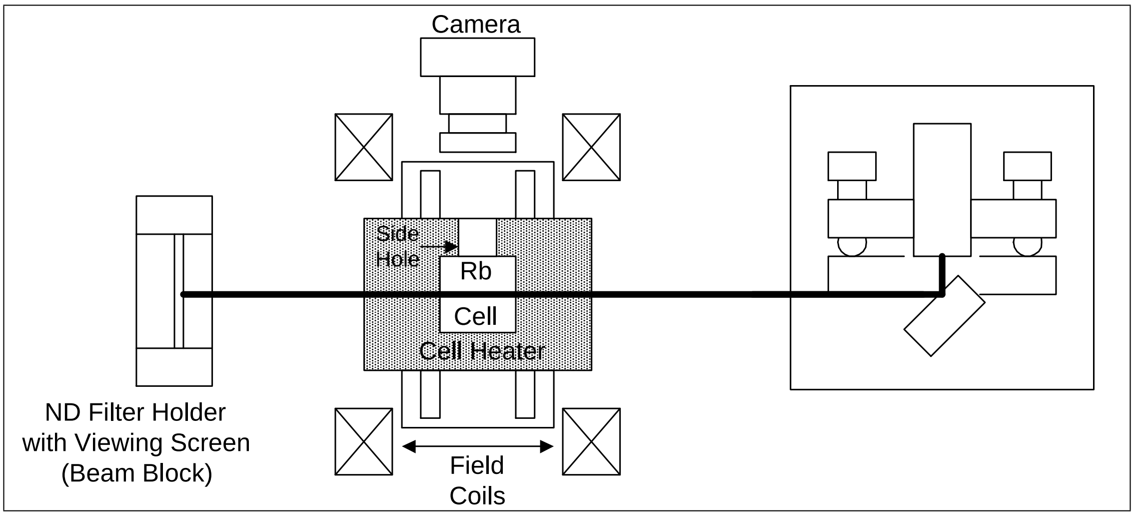

Figure 1: Experimental Setup for Direct Detection

1.2 Results & Discussion

After the laser go through the Rb cell, some of it will be absorbed, and we can detect that. We need to use filters to help getting the absorption spectrum clearer on the oscilloscope. At $50°C$, we obtained this absorption spectrum:

Figure 2: Absorption Spectrum of Rb Sample at $50°C$

Next, we will subtract the frequency pulse from the absorption spectrum, to get this result:

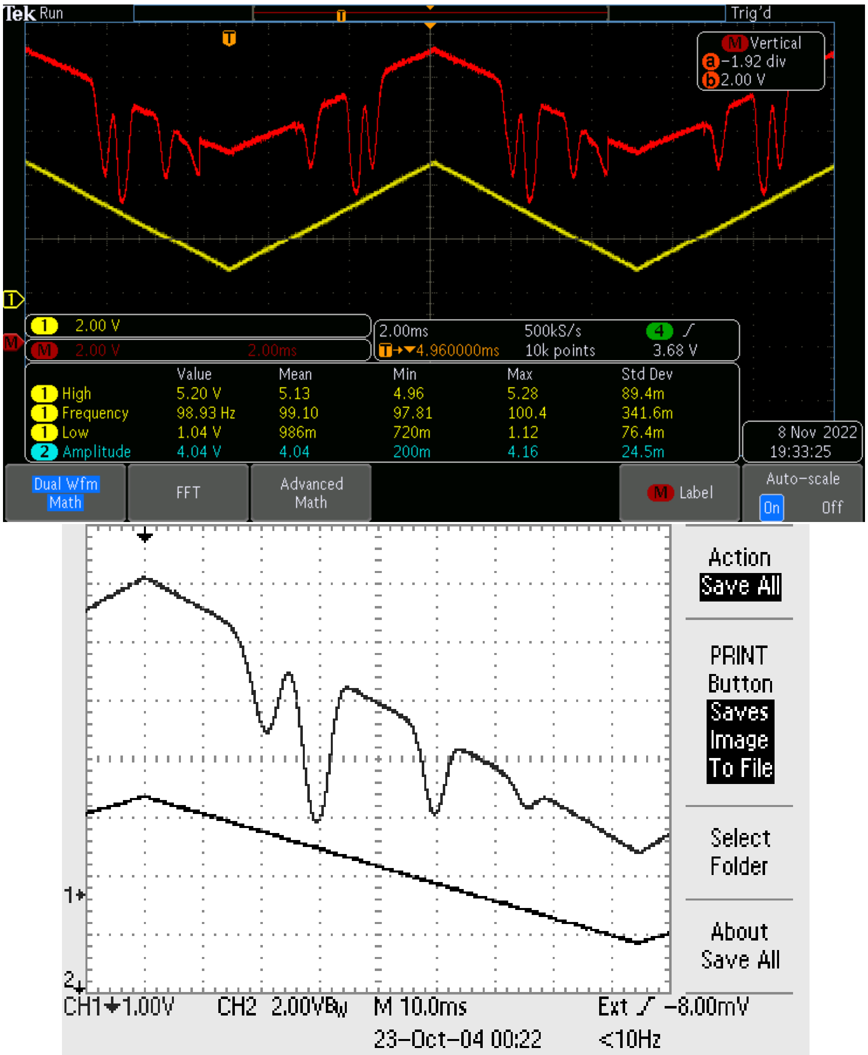

Figure 3: Absorption Spectrum of Rb Sample Compared to Lab Manual

Next thing, we increased the temperature to $100^{\circ}C$, and detected the absorption spectrum:

