

A circular electron diffraction pattern is duplicated with a simple apparatus using a laser beam

CSAAPT Fall 2025 at Virginia Commonwealth University

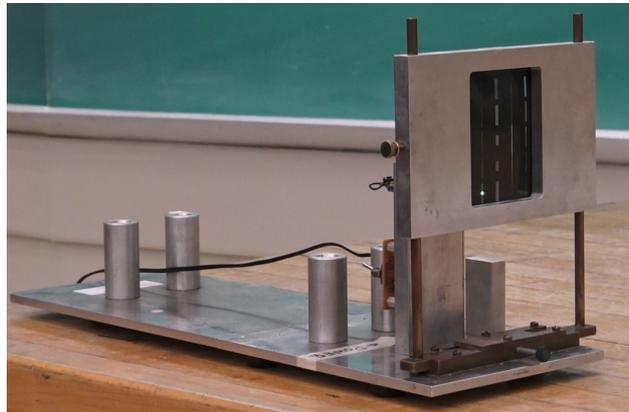
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Wave / Particle Duality

- If light is a wave but can behave like a particle in some circumstances, what about electrons?
- Can electrons, which are considered to be tiny particles, sometimes behave like waves?
- We know a beam of light diffracts when traveling thru a line grating whose spacing is on order of the wavelength of the light.
- Does a beam of electrons traveling thru an appropriately spaced grating diffract like waves as well?
- We can use de Broglie's relation $\lambda = h/p$ to calculate the wavelength of electrons and determine the size of the grating we'll need.

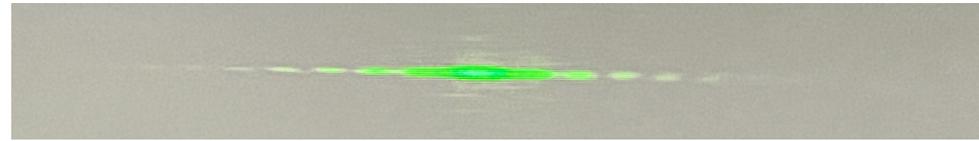
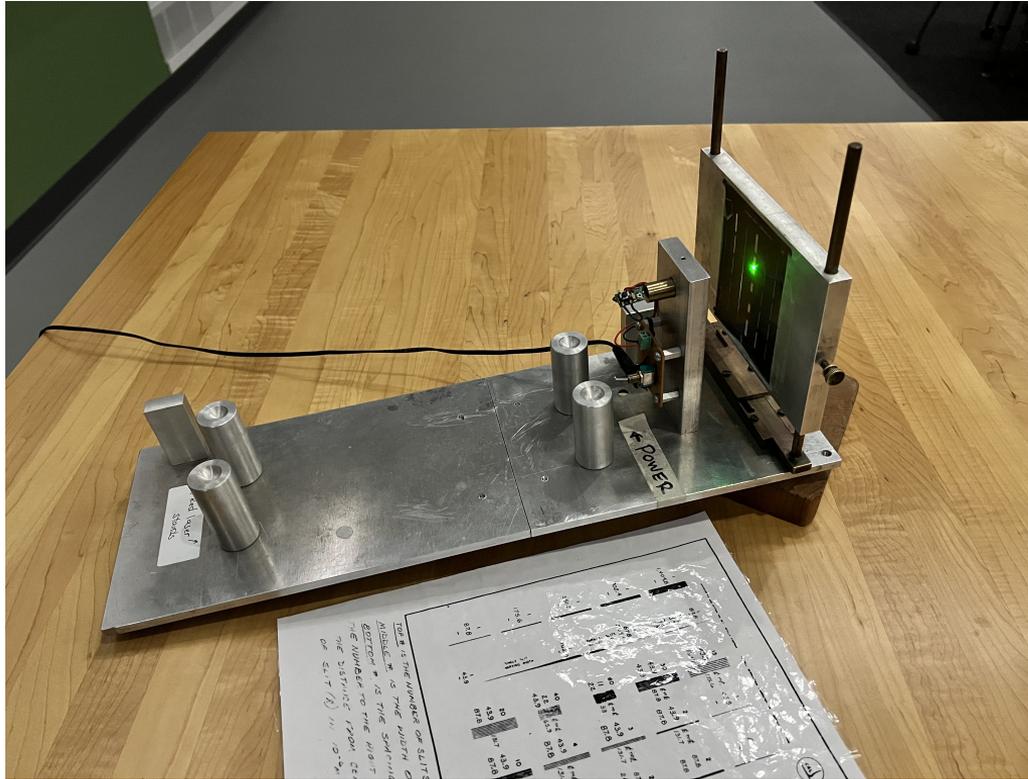
Cornell Slits Plate

