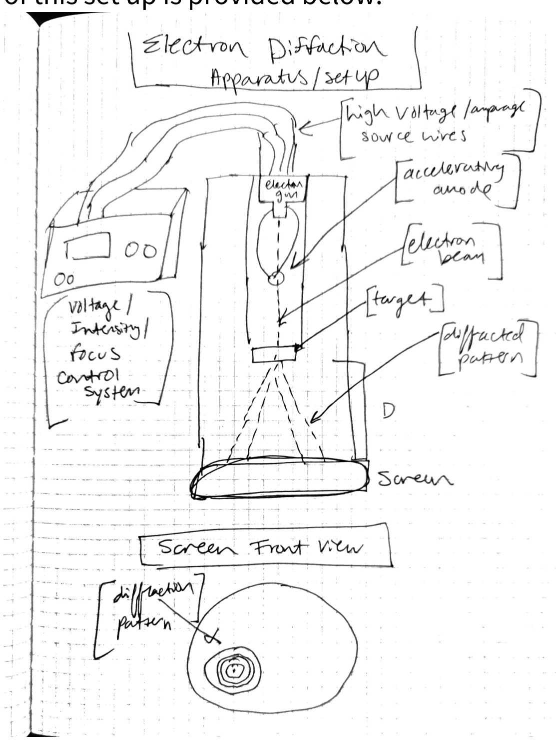
PHYS 2150
#12: Electron Diffraction from Crystals
Cassidy Bliss &
Lab Partner: Sean Gopalakrishnan

Abstract/Introduction

In this lab, our purpose is to verify deBroglie's hypothesis experimentally as well as learn about crystalline structure and diffraction patterns. Louis de Broglie was a student in France when he proposed that matter has a duality in that it behaves like particles under some circumstances and waves in others. De Broglie found the following relationship: $\lambda = \frac{ar}{D(h^2+k^2+l^2)^{1/2}}$ where a is the lattice constant for aluminum, r is radius of diffraction pattern, D is distance and h,k,l are constants associated with allowed wavelengths for aluminum based on its structure. In this lab we observed diffraction patterns of electrons using the apparatus described below. For various voltages, we measured the radii of the diffraction pattern rings directly and recorded these values. From this data, we were able to calculate the associated wavelengths and uncertainty for each. Using calculated known wavelengths, we compared them and found that they agreed with the accepted values for wavelengths given the voltages that were used. The known wavelengths were as follows (in units of meters for all) for the 10kV, 8kV and 6kV settings respectively: 1.20256×10^{-11}, 1.34612×10^{-11}, and 1.54509×10^{-11}. The experimentally derived wavelengths were calculated to be as follows for the 10kV, 8kV and 6kV settings respectively: 1.18878×10^{-11}, 1.32455×10^{-11}, and 1.52686×10^{-11}. With an uncertainty of , 1.34612×10^{-12}, 1.31663×10^{-12}, and 1.33874×10^{-12} (meters) for voltage setting 10kV, 8kV, and 6kV, the results were found to be in agreement with the accepted values. The known lattice constant value is $4.04964 \text{ x } 10^{-10}$ (meters). The first calculated value for a was found to be : 4.04883×10^{-10} (using atomic density etc.) The average experimentally derived value for a, using the measured radii was found to be: 4.04964×10^{-10}. Using the same uncertainty for a as was used for wavelength, we can say that this is in agreement with the accepted value as well.

Apparatus:

The apparatus used in this experiment is slightly different than the set up that de Broglie used, but the concepts and equations that govern the behavior remain the same. This apparatus is made up of an evacuated tube that contains an electron gun. This electron gun forms a small beam of electrons. It also contains an accelerating anode with high voltage of known energy to the electrons within the beam. Crystalline targets are also included to a location a distance from the electron gun for the beam to pass through, creating the diffraction patterns. A screen is placed a distance from the instance electrons beyond the targets to make the diffraction patterns visible to the experimentalists. A diagram of this set up is provided below.