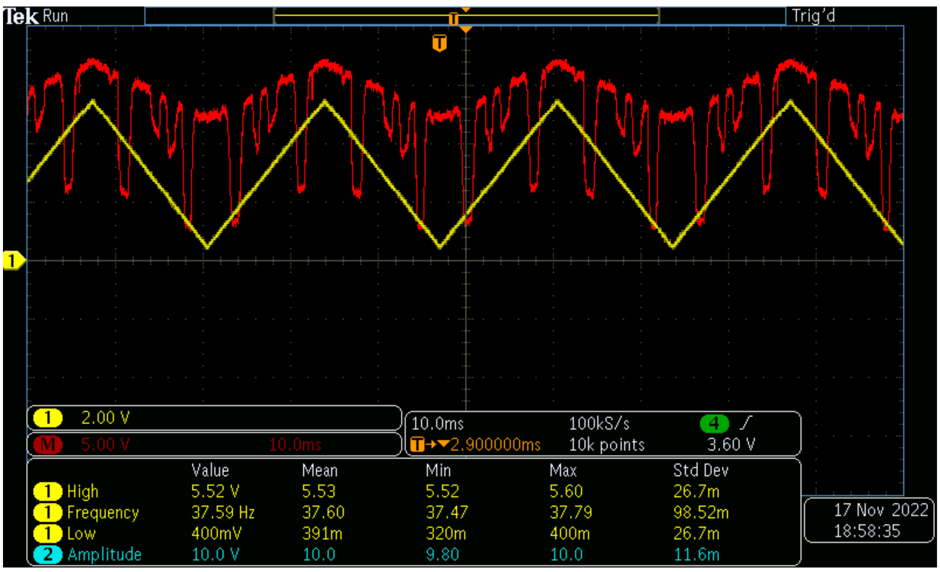

Figure 4: Absorption Spectrum of Rb Sample at $100^{\circ}C$

2 Part II: Direct + Indirect Detection

In order to address the error caused by the background, we will reroute the laser using a beam splitter that will split 50% of the beam and redirect it. By doing so, we will be able to subtract the background noise using the oscilloscope.

2.1 Experimental Setup

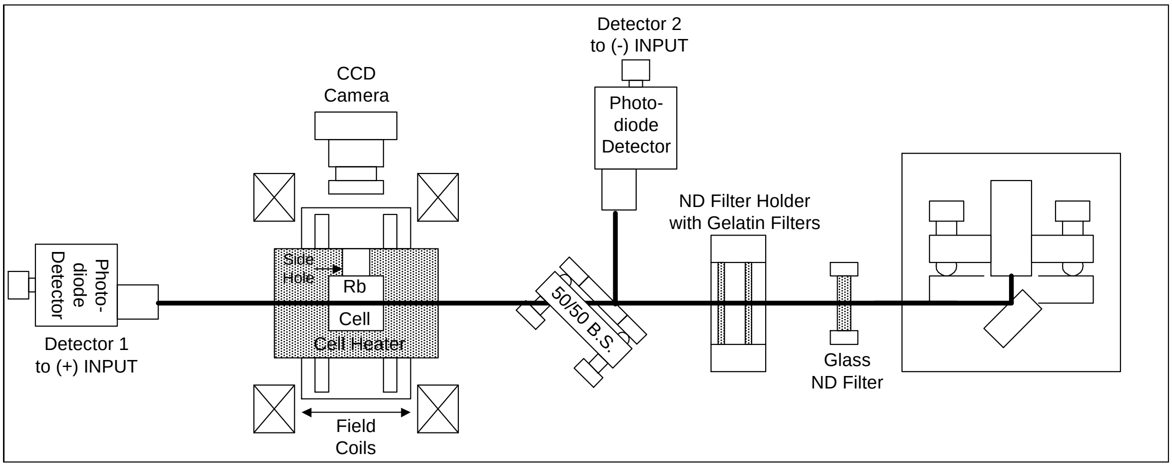

Figure 5: Experimental Setup for Direct Detection

Using this setup, we repeated everything we did in Part I. The results:

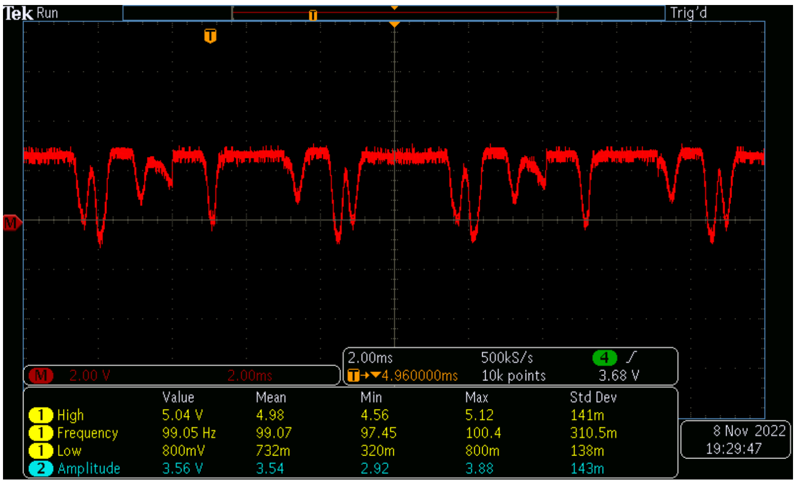

Figure 6: Absorption Spectrum of Rb Sample After Removing Background Noise at 50°C

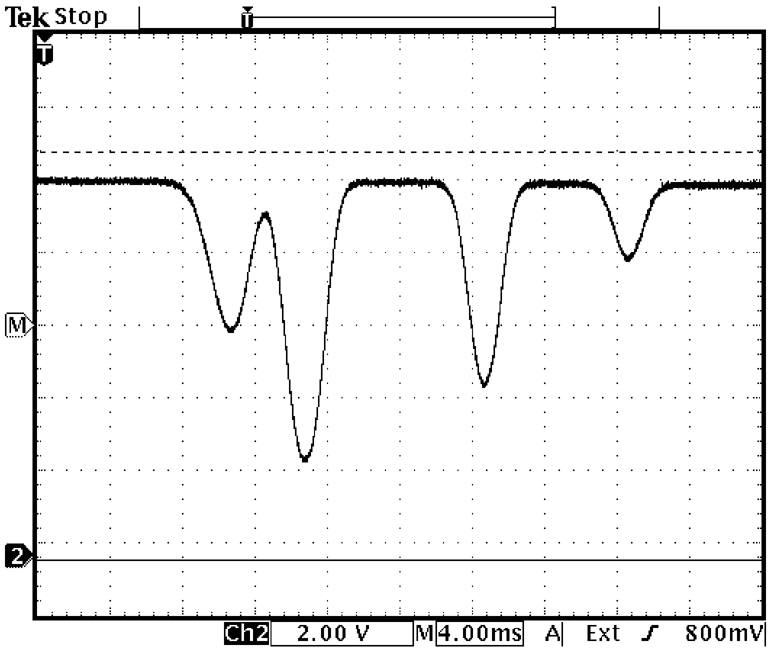

Figure 7: Lab Manual's Results for Figure 6

Finally, we increased the temperature and repeated the same thing, yielding this results:

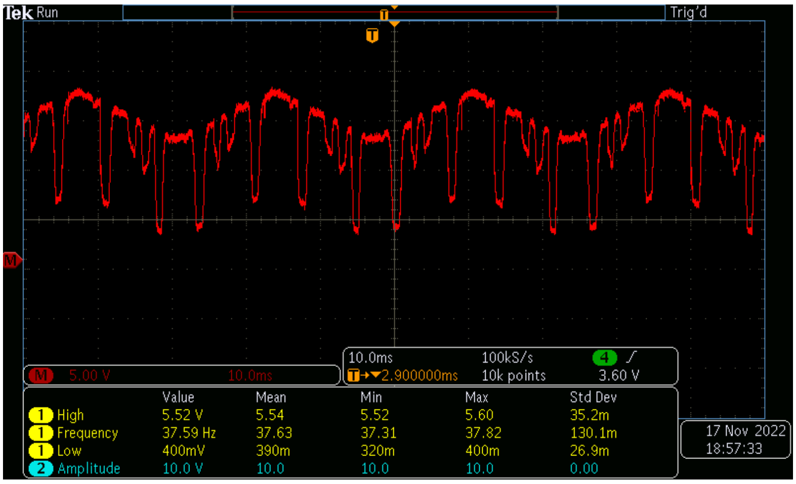

Figure 8: Absorption Spectrum of Rb Sample After Removing Background Noise at 100°C, Subtracted From the Frequency Pulse

3 Conclusion

In conclusion, laser diode spectroscopy is a useful tool for qualitatively determining the absorption spectrum of rubidium. By using a laser diode to excite the sample and measuring the emitted light, the absorption spectrum of rubidium can be accurately determined. This technique is accurate, fast, and cost-effective, making it an ideal choice for many applications.