Practical 5.
Spectrum of the He-Ne LASER

Equipment and accessories: the helium-neon laser, monochromator, neon lamp, and a screen.

1 Introduction

A helium-neon laser or HeNe laser, is a gas laser whose gain medium consists of a mixture of helium (85 %) and neon (15 %) gases contained at a low pressure inside of a tube. The best-known and most widely used HeNe laser operates at a wavelength of 632.8 nm, in the red part of the visible spectrum. A general schematic is shown in Fig. 1.

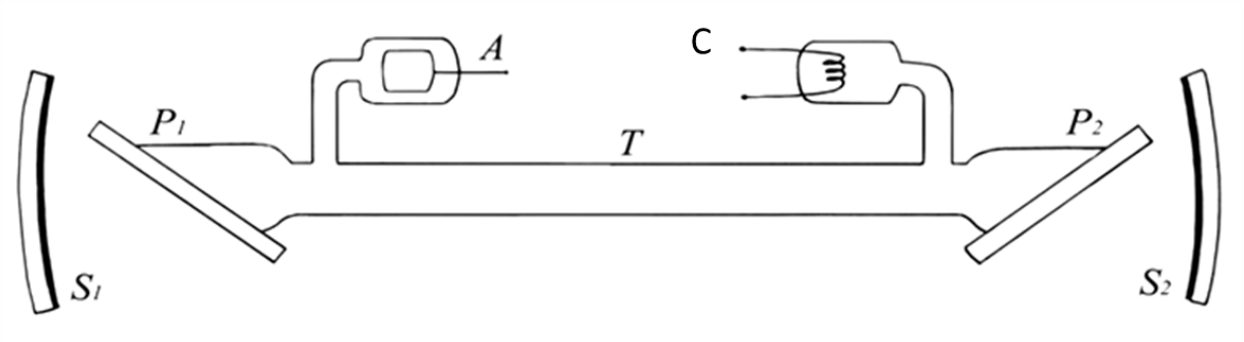

Figure 1: Schematic of a gas laser

2 Experimental setup

A schematic of the experimental setup is depicted in Fig. 2. In this practical the spectrum is studied with a special spectroscopic tool - *monochromator*. As a light source whose spectrum is analysed, a helium-neon laser (HNL) is used. Neon lamp (NL) is used as a reference source. The light from the source, focused by the lens (L) at the input slit of the monochromator, passes through the objective Ob_1 lens and is transformed into a parallel beam. Inside the monochromator, the light is dispersed by a prism (Pr) and the spectrum is focused by the objective (Ob_2) onto the plane of the pointer (Pt). The picture is observed with the aid of an ocular eyepiece (Oc) which is protected by a polaroid (Pl). During the work with a monochromator, you first have to focus the eyepiece, achieving a clear image of the pointer. Then rotate screw (S), which moves Ob_1 in order to achieve a clear image of the spectral lines in

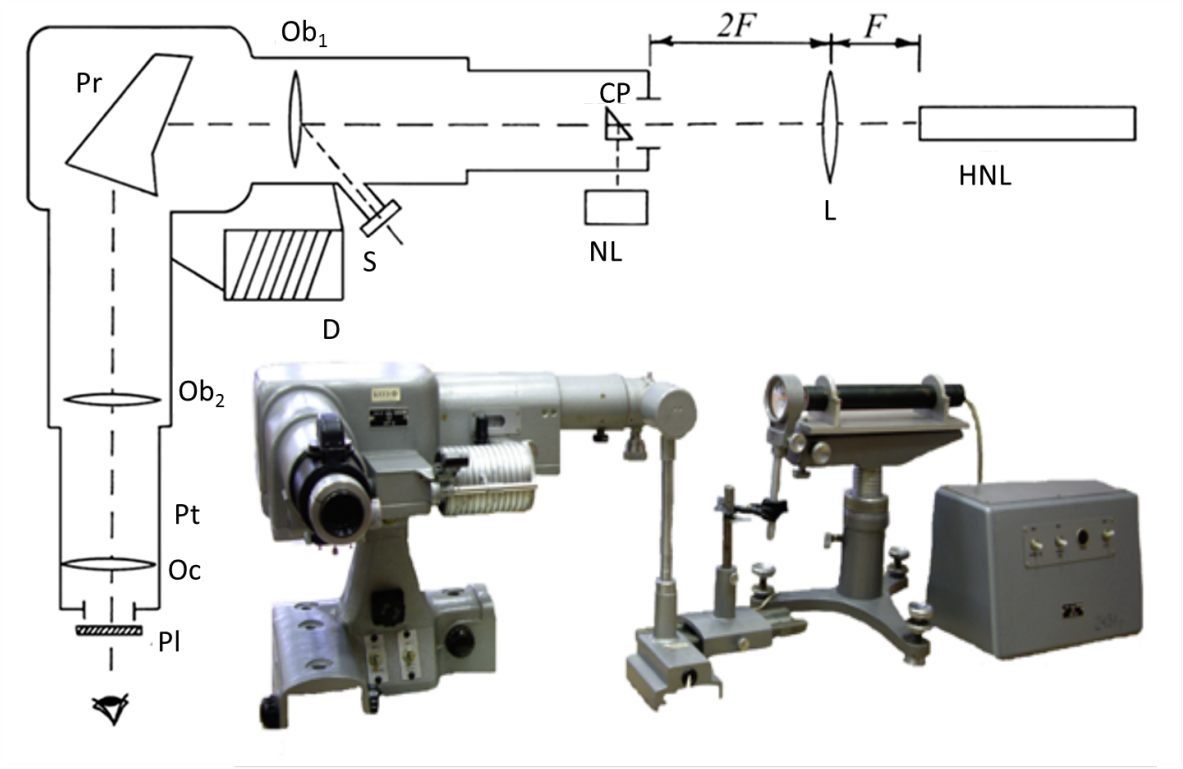

Figure 2: Schematic and a photograph of the experimental setup.