Description of Experimental Procedure

Obtaining the Diffraction Patterns

First, we set the intensity and high voltage controls to their lowest settings. Then we turned on the AC power and waited for a few minutes for the diffraction tube filament to warm up. After that, we started at the highest voltage setting for the experiment which was 10,000 V, which corresponded to 100 on the voltmeter of the apparatus. The settings are a bit off of the actual values and the known actual values for these voltage settings are stored in the data section of this lab report. After the voltage is set at about 10 kV, we turned up the intensity slowly until we could see a spot/pattern appear on the observing screen, being careful not to turn the system past 10 microamperes. Then we began to adjust the focus control to a clearer image on the screen. Then we moved the electron beam vertically and horizontally around the screen to scan for the target crystalline materials. we found four observable target spots and one spot in the lower left corner that created the pattern indicating a polycrystalline aluminum target. We observed all the diffraction patterns for each of the four targets and then moved the electron beam to the aluminum target for analysis, adjusting the focus controls for the clearest image of the rings that were present on the screen.

Making the Measurements

Once we were satisfied with the clarity of our image and brightness of the diffraction pattern rings of the electron beam, we were able to determine the radii of the observable rings. We did this by using a transparent ruler and measured each ring from the center of the diffraction patter to the center of the illuminated ring on the screen, recording the results. We made four measurements at different angles from the center for each ring, and will use the average of these as the representative radius for each.

We repeated this process for each of the three voltage settings: 10 kV, 8 kV and 6 kV. These voltages are considered to me the accelerating voltages as they are responsible for accelerating the electrons through the evacuated tube. The position and focus was slightly adjusted each time the voltage setting was changed to get a clear, bright image. Once all of the measurements had been made, we turned down the intensity and voltage controls to their lowest positions and turned the system off.

Results

Data Analysis

In this section, all experimentally measured radii were stored and then their average values computed. Then the de Broglie wavelengths were computed using known voltages and constants. Then experimentally derived wavelengths were calculated by using the measured radii and “guessing” the values of h,k and l, until a value close to the known value was obtained. Uncertainty and error are then calculated (with satisfactory results). The final calculations done in this section were for the lattice constant a in two separate ways; once by using molecular density, atomic weight and Avogadro’s number along with known physical properties of the unit cell structure. The second way a was calculated was by using radii found experimentally. All values for wavelength were satisfactory in that they agreed with the accepted value given the uncertainty calculated. The lattice constant values were also found to be satisfactory for both methods of calculation given that the uncertainty would be the same for the lattice constant as it was for the wavelength (given the nature of de Broglie’s equation). For reference, the de Broglie equation used in this section was as follows:

$$\lambda = \frac{\text{ar}}{D\left(h^2+k^2+l^2\right)^{1/2}}$$

Data input

In[277]:=
```
(*Known voltage settings*)
voltageSetting1 = 10.4 * 10^3; (*V*)
voltageSetting2 = 8.3 * 10^3;  (*V*)
voltageSetting3 = 6.3 * 10^3 (*V*)
```
Out[278]= 6300.

In[364]:=
```
(*lattice constant for aluminum*)
a = 4.04964 * 10^-10; (*m*)
```

In[280]:=
```
(*Distance from target to screen*)
distance = 17.8 * 10^-2; (*m*)
δdistance = 0.2 * 10^-2;
(*m*)
```

In[282]:=
```
(*uncertainty in measurement of radii*)
δr = 0.1 * 10^-2 (*m*)
```
Out[282]= 0.001

In[283]:=
```
(*Ring 1 radii measurements 10 kV setting*)
R1rad10kVM1 = 0.9 * 10^-2; (*m*)
R1rad10kVM2 = 0.85 * 10^-2; (*m*)
R1rad10kVM3 = 0.9 * 10^-2; (*m*)
R1rad10kVM4 = 0.9 * 10^-2; (*m*)
R1averageRad10kV = (R1rad10kVM1 + R1rad10kVM2 + R1rad10kVM3 + R1rad10kVM4) / 4;  (*m*)


(*Ring 2 radii measurements 10 kV setting*)
```

In[288]:=
```
R2rad10kVM1 = 1.0 * 10^-2; (*m*)
R2rad10kVM2 = 1.0 * 10^-2; (*m*)
R2rad10kVM3 = 1.0 * 10^-2; (*m*)
R2rad10kVM4 = 1.1 * 10^-2;  (*m*)
R2averageRad10kV =  (R2rad10kVM1 + R2rad10kVM2 + R2rad10kVM3 + R2rad10kVM4) / 4;  (*m*)
```

