AGH University of Science and Technology in Cracow

Department of Electronics

Laboratory Manual
Physics_1

Title:

Energy levels of hydrogen atoms. Rydberg constant

2009 r.

Experiment No.

11

1. Goal

Spectra analyses of light emitted by hydrogen atoms, determining of ionization energy.

2. What to learn?

Diffraction grating, emission and absorption spectrum, continuous spectrum, line spectrum, band spectrum. emission spectrum of hydrogen atom in visible light, Balmer series, Rydberg formula. Bohr model of the atom, energy states, Rydberg constant, spectral series Lyman (ultraviolet), Paschen, Brackett, Pfund (infrared). ionization energy of hydrogen atom.

3. Equipment

Spectroscopic lamps: helium and hydrogen, handle for lamps, power supply adapter 0 – 10 kV, stand, diffraction grating, micro spectrometer with optical waveguide, computer.

4. Measurements

1. Carefully set a helium lamp in a stand and connect to the power supply.
2. Turn on the power supply, increase voltage until the lamp is shining stable.
3. Carry out observations of a spectrum emitted by the lamp; observe the discharge lamp through a diffracting grating.
4. Insert an optical waveguide terminal into a hole in a lamp shield.
5. Turn on the power supply of the spectrometer – red diode should be lighting.
6. Launch the computer program „SPM” for the spectrometer. In „settings” („Ustawienia”) assume: averaging 10 and the time at least 100 millisecond.
7. Start measurements with "Pomiar". During measurements the computer mouse is not active. After the measurements, record the wavelengths corresponding to the maxima of the spectrum. Position of a cursor is displayed in the right-hand top corner of the computer screen.
8. You can save the measured spectrum using the command “Zapisz”.
9. Decrease voltage to zero then turn off the power supply and remove the optical waveguide terminal from the lamp shield.
10. Carefully exchange the helium lamp to the hydrogen lamp and connect the optical waveguide.

11. Repeat points 5-7. If necessary prolong the time of measurements to be able to find four hydrogen spectrum lines.

    Note: the lowest intensities of spectral lines correspond to the lowest wavelengths.
12. Record the wavelengths and intensities corresponding to the maxima in spectrum.
13. After finishing measurements decrease voltage to zero, then turn off the lamp power supply. Turn off the spectrometer power supply and remove the optical waveguide terminal from the lamp shield. Carefully remove the lamp from the stand and put into a box.

5. Data handling

1. Check the calibration of the x-axis of a spectrometer computer program on the basis of the measurements of the helium wavelength. Plot the theoretical helium wavelength versus the measured one. Wavelengths of intense spectral lines of helium in visible range are collected in the table 1. To make easier identification of the spectral lines, the intensities of helium lines are also included in the table (origin: American Physics Handbook).
2. Approximate the relationship from point 1 using the linear regression method.
3. Correct the measured wavelength for hydrogen using the relationship from point 2.
4. Write down the results in the table:

Wavelength (nm)	1/wavelength (nm^{-1})	Intensity (arb. units)	$1/n^2$

If wavelengths are placed from the largest to the smallest, then natural numbers *n* will be in order *3, 4*,... etc.

5. Plot the graph 1/wavelength = $f(1/n^2)$.
6. Approximate the relationship from point 5 and plot the line using the linear regression method. Determine the Rydberg constant and the band head using the linear regression parameters.
7. Calculate the ionization energy of a hydrogen atom.
8. Calculate uncertainty of the Rydberg constant from the linear regression parameters.

Table 1. Wavelengths of helium line spectrum in visible range

Wavelength (nm)	388,8	402,6	438,8	447,2	471,3	492,1
Intensity (arb. units)	10 000	1 450	590	2 220	370	1 800
Wavelength (nm)	501,6	504,8	587,6	667,8	706,5	728,1
Intensity (arb. units)	3 100	860	7 100	1 850	1 450	1 450

Updated: 14.02.2009 by Jarosław Kanak