Laboratory work 3.7.1.

Monochromator

Spectral instruments are used to separate a narrow band of wavelength from a wider range of wavelengths available at the input. The simplest of such instruments called spectrometers (or monochromators) consists of collimator, resolving system and spyglass, and are used for observation of visible spectra. The optical scheme of a spectrometer is shown in the fig.1. The collimator consists of the slit with variable width *S* and objective O_1. The objective makes the light beams passing through the slit parallel and leads them to the resolving system. The slit *S* is placed in the focal plane of the objective O_1. The resolving system is a prism, or diffraction grating. The spatial resolution of the light beams with different wavelengths appears there. The spyglass consists from objective O_2 and ocular *Oc*. Bunches of parallel beams are coming out from the resolving system and entering objective O_2. Objective O_2 focuses each monochromatic bunch in such a way, that each of them gives the image of the slit in a main focal plane. These images are observable by the ocular *Oc*.

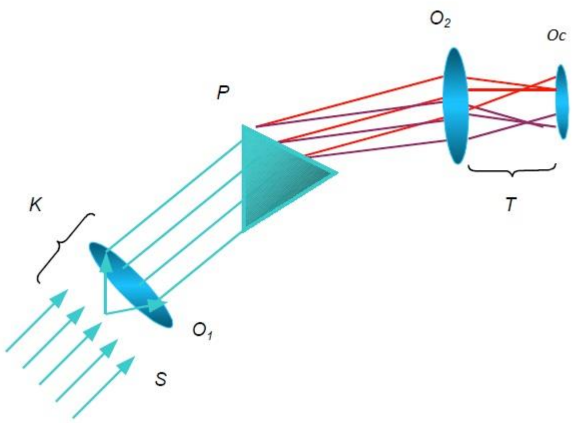

Fig.1. The scheme of the spectrometer: *K* – colimator, *S* – entering slit, O_1 – objective; *P* – prism; *T* – spyglass, consisting of: O_2 – objective, *Oc* – ocular.

The monochomator used in the laboratory work is designed for optical diapason from 300 nm up to 1000 nm. The whole spectrum can be shifted with respect to the observation region by measuring cylinder. The scale of the cylinder is graduated in degrees of its rotation. Measurements have to be performed with respect to the spectral arrow. When the line in spectrum is positioned on the arrow, the corresponding angle of rotation is defined from the measuring cylinder.

At first it is necessary to graduate the monochromator. For this purpose the source with known spectrum (for example *Hg*, or *Ne* lamp) is used. By comparison of the given spectrum with experimental one, the measured angles of rotation *m* for each line (with given wavelength λ) of spectrum are recorded. As a result, the dependence of *m* on λ can be created.

Light sources can emit electromagnetic radiation consisting from different frequencies (wavelengths), therefore sources can be characterised not by one frequency, but with a whole spectrum of frequencies. If the spectrum consists of separated, well-defined wavelengths it is called line spectrum. Spectra can be also the band and the continuous.

The wavelengths for some of spectra it is possible to calculate by using of a theoretical equation. For example the spectrum of hydrogen we can calculate by Mozly's or Balmer's equation:

$$\upsilon = Rc\left(\frac{1}{k^2} - \frac{1}{n^2}\right) \qquad (1)$$

where υ is a frequency of emitted radiation; R – Ridberg's constant $R=1.096776\cdot10^7$ m^{-1}; c – speed of light in vacuum; k – integer number (k = *1, 2, 3, ...*); n – integer number ($n = k+1$; $k+2$; ...). k and n corresponds to the quantum numbers of the stationary states of electron before and after emission of the photon. Knowing the frequencies of emitted radiation and the equation $c=\lambda\cdot\upsilon$ the corresponding wavelengths can be calculated.

The main reason to investigate spectra is the unique character of emitted radiation. Each chemical element has its own spectrum which does not coincide with the spectra of any other chemical element. This property is used for spectral analysis of the matter. If the radiation of any material has characterising spectral lines, it is possible to maintain, that the source contains this chemical element.

Possible appointments:

1. To graduate the monochromator by using source with known (mercury or neon) spectrum.

2. Determine by using monochromator and the corresponding graduation curve, the wavelengths of brightest lines of given source.

Protocol for laboratory work 3.7.1.

Monochromator

Students: 1.

2.

Appointments:

1. Graduate the monochromator by using source with known (mercury or neon) spectrum.

2. Determine by using monochromator and the corresponding graduation curve, the wavelengths of brightest lines of given source.

3. Compare defined wavelengths with an etalon spectrum.

4. Compare experimentally defined wavelengths with theoretically calculated.

Used measuring devices and set-up

Nr..	***Title***	***Type, number***	***Measuring diapason***	***The value of smallest scale***
1.	Spectrometer			

Measured data

Graduation:

Source of the light: ....

	λ, nm	m, °
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		

	colour	m, °
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		

Appendix. Spectra of the mostly used sources:

Hg		
	λ, nm	
1.	404,7	
2.	407,8	
3.	433,9	
4.	434,7	
5.	435,8	
6.	491,6	
7.	496,2	
8.	512,1	
9.	546,1	
10.	567,6	
11.	577,0	
12.	579,0	
13.	607,3	
14.	612,3	
15.	623,4	
16.	671,6	
17.	697,7	
18.		

Ne		
	λ, nm	
1.	540,1	
2.	576,4	
3.	585,2	
4.	588,2	
5.	594,5	
6.	597,5	
7.	603,0	
8.	607,4	
9.	609,6	
10.	614,3	
11.	616,3	
12.	621,2	
13.	626,6	
14.	630,4	
15.	633,2	
16.	638,2	
17.	640,2	
18.	650,6	
19.	653,3	
20.	659,8	
21.	667,8	
22.	671,7	

Na		
	λ, nm	
1.	454,5	
2.	466,5	
3.	466,9	
4.	497,9	
5.	498,3	
6.	515,3	
7.	568,8	
8.	589,0	
9.	589,6	
10.	615,4	
11.	616,1	