In[292]:=
```
(*Ring 3 radii measurements 10 kV setting*)
R3rad10kVM1 = 1.45 * 10^-2; (*m*)
R3rad10kVM2 = 1.4 * 10^-2; (*m*)
R3rad10kVM3 = 1.5 * 10^-2; (*m*)
R3rad10kVM4 = 1.45 * 10^-2;  (*m*)
R3averageRad10kV =  (R3rad10kVM1 + R3rad10kVM2 + R3rad10kVM3 + R3rad10kVM4) / 4;
(*m*)
```

In[296]:=
```
(*Ring 4 radii measurements 10 kV setting*)
R4rad10kVM1 = 1.7 * 10^-2; (*m*)
R4rad10kVM2 = 1.65 * 10^-2; (*m*)
R4rad10kVM3 = 1.7 * 10^-2; (*m*)
R4rad10kVM4 = 1.75 * 10^-2; (*m*)
R4averageRad10kV = (R4rad10kVM1 + R4rad10kVM2 + R4rad10kVM3 + R4rad10kVM4) / 4;
(*m*)
```

In[300]:=
```
(*Ring 5 radii measurements 10 kV setting*)
R5rad10kVM1 = 2.2 * 10^-2; (*m*)
R5rad10kVM2 = 2.2 * 10^-2; (*m*)
R5rad10kVM3 = 2.3 * 10^-2; (*m*)
R5rad10kVM4 = 2.3 * 10^-2; (*m*)
R5averageRad10kV = (R5rad10kVM1 + R5rad10kVM2 + R5rad10kVM3 + R5rad10kVM4) / 4;
(*m*)
```

In[304]:=
```
(*Ring 1 radii measurements 8 kV setting*)
R1rad8kVM1 = 1.05 * 10^-2; (*m*)
R1rad8kVM2 = 1.0 * 10^-2; (*m*)
R1rad8kVM3 = 1.0 * 10^-2; (*m*)
R1rad8kVM4 = 1.0 * 10^-2; (*m*)
R1averageRad8kV = (R1rad8kVM1 + R1rad8kVM2 + R1rad8kVM3 + R1rad8kVM4) / 4; (*m*)
```

In[308]:=
```
(*Ring 2 radii measurements 8 kV setting*)
R2rad8kVM1 = 1.25 * 10^-2; (*m*)
R2rad8kVM2 = 1.15 * 10^-2; (*m*)
R2rad8kVM3 = 1.2 * 10^-2; (*m*)
R2rad8kVM4 = 1.15 * 10^-2; (*m*)
R2averageRad8kV = (R2rad8kVM1 + R2rad8kVM2 + R2rad8kVM3 + R2rad8kVM4) / 4; (*m*)
```

In[312]:=
```
(*Ring 3 radii measurements 8 kV setting*)
R3rad8kVM1 = 1.7 * 10^-2; (*m*)
R3rad8kVM2 = 1.65 * 10^-2; (*m*)
R3rad8kVM3 = 1.7 * 10^-2; (*m*)
R3rad8kVM4 = 1.6 * 10^-2; (*m*)
R3averageRad8kV = (R3rad8kVM1 + R3rad8kVM2 + R3rad8kVM3 + R3rad8kVM4) / 4;
(*m*)
```

In[316]:=
```
(*Ring 4 radii measurements 8 kV setting*)
R4rad8kVM1 = 2.0 * 10^-2;(*m*)
R4rad8kVM2 = 1.9 * 10^-2;(*m*)
R4rad8kVM3 = 1.9 * 10^-2;(*m*)
R4rad8kVM4 = 1.9 * 10^-2; (*m*)
R4averageRad8kV = (R4rad8kVM1 + R4rad8kVM2 + R4rad8kVM3 + R4rad10kVM4) / 4;
(*m*)
```