- single, double and multiple slits with various widths and separations
- numbers to the left of each slit are:
 # of slits
 width in 10^{-6}m
 separation in 10^{-6}m

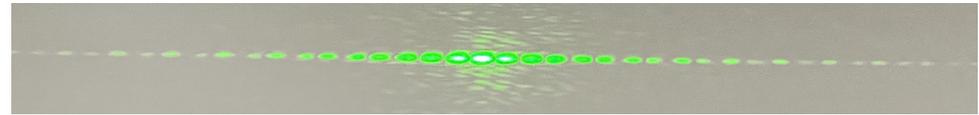


Slit Configuration	Width (10^{-6}m)	Separation (10^{-6}m)	Number of Slits	Other Parameters
Single slit	87.8	43.9	1	15
Single slit	175.6	43.9	1	1
Single slit	87.8	87.8	1	1
Double slit	87.8	87.8	2	2
Double slit	175.6	87.8	2	2
Double slit	87.8	175.6	2	2
Multiple slits	87.8	87.8	30	2
Multiple slits	175.6	87.8	30	2
Multiple slits	87.8	175.6	30	2
Multiple slits	87.8	87.8	80	3
Multiple slits	175.6	87.8	11	3
Multiple slits	87.8	175.6	22	3
Multiple slits	87.8	87.8	40	4
Multiple slits	175.6	87.8	22	4
Multiple slits	87.8	175.6	43.9	4
Multiple slits	87.8	87.8	20	10
Multiple slits	175.6	87.8	43.9	10
Multiple slits	87.8	175.6	87.8	10

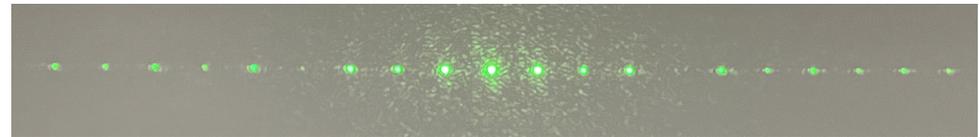
Cornell Slits Plate



Single Slit Diffraction



Double Slit Interference



Thirty Slit Interference

Diffraction Grating

- approaching infinite slits defined by number of slits per mm
- as number of slits increases, separation of slits decreases & separation of fringes increases
- 500 slits/mm $d = 2 \times 10^{-6} \text{m}$
- 1000 slits/mm $d = 1 \times 10^{-6} \text{m}$



