**X-ray Scattering: The Duane-Hunt Displacement Law**

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***Objective:***  In this experiment, we produce x-ray spectra at specific accelerating potentials by using 35 kV x-ray unit. The produced x-rays scattered from a crystal, which was NaCl(100) crystal for our experiment. Then, the experiment is a push-button one, due to computer connected to the x-ray unit.

***Introduction***

After Roentgen discovered x-ray in 1895, the father and the son Bragg achieved to reveal the structure of crystals with the help of the x-ray scattering through the crystal layers. The method is still used in today’s crystallography, since to see the structural details of crystals, we must transmit an electromagnetic radiation which has the wavelength closer to the crystal’s size order (in our experiment, it is in the order of Angstrom).

When energetic electrons strike a high-Z material, x-rays are produced. The spectrum has a continuous trend and some discrete peaks. The continuous one is Bremsstrahlung process in which the accelerated electrons are decelerated by the ‘positive’ nucleus due to Coulomb’s law and the loss energy is emitted. The second one occurs when an electron has enough energy to eject an electron of the target and then the vacant position is filled by an electron at higher level. This transition’s energy is called characteristic x-ray.

The fact that there is a minimum wavelength for a given accelerating potential can be used to determine the value of Planck’s constant. The minimum wavelength corresponds to the maximum frequency and the maximum energy of x-rays. Since the energy of electrons is gained by accelerating potential, the relationship

exists between the potential and the frequency. This is called Duane-Hunt Displacement law.

The wavelengths of the x-rays are determined by Bragg scattering law:

where d is the spacing between the planes of the crystal, m is the order of diffraction and is the specific angle observed.

The aim of the experiment is to extract Planck’s ‘quantum of action’. This experiment’s results are very important, because the discrete energy levels, transitions are the key words of the beginning of the quantum era.

***Experimental Setup***

In the experiment, the following apparatus are used:

* 35 kV x-ray unit
* X-ray detector
* Zr filter
* NaCl(100) crystal
* A computer connected to the x-ray unit

In the experiment, computer changed the scattering angles from 0 to 30 degrees. Until about 4 degrees, because of no scattering, there is a huge impulse per second values, in other words, direct radiation through detector. In the full spectrum graph we see the peaks due to the de-excitation of atoms’ levels. These are taken as experimental values at the specific scattering angles. In the data analysis part, we obtained the theoretical values for those angles, plotted their graphs and extracted the corrected equation.

Finally, we obtained the Planck’s constant from formulas given in the Introduction part.

***Data & Analysis***

From the text file “35.txt”, the datasets in this file are used to obtain the scattering graph on python. From the graph experimental theta values are taken.

Moreover, from the text file “x-ray emission lines.txt”, Kα and Kβ energy values are taken in order to find the theoretical values of each theta.

From this equation, lambda values for each energy level can be found. Then, using Bragg’s Law, theoretical theta values can be calculated.

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| *7.15* | *7.3* |
| *6.35* | *6.5* |
| *14.41* | *14.7* |
| *12.72* | *13.0* |
| *21.93* | *22.3* |
| *19.38* | *19.7* |