In[320]:=
```
(*Ring 5 radii measurements 8 kV setting*)
R5rad8kVM1 = 2.6 * 10^-2;(*m*)
R5rad8kVM2 = 2.6 * 10^-2;(*m*)
R5rad8kVM3 = 2.6 * 10^-2;(*m*)
R5rad8kVM4 = 2.5 * 10^-2; (*m*)
R5averageRad8kV = (R5rad8kVM1 + R5rad8kVM2 + R5rad8kVM3 + R5rad8kVM4) / 4;
(*m*)
```

In[324]:=
```
(*Ring 1 radii measurements 6 kV setting*)
R1rad6kVM1 = 1.15 * 10^-2;(*m*)
R1rad6kVM2 = 1.2 * 10^-2;(*m*)
R1rad6kVM3 = 1.15 * 10^-2;(*m*)
R1rad6kVM4 = 1.1 * 10^-2; (*m*)
R1averageRad6kV = (R1rad6kVM1 + R1rad6kVM2 + R1rad6kVM3 + R1rad6kVM4) / 4; (*m*)
```

In[328]:=
```
(*Ring 2 radii measurements 6 kV setting*)
R2rad6kVM1 = 1.35 * 10^-2;(*m*)
R2rad6kVM2 = 1.35 * 10^-2;(*m*)
R2rad6kVM3 = 1.35 * 10^-2;(*m*)
R2rad6kVM4 = 1.3 * 10^-2; (*m*)
R2averageRad6kV = (R2rad6kVM1 + R2rad6kVM2 + R2rad6kVM3 + R2rad6kVM4) / 4; (*m*)
```

In[332]:=
```
(*Ring 3 radii measurements 6 kV setting*)
R3rad6kVM1 = 1.9 * 10^-2;(*m*)
R3rad6kVM2 = 1.9 * 10^-2;(*m*)
R3rad6kVM3 = 1.95 * 10^-2;(*m*)
R3rad6kVM4 = 1.9 * 10^-2; (*m*)
R3averageRad6kV = (R3rad6kVM1 + R3rad6kVM2 + R3rad6kVM3 + R3rad6kVM4) / 4;
(*m*)
```

In[336]:=
```
(*Ring 4 radii measurements 6 kV setting*)
R4rad6kVM1 = 2.2 * 10^-2; (*m*)
R4rad6kVM2 = 2.2 * 10^-2; (*m*)
R4rad6kVM3 = 2.25 * 10^-2; (*m*)
R4rad6kVM4 = 2.2 * 10^-2; (*m*)
R4averageRad6kV = (R4rad6kVM1 + R4rad6kVM2 + R4rad6kVM3 + R4rad6kVM4) / 4;
(*m*)
```

In[340]:=
```
(*Ring 5 radii measurements 6 kV setting*)
R5rad6kVM1 = 3.0 * 10^-2; (*m*)
R5rad6kVM2 = 2.9 * 10^-2; (*m*)
R5rad6kVM3 = 3.05 * 10^-2; (*m*)
R5rad6kVM4 = 2.9 * 10^-2; (*m*)
R5averageRad6kV = (R5rad6kVM1 + R5rad6kVM2 + R5rad6kVM3 + R5rad6kVM4) / 4;
(*m*)
```

Calculation of the de Broglie Wavelengths

In[376]:= (*Calculating wavelengths with known voltages*)

$$\lambda 10kV = \sqrt{\frac{150.4}{voltageSetting1}} * 10^{-10} \text{ (*meters*)}$$

Out[376]= 1.20256×10^{-11}

In[377]:= $$\lambda 8kV = \sqrt{\frac{150.4}{voltageSetting2}} * 10^{-10} \text{ (*meters*)}$$

Out[377]= 1.34612×10^{-11}

In[378]:= $$\lambda 6kV = \sqrt{\frac{150.4}{voltageSetting3}} * 10^{-10} \text{ (*meters*)}$$

Out[378]= 1.54509×10^{-11}

```
(*Calculating wavelengths with experimental values*)

(*-----10kV EXPERIMENTAL WAVELENGTHS------*)


(*wavelength Ring 1 @ 10 kV*)
```

$$\lambda 10kVR1 = \frac{a * R1averageRad10kV}{distance * \sqrt{1^2 + 1^2 + 1^2}} \text{ (*m*)}$$