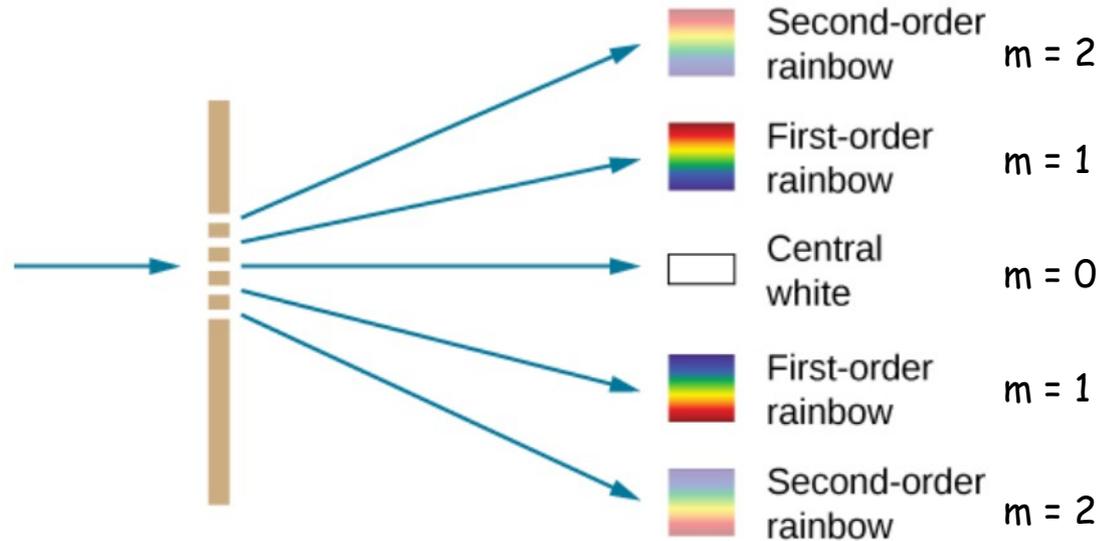
Diffraction Grating

$$\sin(\theta_m) = \frac{m\lambda}{d}$$

θ_m - angle of m^{th} band
 $m = 0, 1, 2, \dots$

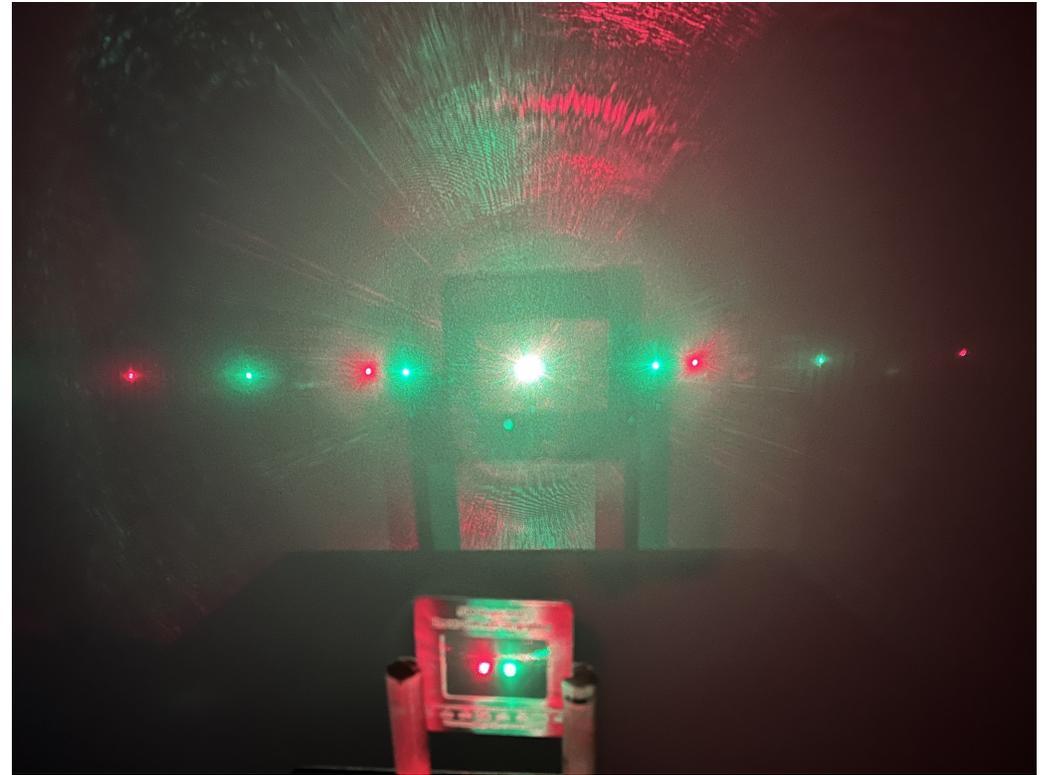
λ - wavelength of light (nm)

