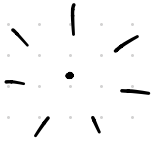
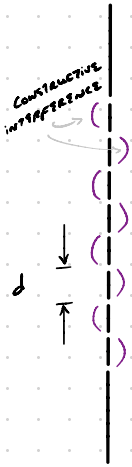
DIFFRACTION GRATING

- MANY [$N \approx 10{,}000$] SLITS, EVENLY SPACED [$d \approx 1\,\mu m$]



POINT SOURCE



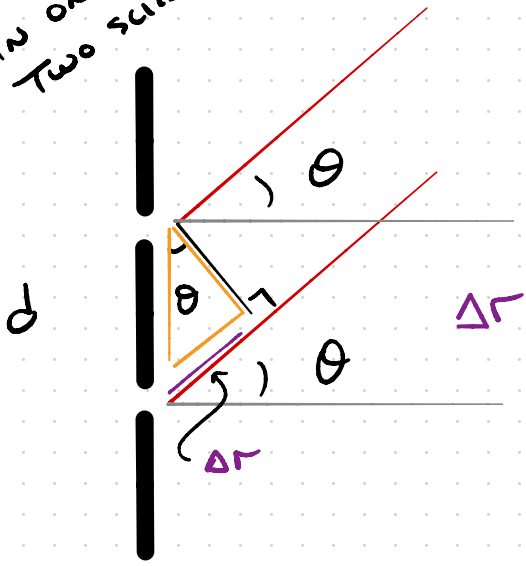
IF $\Delta r = 0, \lambda, 2\lambda, \ldots$ FOR ADJACENT SLITS, WE GET CONSTRUCTIVE INTERFERENCE BETWEEN ALL SLITS.

[TOTAL CONST. INTERF.]

SCREEN

- CONSTRUCTIVE MAXIMA (DIFFRACTION "PEAKS")

ZOOMED IN ON TWO SLITS



$$\Delta r = d \sin\theta = 0, \lambda, 2\lambda, \ldots$$

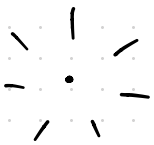
SEPARATION $\Delta\theta_c$ BETWEEN CONST. INT. PEAKS:

SMALL ANGLE APPROX

$$\sin\theta \approx \theta = 0, \frac{\lambda}{d}, \frac{2\lambda}{d}$$

$$\Delta\theta_c = \lambda/d$$

DIFFRACTION GRATING



POINT SOURCE

DESTRUCTIVE INTERFERENCE (i.e. $\Delta r = \frac{\lambda}{2}, 3\frac{\lambda}{2}, \ldots$)

ANY TWO SLITS BETWEEN IN (NEAR) TOTAL DESTRUCTIVE INTERFERENCE RESULTS

- MANY (N TIMES) MORE CONDITIONS OF DEST. INT. THAN CONST. INT.

SCREEN

• DESTRUCTIVE MINIMA

E.G.

DEST. INT. BETWEEN SLITS SPACED $\frac{N}{2}$ SLITS APART:

$$\Delta r = \frac{N}{2} \times d \sin\theta \approx \frac{N}{2} d\theta = \frac{\lambda}{2}, 3\frac{\lambda}{2}, \ldots$$

SEPARATION $\Delta\theta$ BETWEEN 0^{TH} ORDER CONST. INT ($\theta = 0$) AND SMALLEST ANGLE OF TOTAL DESTRUCTIVE INT:

$$\left(\frac{N}{2} d\theta = \frac{\lambda}{2} \longrightarrow \theta = \frac{\lambda}{d} / N\right)$$

WIDTH OF DIFFRAC. PEAKS

$$\Delta\theta_D = \frac{\lambda}{d} / N - 0 = \frac{\lambda}{d} / N$$

(1^{ST} DEST. MIN. − 0^{TH} CONST. MAX)

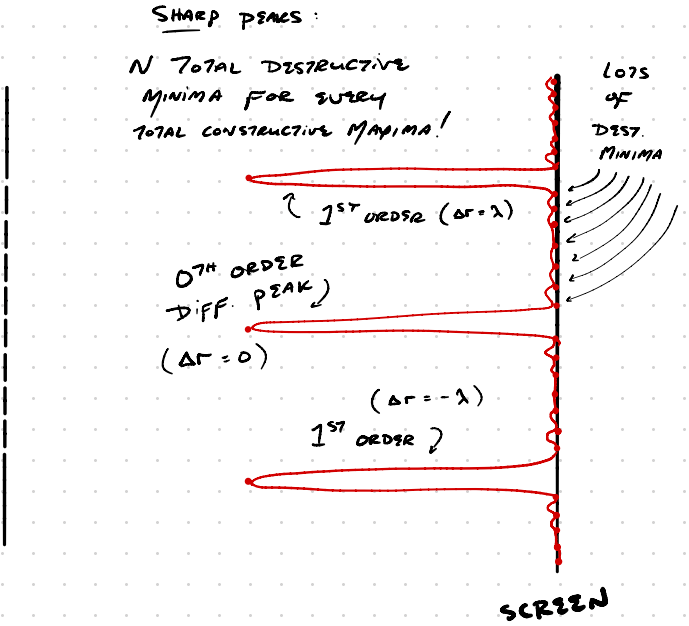
RATIO OF DIFF. PEAK WIDTH $\Delta\theta_D$ TO DIFF. PEAK SPACING $\Delta\theta_c$:

$$\frac{\Delta\theta_D}{\Delta\theta_c} = \frac{1}{N}$$

SINCE N IS LARGE ($\approx 10{,}000$), PEAKS ARE VERY NARROW!