the plane of the pointer (which is wavelength dependent). The width of the spectral lines is set by adjusting width of the input slit. The wavelengths of the spectral lines are determined as follows. With the help of the drum (D), the pointer is adjusted with a certain spectral line. Then the readings from the drum are read and the required wavelength is determined from the specific calibration curve (which is instrument dependent). A coupling prism (CP) allows simultaneous observation of spectra produced by different sources. In the practical, HNL spectrum is compared to the NL spectrum.

3 Measurement and data processing

3.1 Task 1. Observation of the emission spectrum of a helium-neon laser and its investigation using reference sources

1. Turn on the power supply and observe the emission spectrum of the helium-neon laser. Find the lasing line of the laser radiation in the red region of the spectrum. Determine its wavelength.

2. Turn on the neon lamp and get the spectrum of Ne in the plane of the pointer (using the CP). Compare the emission spectrum of the reference Ne lamp with the He-Ne laser emission spectrum (as depicted in Fig. 3) and make sure that:

   - Neon emission lines (Ne) are present in the emission spectrum of a He-Ne laser;

   - the generation line belongs to the spectrum of neon radiation;

   - the remaining lines belong to helium (He).

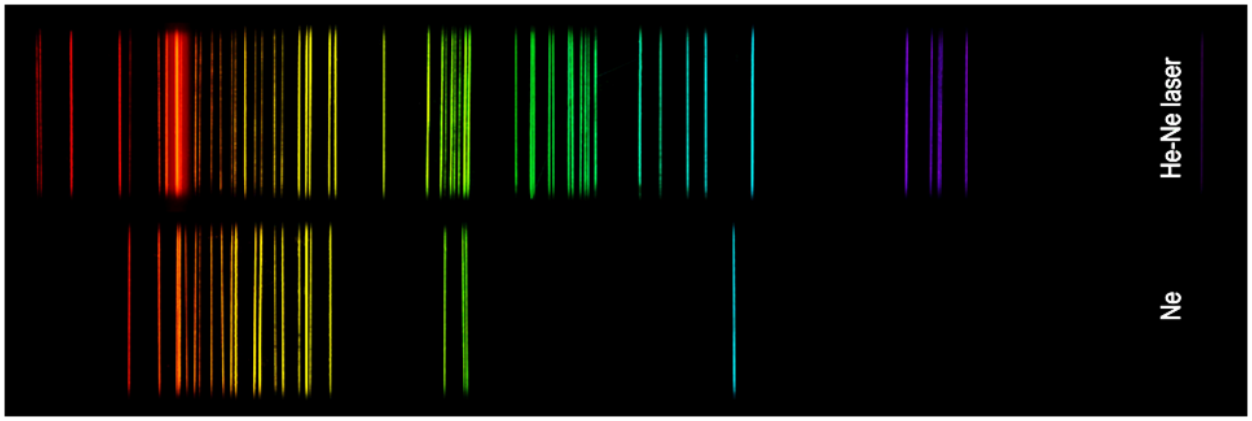

Figure 3: He-Ne laser and NL spectra comparison.

3. Find the bright yellow emission line of Ne in the spectrum of the He-Ne laser and measure its wavelength. In addition, measure the wavelengths of the following lines:

   a) all bright lines of Ne to the left of the bright yellow line;

   b) the brightest red lines of Ne to the left of the generation line;

   c) a single green and two close green Ne lines to the right of the bright yellow line.

4. Measure the wavelengths of the brightest lines in the yellow, yellow-green, blue, and violet portions of the He-Ne laser spectrum.

5. Find the Ne and He lines studied in the Spectral Lines Table. Using the Tables of spectral lines, specify the measured wavelengths of the spectra of helium and neon. (The divergence of 1-2 nm is allowed).

6. Record the data obtained in the measurement and compare measured and reference wavelengths in a table.

3.2 Task 2. Determination of the polarization of laser radiation

Rotating the polaroid on the eyepiece of the monochromator, make sure that the laser radiation is linearly polarized, and the radiation from the neon lamp is not polarized.

4 Questions

1. What are the general principles of operation of optical quantum amplifiers and optical quantum generators? What conditions are necessary to enhance light and generate light?
2. What is spontaneous and stimulated emission? What is their difference?
3. What is the physical meaning of the Einstein coefficients and the relationship between them?
4. What is an inverse population? How is the population inversed in the laser? What is the role of helium in this process?
5. At what spectral lines does laser generation occur? Are the generation conditions for those lines independent?
6. What is the role of the resonator in the formation of the geometry of the output beam and its spectral composition?
7. Is it possible to say that the radiation of a helium-neon laser is monochromatic?
8. What determines the state of polarization of the laser beam?