d - distance between slits
in grating, 1mm/lines



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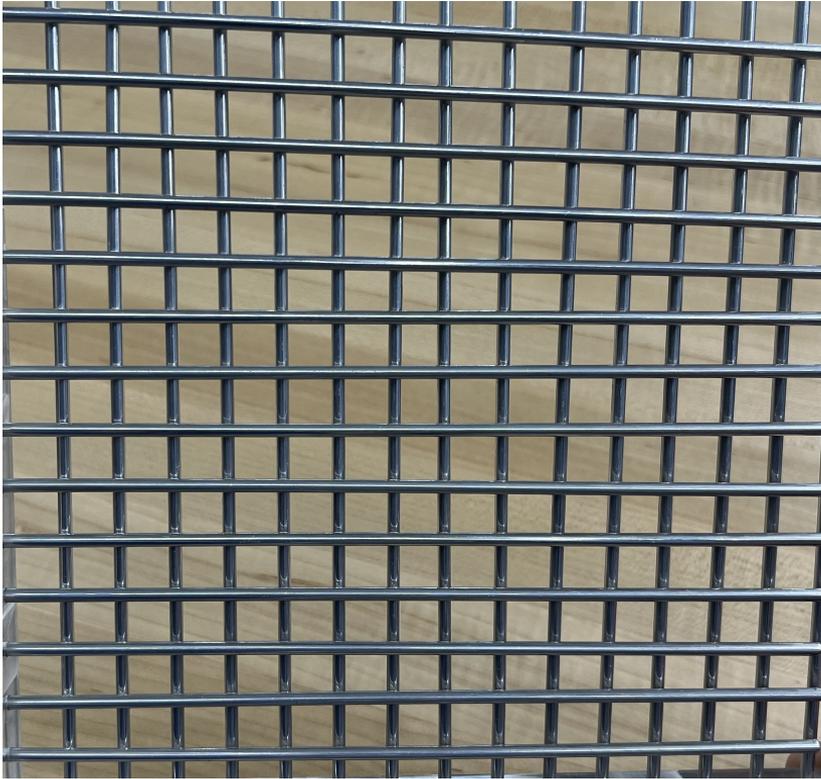
Vertical Grating



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Cross Gratings



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de Broglie

$$p = \frac{h}{\lambda} \quad \text{for a photon}$$

$$\lambda = \frac{h}{p} = \frac{h}{mv} \quad \text{for an electron}$$

accelerate e^- thru potential V :

$$qV = \frac{1}{2}mv^2 \rightarrow v_e = \sqrt{\frac{2eV}{m_e}}$$

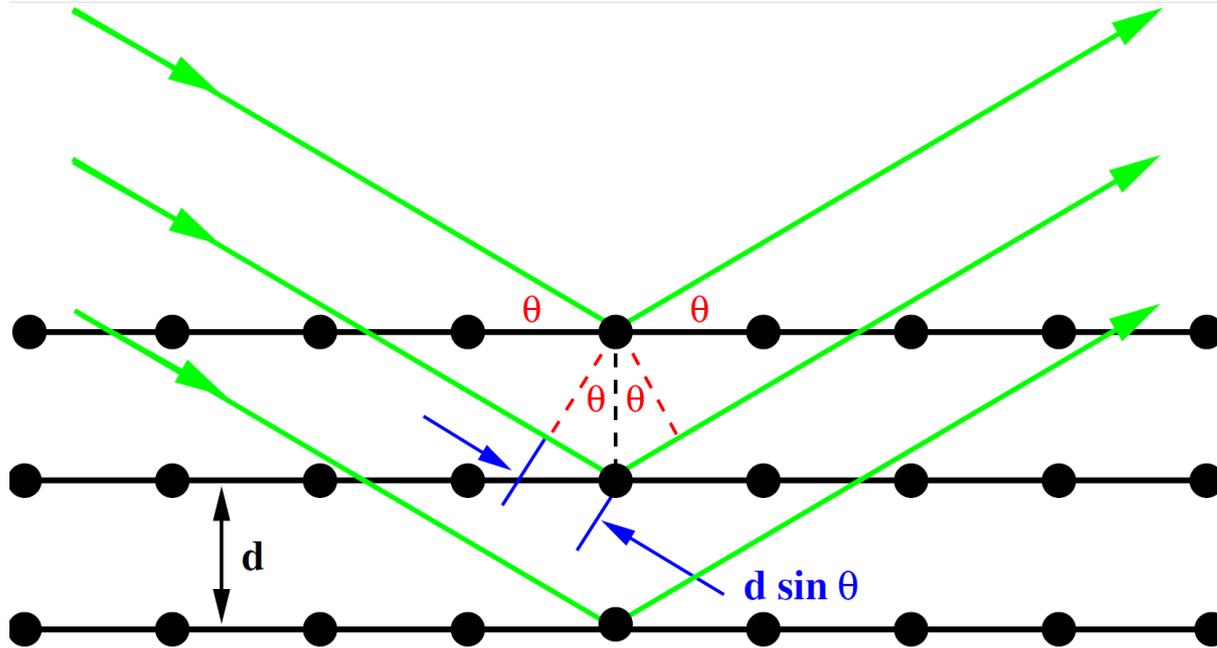
for $V = 100\text{V}$:

$$\lambda_e \approx 1 \times 10^{-10} \text{m}$$

for $V = 2500\text{V}$:

$$\lambda_e \approx 2 \times 10^{-11} \text{m}$$

Bragg's Law



Constructive interference:

$$n\lambda = 2d \sin \theta$$

incident angle = scattered angle

pathlength difference = integer

number of wavelengths

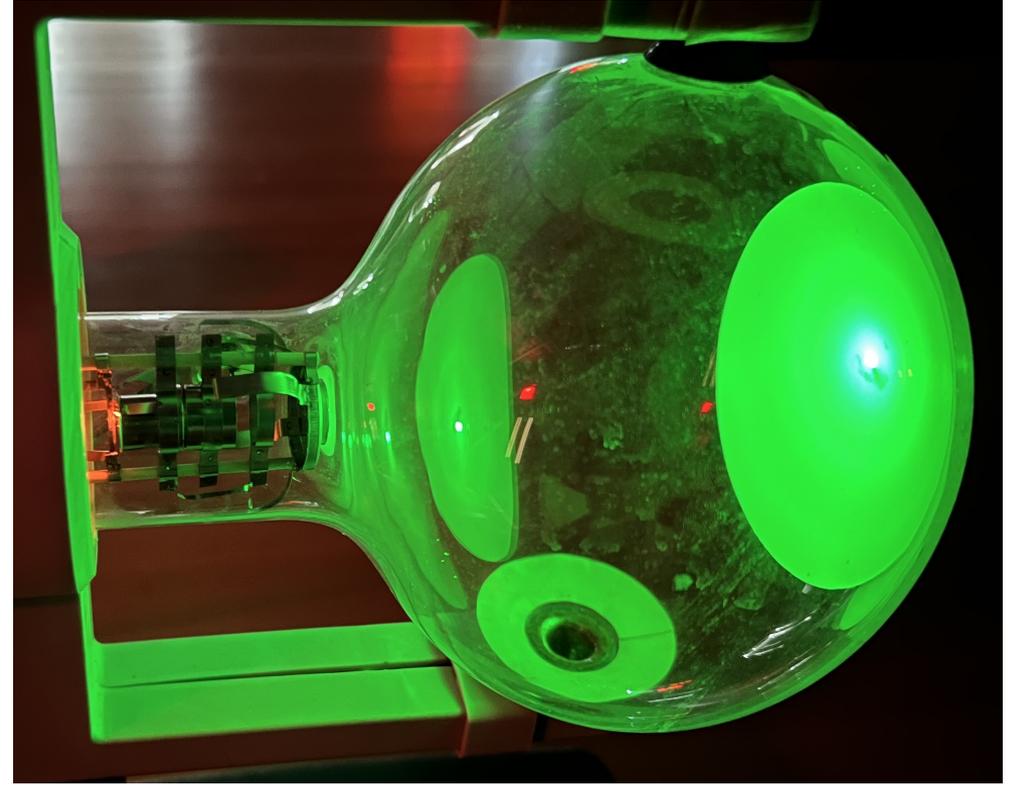
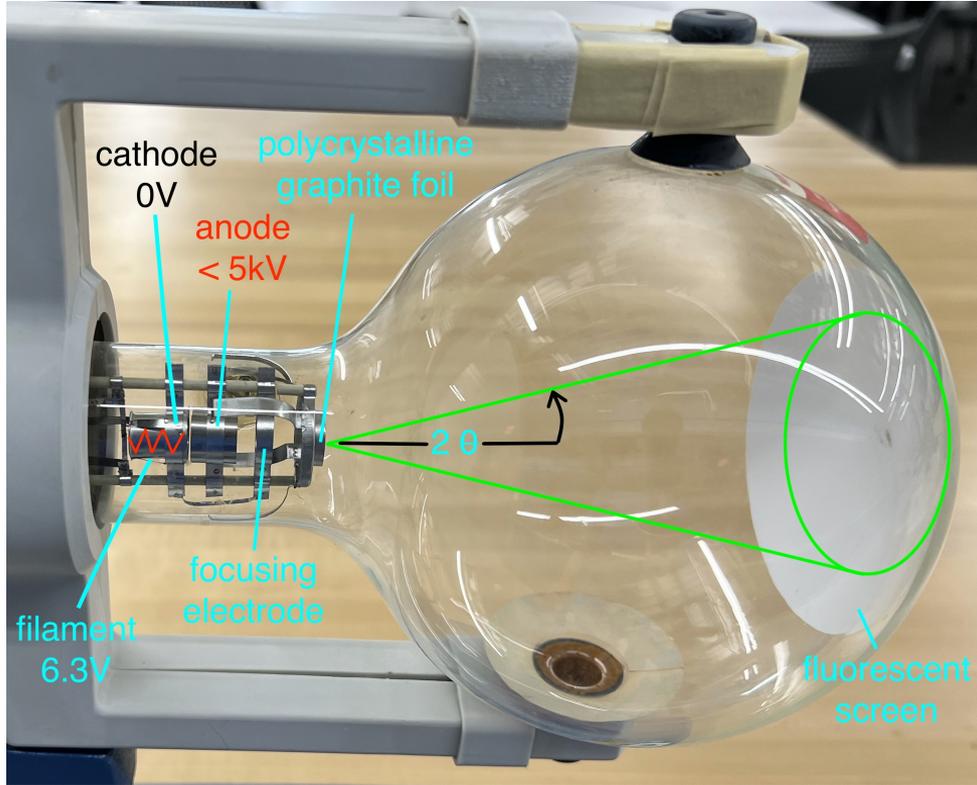
W.L. & W.H. Bragg - determined for X-ray diffraction off crystals, Nobel Prize 1915