Out[573]= 1.16575×10^{-11}

In[892]:=

```
(*wavelength Ring 2 @ 10 kV*)
```

$$\lambda 10kVR2 = \frac{a * R2averageRad10kV}{distance * \sqrt{2^2 + 0^2 + 0^2}} \text{ (*m*)}$$

Out[892]= 1.16598×10^{-11}

In[898]:=

```
(*wavelength Ring 3 @ 10 kV*)
```

$$\lambda 10kVR3 = \frac{a * R3averageRad10kV}{distance * \sqrt{2^2 + 2^2 + 0^2}} \text{ (*m*)}$$

Out[898]= 1.16632×10^{-11}

In[909]:=

```
(*wavelength Ring 4 @ 10 kV*)
```

$$\lambda 10kVR4 = \frac{a * R4averageRad10kV}{distance * \sqrt{3^2 + 1^2 + 1^2}} \text{ (*m*)}$$

Out[909]= 1.16614×10^{-11}

In[905]:=

```
(*wavelength Ring 5 @ 10 kV*)
```

$$\lambda 10kVR5 = \frac{a * R5averageRad10kV}{distance * \sqrt{4^2 + 0^2 + 0^2}} \text{ (*m*)}$$

Out[905]= 1.27973×10^{-11}

In[915]:= λAverage10kV = (λ10kVR1 + λ10kVR2 + λ10kVR3 + λ10kVR4 + λ10kVR5) / 5

Out[915]= 1.18878×10^{-11}

```
(*-----8kV EXPERIMENTAL WAVELENGTHS------*)

(*wavelength Ring 1 @ 8 kV*)
```

$$\lambda 8kVR1 = \frac{a * R1averageRad8kV}{distance * \sqrt{1^2 + 1^2 + 1^2}} \ (*m*)$$

Out[578]= 1.32994×10^{-11}

In[621]:=

```
(*wavelength Ring 2 @ 8 kV*)
```

$$\lambda 8kVR2 = \frac{a * R2averageRad8kV}{distance * \sqrt{2^2 + 0^2 + 0^2}} \ (*m*)$$

Out[621]= 1.35083×10^{-11}

In[622]:=

```
(*wavelength Ring 3 @ 8 kV*)
```

$$\lambda 8kVR3 = \frac{a * R3averageRad8kV}{distance * \sqrt{2^2 + 2^2 + 0^2}} \ (*m*)$$

Out[622]= 1.33725×10^{-11}

In[709]:=

```
(*wavelength Ring 4 @ 8 kV*)
```

$$\lambda 8kVR4 = \frac{a * R4averageRad8kV}{distance * \sqrt{3^2 + 1^2 + 1^2}} \ (*m*)$$

Out[709]= 1.29475×10^{-11}

In[710]:=

```
(*wavelength Ring 5 @ 8 kV*)
```

$$\lambda 8kVR5 = \frac{a * R5averageRad8kV}{distance * \sqrt{4^2 + 2^2 + 0^2}} \ (*m*)$$

Out[710]= 1.30996×10^{-11}

In[918]:= λAverage8kV = (λ8kVR1 + λ8kVR2 + λ8kVR3 + λ8kVR4 + λ8kVR5) / 5

Out[918]= 1.32455×10^{-11}

```
(*-----10kV EXPERIMENTAL WAVELENGTHS------*)

(*wavelength Ring 1 @  6kV*)
```

$$\lambda 6kVR1 = \frac{a * R1averageRad6kV}{distance * \sqrt{1^2 + 1^2 + 1^2}} \ (*m*)$$

Out[776]= 1.51054×10^{-11}

In[953]:=

```
(*wavelength Ring 2 @  6kV*)
```

$$\lambda 6kVR2 = \frac{a * R2averageRad6kV}{distance * \sqrt{2^2 + 0^2 + 0^2}} \ (*m*)$$

Out[953]= 1.52146×10^{-11}

In[809]:=

```
(*wavelength Ring 3 @  6kV*)
```

$$\lambda 6kVR3 = \frac{a * R3averageRad6kV}{distance * \sqrt{2^2 + 2^2 + 0^2}} \ (*m*)$$

