BIRZEIT UNIVERSITY

Faculty of Science

Physics Department

Physics 212

Atomic Spectra

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– Abstract:

The aim of this experiment is to measure the wavelengths of the spectral lines of Argon and Oxygen in the visible region using discharge tube sources and a diffraction grating spectroscope. The results of this experiment were having a high precisely values, with errors can be estimated to nanometers.

The range of colors

color	range (nm)
violet	435-440
turquoise	490-493
bold green	526-527
light green	563-564
orange	600-627
red	662-672

The average wavrlenght of colors

color	λ_{avg}(nm)
violet	437
turquoise	492
bold green	527
light green	564
orange	614
red	667

– **Data:**

$\theta_0 = 105°$

$\Delta\theta = 1' = \left(\frac{1}{60}\right)°$

Ar

80 rulings/mm

m	color	angle (º)
+1	violet	107.00
+1	turquoise	107.25
+1	bold green	107.42
+1	light green	107.58
+1	orange	107.75
+1	red	108.08

300 rulings/mm

m	color	angle (º)
+1	violet	112.50
+1	turquoise	113.50
+1	bold green	114.08
+1	light green	114.75
+1	orange	115.58
+1	red	116.50

O

80 rulings/mm

m	color	angle (º)
+1	violet	107.00
+1	turquoise	107.25
+1	bold green	107.42
+1	light green	107.58
+1	orange	107.83
+1	red	108.08
+2	turquoise	109.50
+2	red	111.08

300 rulings/mm

m	color	angle (º)
+1	violet	112.58
+1	turquoise	113.50
+1	orange	115.83
+1	red	116.50
+2	turquoise	122.17
+2	red	128.50

– Calculations:

$$\lambda = \frac{h \sin\theta}{m}$$

Where,

λ: the wavelenght

h: grating spacing (rulings/mm)$^{-1}$

m: 0,1,2,…

$$\Delta\lambda = \frac{\Delta\theta h \cos\theta}{m}$$

θ is very small, so $\cos\theta \approx 1$

$$\Delta\theta = \frac{1}{60}$$

$$\Delta\lambda = \frac{\frac{1}{60}h}{m}$$

Ar: 80 rulings/mm

m	color	angle (º)	θ (º)	sinθ	λ(mm)	λ(nm)	Δλ(mm)	Δλ(nm)
+1	violet	107.00	2.00	0.0349	0.000436	436	0.000208	208
+1	turquoise	107.25	2.25	0.0393	0.000491	491	0.000208	208
+1	bold green	107.42	2.42	0.0422	0.000527	527	0.000208	208
+1	light green	107.58	2.58	0.0451	0.000563	563	0.000208	208
+1	orange	107.75	2.75	0.0480	0.000600	600	0.000208	208
+1	red	108.08	3.08	0.0538	0.000672	672	0.000208	208

Ar: 300 rulings/mm

m	color	angle (º)	θ (º)	sinθ	λ(mm)	λ(nm)	Δλ(mm)	Δλ(nm)
+1	violet	112.50	7.50	0.1305	0.000435	435	0.000056	56
+1	turquoise	113.50	8.50	0.1478	0.000493	493	0.000056	56
+1	bold green	114.08	9.08	0.1579	0.000526	526	0.000056	56
+1	light green	114.75	9.75	0.1693	0.000564	564	0.000056	56
+1	orange	115.58	10.58	0.1837	0.000612	612	0.000056	56
+1	red	116.50	11.50	0.1994	0.000665	665	0.000056	56

O: 80 rulings/mm

m	color	angle (º)	θ (º)	sinθ	λ(mm)	λ(nm)	Δλ(mm)	Δλ(nm)
+1	violet	107.00	2.00	0.0349	0.000436	436	0.000208	208
+1	turquoise	107.25	2.25	0.0393	0.000491	491	0.000208	208
+1	bold green	107.42	2.42	0.0422	0.000527	527	0.000208	208
+1	light green	107.58	2.58	0.0451	0.000563	563	0.000208	208
+1	orange	107.83	2.83	0.0494	0.000618	618	0.000208	208
+1	red	108.08	3.08	0.0538	0.000672	672	0.000208	208
+2	turquoise	109.50	4.50	0.0785	0.000490	490	0.000104	104
+2	red	111.08	6.08	0.1060	0.000662	662	0.000104	104

O: 300 rulings/mm

m	color	angle (º)	θ (º)	sinθ	λ(mm)	λ(nm)	Δλ(mm)	Δλ(nm)
+1	violet	112.58	7.58	0.1320	0.000440	440	0.000056	56
+1	turquoise	113.50	8.50	0.1478	0.000493	493	0.000056	56
+1	orange	115.83	10.83	0.1880	0.000627	627	0.000056	56
+1	red	116.50	11.50	0.1994	0.000665	665	0.000056	56
+2	turquoise	122.17	17.17	0.2952	0.000492	492	0.000028	28
+2	red	128.50	23.50	0.3987	0.000665	665	0.000028	28

The range of colors:

color	range (nm)
violet	435-440
turquoise	490-493
bold green	526-527
light green	563-564
orange	600-627
red	662-672

The average wavrlenght of colors:

color	sum	n	λ_{avg} (nm)
violet	1747	4	437
turquoise	2949	6	492
bold green	1580	3	527
light green	1691	3	564
orange	2456	4	614
red	4001	6	667

– Results:

The range of colors

color	range (nm)
violet	435-440
turquoise	490-493
bold green	526-527
light green	563-564
orange	600-627
red	662-672

The average wavrlenght of colors

color	λ_{avg} (nm)
violet	437
turquoise	492
bold green	527
light green	564
orange	614
red	667

– Discussion:

Approximate wavelength For the various colors from website LivePhysics:

Color	Wavelength (nm)
Red	780 - 622
Red	780 - 622
Orange	622 - 597
Yellow	597 - 577
Green	577 - 492
Blue	492 - 455
Violet	455 - 390

The results of this experiment were close to these values. Therefore, the results is accepted.

The first order of diffraction pattern was clear, but the second order was pale colors. Moreover, the distances between colors in first order would increase in the second order.

Argon spectrum had more colors than Oxygen spectrum. The reason related to number of electrons on their energy states. On the other hand, the second order in Argon spectrum was so pale in comparable with second order of Oxygen spectrum.

There are many sources of systematic errors. For example, the detector line was so small, so the process of determination the angle θ was so hard and includes experimenter's error. Moreover, one color has a range of same type colors, so the determination of which color we have to record was complicated. To facilitate the process, we chose the middle color. The systematic errors in the calibration of spectroscope also make an error in this experiment.

– References:

1. H. Abusara, & A. Shawabkeh (2016, November). *Laboratory Manual: Modern Physics Lab* (Second Edition). *Atomic Spectra* (pp. 105-118). Birzeit University: Faculty of Science.
2. *LivePhysics*. http://www.livephysics.com/physical-constants/optics-pc/wavelength-colors/.