Davisson & Germer - verified for electrons diffracting off nickel crystal, Nobel Prize 1937

Powder Method

- Debye-Scherrer diffraction
- use polycrystalline sample
- made up of many randomly oriented crystallites
- each crystallite maintains the properties of the crystal
- graphite carbon deposited by vaporization

Electron Diffraction Tube

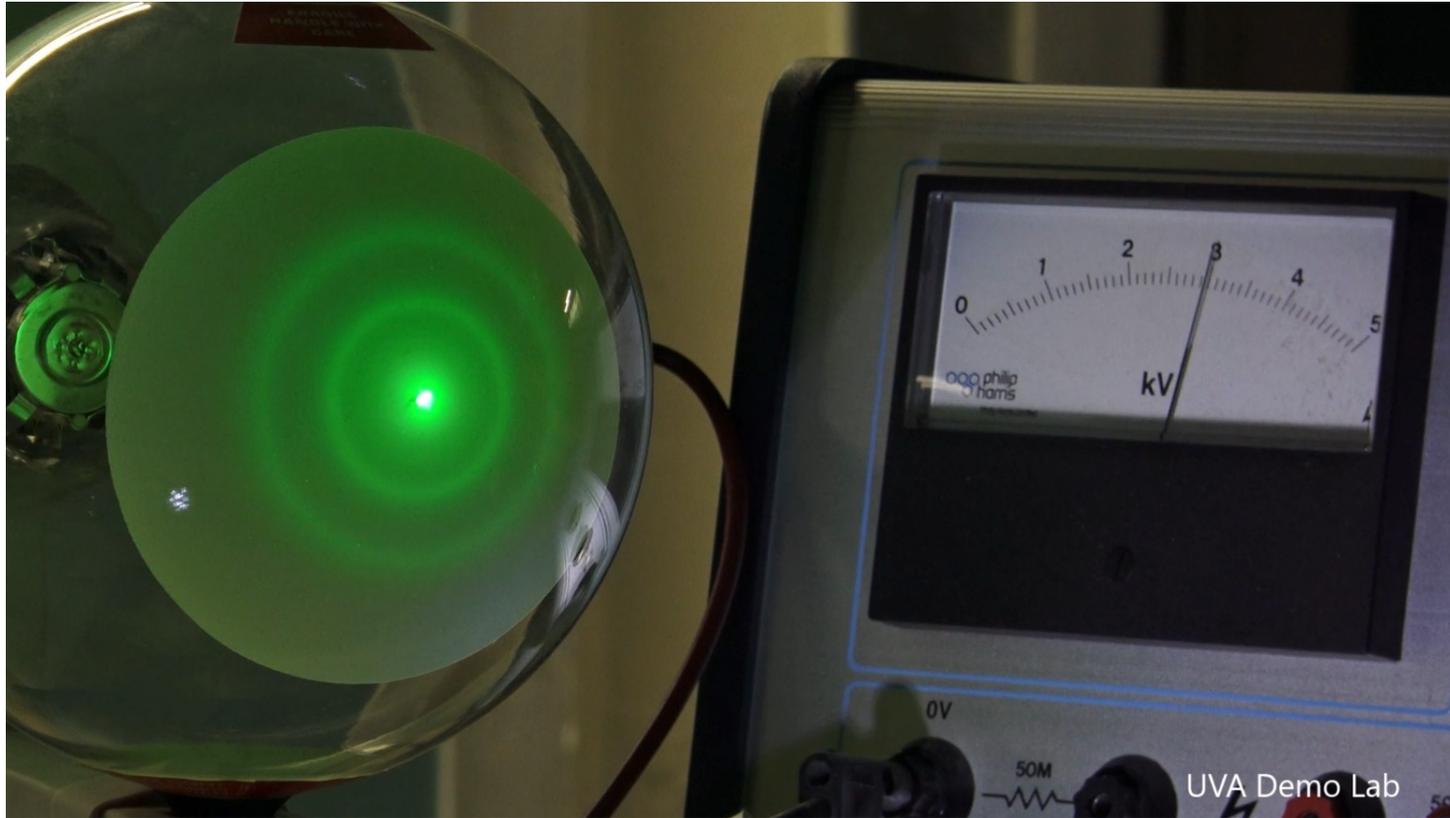


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Electron Diffraction Tube

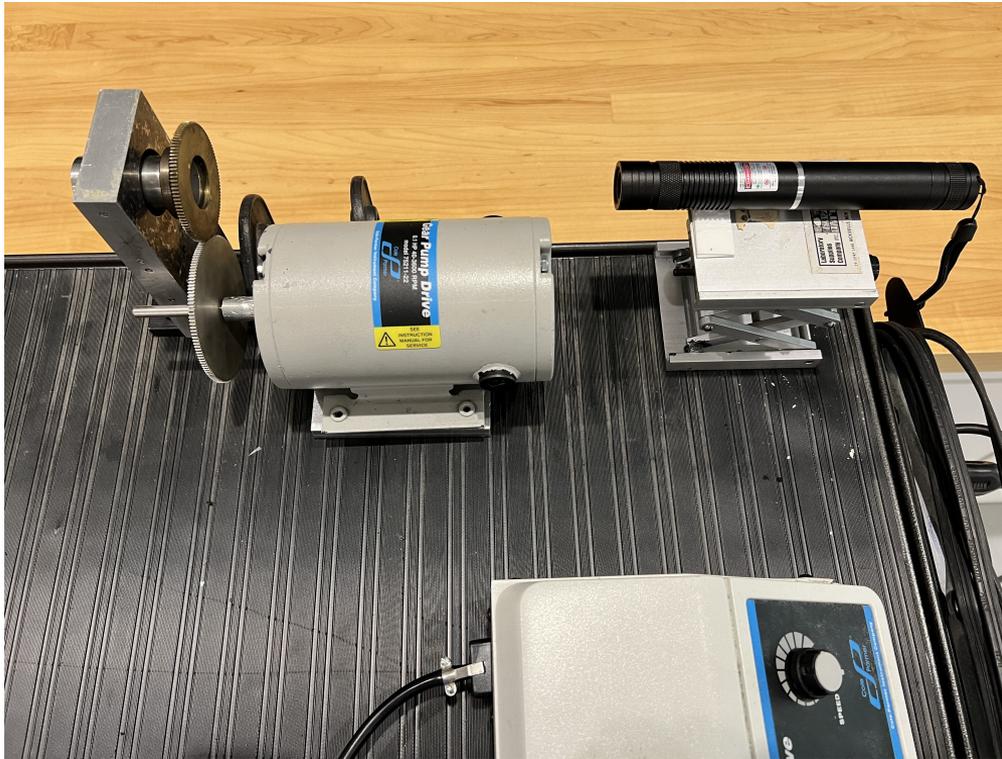


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Rotation Apparatus w/ Gears



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Rotation Apparatus w/ Belt