Out[809]= 1.53834×10^{-11}

In[888]:=

```
(*wavelength Ring 4 @  6kV*)
```

$$\lambda 6kVR4 = (a * R4averageRad6kV) \Big/ \left(distance * \sqrt{} \left(3^2 + 1^2 + 1^2\right)\right) \ (*m*)$$

Out[888]= 1.51769×10^{-11}

In[956]:=

```
(*wavelength Ring 5 @  6kV*)
```

$$\lambda 6kVR5 = \frac{a * R5averageRad6kV}{distance * \sqrt{3^2 + 3^2 + 1^2}} \ (*m*)$$

Out[956]= 1.54624×10^{-11}

In[925]:= $\lambda Average6kV = (\lambda 6kVR1 + \lambda 6kVR2 + \lambda 6kVR3 + \lambda 6kVR4 + \lambda 6kVR5) / 5$

Out[925]= 1.52686×10^{-11}

Error and Uncertainty in Wavelengths

```
(*Total uncertainty in wavelength in meters*)
```

In[926]:= $$\delta\lambda 10kV = \lambda Average10kV * \sqrt{\left(\frac{\delta r}{R1averageRad10kV}\right)^2 + \left(\frac{\delta distance}{distance}\right)^2}$$

Out[926]= 1.34612×10^{-12}

In[927]:= $$\delta\lambda 8kV = \lambda Average8kV * \sqrt{\left(\frac{\delta r}{R1averageRad8kV}\right)^2 + \left(\frac{\delta distance}{distance}\right)^2}$$

Out[927]= 1.31663×10^{-12}

In[928]:= $$\delta\lambda 6kV = \lambda Average6kV * \sqrt{\left(\frac{\delta r}{R1averageRad6kV}\right)^2 + \left(\frac{\delta distance}{distance}\right)^2}$$

Out[928]= 1.33874×10^{-12}

In[916]:=
```
(*Examining error*)
λ10kVErrorValue = Abs[λ10kV - λAverage10kV]
```
Out[916]= 1.37781×10^{-13}

In[919]:=
```
λ8kVErrorValue = Abs[λ8kV - λAverage8kV]
```
Out[919]= 2.15772×10^{-13}

In[929]:=
```
λ6kVErrorValue = Abs[λ6kV - λAverage6kV]
```
Out[929]= 1.82334×10^{-13}

Calculating Lattice Constant 2 Ways

```
(*Calculation of the Lattice Constant for Aluminum*)
```

In[945]:=
```
aluminumDensity = 2.7; (*g/cm^3*)
aluminumMolecularWeight = 26.98; (*g/mol*)
avogadroNumber = 6.0221409 * 10^23; (*mol^-1*)
knownLatticeConstAluminum = 4.04964 * 10^-10; (*meters*)

unitCellVolumeAluminum =
 aluminumMolecularWeight * (1 / aluminumDensity) * (1 / avogadroNumber) * 4 (*cubic cm*)
```
Out[937]= 6.63724×10^{-23}

In[962]:=
$$\text{latticeConstAluminum} = \sqrt[3]{\text{unitCellVolumeAluminum}} * 10^{-2} \ (*m*)$$
Out[962]= 4.04883×10^{-10}

```
(*Calculation of the Lattice Constant using de Broglie wavelength*)
```

In[949]:=
$$\text{a10kVR3} = \frac{\lambda\text{10kVR3} * \text{distance} * \sqrt{2^2 + 2^2 + 0^2}}{\text{R3averageRad10kV}}$$
Out[949]= 4.04964×10^{-10}

In[951]:=
$$\text{a10kVR2} = \frac{\lambda\text{10kVR2} * \text{distance} * \sqrt{2^2 + 0^2 + 0^2}}{\text{R2averageRad10kV}}$$
Out[951]= 4.04964×10^{-10}

In[954]:=
$$\text{a8kVR2} = \frac{\lambda\text{8kVR2} * \text{distance} * \sqrt{2^2 + 0^2 + 0^2}}{\text{R2averageRad8kV}}$$
Out[954]= 4.04964×10^{-10}

In[955]:= $a8kVR3 = \frac{\lambda 8kVR3 * distance * \sqrt{2^2 + 2^2 + 0^2}}{R3averageRad8kV}$