DIFFRACTION GRATING

POINT SOURCE



- DIFFRACTION PATTERN

QUESTION FOR YOU:

- WHAT IS THE PATTERN FORMED BY A POINT SOURCE COMPOSED OF TWO COLORS $[\lambda_1 \neq \lambda_2]$?

DIFFRACTION GRATING EXAMPLES

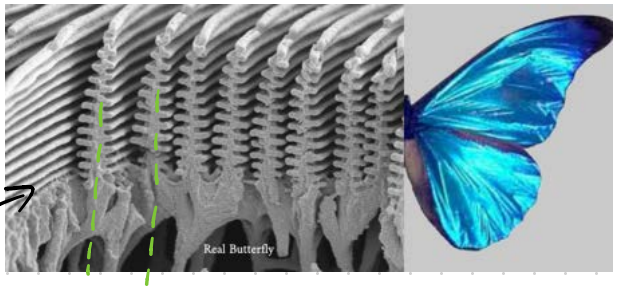
- "STRUCTURAL COLOR"
  - IRIDESCENCE
  - CHANGE IN PERCEIVED COLOR W/ VIEWING ANGLE.

SUN

WHITE LIGHT

PERCEIVED COLOR DEPENDS ON WHERE you look!

BUTTERFLY SCALES FORM A DIFFRACTION GRATING*, DISPERSES SUNLIGHT INTO SPECTRUM



≈ 700nm

BUTTERFLY SCALES [ELECTRON MICROSCOPE]

* THE "SLITS" HERE ARE REFLECTIVE INSTEAD OF TRANSMISSIVE, BUT THE IDEA IS THE SAME.

• MATTER WAVES?

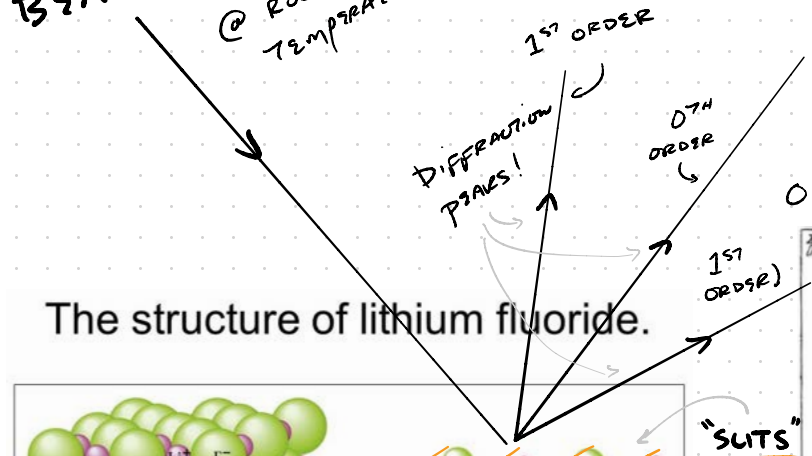
• DE BROGLIE HYPOTHESIS (1924):

• MASSIVE PARTICLES ARE WAVES W/ A WAVELENGTH

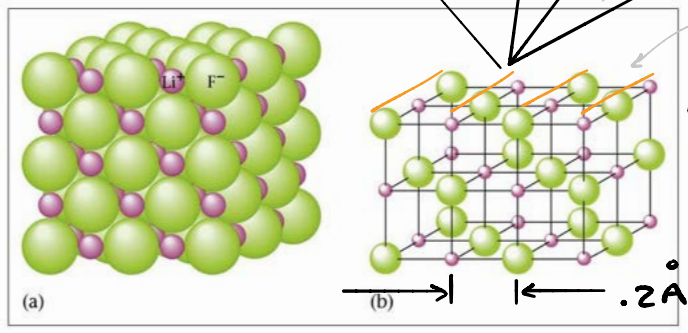
$$\lambda = \frac{h}{p}$$

(h: PLANCK'S CONSTANT; p: PARTICLE'S MOMENTUM [I.E. MASS × VELOCITY])

HELIUM BEAM ($\lambda \approx 1$ Å @ ROOM TEMPERATURE)



OTTO STERN 1930



"SLITS" (REFLECTIVE)

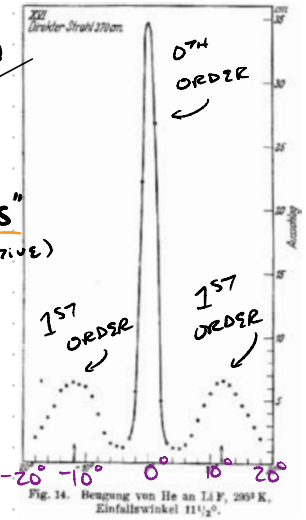


Fig. 14. Beugung von He an LiF, 293° K. Einfallswinkel 11½°.