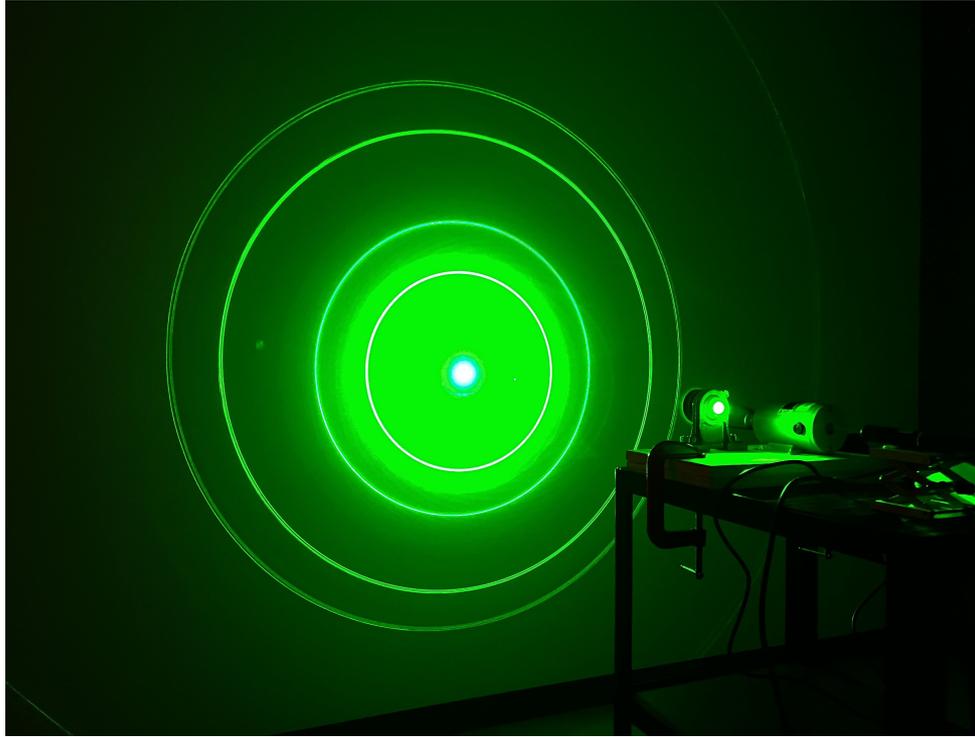


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Rotating Cross Grating



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Acknowledgements

Robert Jones for prototype rotation apparatus with gears.

Richard Lindgren for general physics discussions and proof reading.

Richard Marshall for discussions on UVA teaching lab's electron diffraction expt.

Airy Disk

Dots Pattern

100 opaque circles are scattered on a transparent background as illustrated.

Holes Pattern

100 transparent circles are scattered on an opaque background. The holes pattern is the same as the dots pattern, but with transparent and opaque areas switched.