Out[955]= 4.04964×10^{-10}

In[957]:= $a6kVR3 = \frac{\lambda 6kVR3 * distance * \sqrt{2^2 + 2^2 + 0^2}}{R3averageRad6kV}$

Out[957]= 4.04964×10^{-10}

In[960]:= $a6kVR5 = \frac{\lambda 6kVR5 * distance * \sqrt{3^2 + 3^2 + 1^2}}{R5averageRad6kV}$

Out[960]= 4.04964×10^{-10}

In[961]:= averageLatticeConst = (a10kVR2 + a10kVR3 + a8kVR2 + a8kVR3 + a6kVR3 + a6kVR5) / 6

Out[961]= 4.04964×10^{-10}

Discussion

In this lab, the data was collected carefully an the results were what we consider to be satisfactory. The known wavelengths were as follows (in units of meters for all) for the 10kV, 8kV and 6kV settings respectively: 1.20256×10^{-11}, 1.34612×10^{-11}, and 1.54509×10^{-11}. The experimentally derived wavelengths were calculated to be as follows for the 10kV, 8kV and 6kV settings respectively: 1.18878×10^{-11}, 1.32455×10^{-11}, and 1.52686×10^{-11}. With an uncertainty of , 1.34612×10^{-12}, 1.31663×10^{-12}, and 1.33874×10^{-12} (meters) for voltage setting 10kV, 8kV, and 6kV, the results were found to be in agreement with the accepted values. The known lattice constant value is $4.04964 \text{ x } 10^{-10}$ (meters). The first calculated value for a was found to be : 4.04883×10^{-10} (using atomic density etc.) The average experimentally derived value for a, using the measured radii was found to be: 4.04964×10^{-10}. Using the same uncertainty for a as was used for wavelength, we can say that this is in agreement with the accepted value as well. Sources of error could stem from direct measurement (given that each “ring” had a thickness). Taking multiple measurements of the radii from various angles seemed to lower this error. This lab was difficult to understand due to the complexity of the lattice structures, and the most difficult part was “guessing” the values for h,k and l during the calculations in order to find results that were satisfactorily close to the known wavelengths.

Conclusion

In conclusion, the experimentally derived wavelengths were found to be in agreement with the accepted values given our calculated uncertainty in wavelength. Both the calculated and experimentally derived values for the lattice constant were also found to be in agreement with the accepted value.

Scanned Sheets from Lab Notebook

Electron Diffraction from Crystals

11/16/21

Experiment 12

Cassidy Bliss

University of Colorado

Lab partner: Sean Gopalakrishnan

$D + \delta D = 17.8 \pm 0.2$ cm

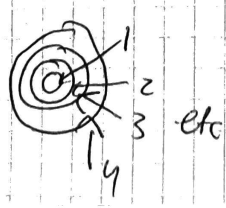
Measurements for 10,000 V:

~~| V out | Radii 1 | R2 | R3 | R4 |~~

~~1~~

measurements

in to out	R^m_1	R^m_2	R^m_3	R^m_4	(Units cm)
ring1	0.9	0.85	0.9	0.9	
ring2	1.0	1.0	1.0	1.1	
ring3	1.45	1.4	1.5	1.45	
ring4	1.7	1.65	1.7	1.75	
ring5	2.2	2.2	2.3	2.3	



R^m_n = measurement #n of radii

11/16/21

Measurements for 8,000 V

	R_{M_1}	R_{M_2}	R_{M_3}	R_{M_4}	Units cm
ring 1	1.05	1.0	1.0	1.0	± 0.05 cm
ring 2	1.25	1.15	1.2	1.15	
ring 3	1.7	1.65	1.7	1.6	
ring 4	2.0	1.9	1.9	1.9	
ring 5	2.6	2.6	2.6	2.5	

11/16/21

Measurements for 6,000 V

	R M1	R M2	R M3	R M4	Units cm
ring 1	1.15	1.2	1.15	1.1	± 0.05 cm
ring 2	1.35	1.35	1.35	1.3	
ring 3	1.9	1.9	1.95	1.9	
ring 4	2.2	2.2	2.25	2.2	
ring 5	3.0	2.9	3.05	2.9	

TA: Y. [signature]
11/16/21