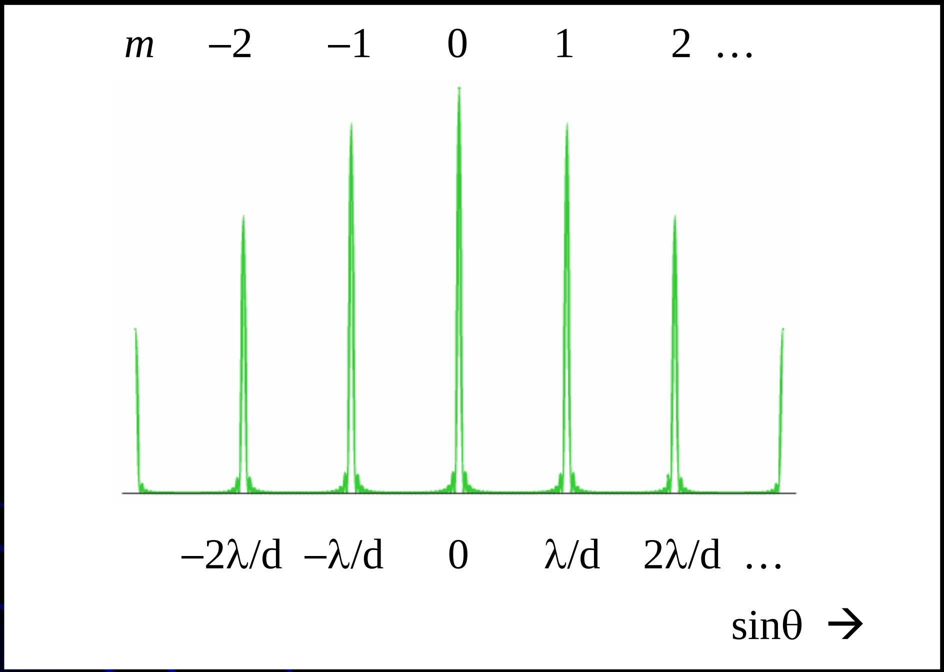
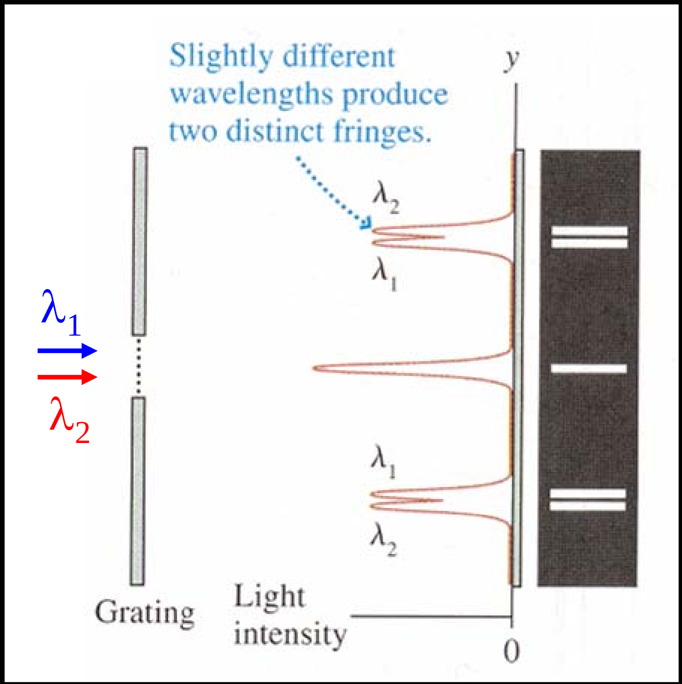
(2) The diffracting grating

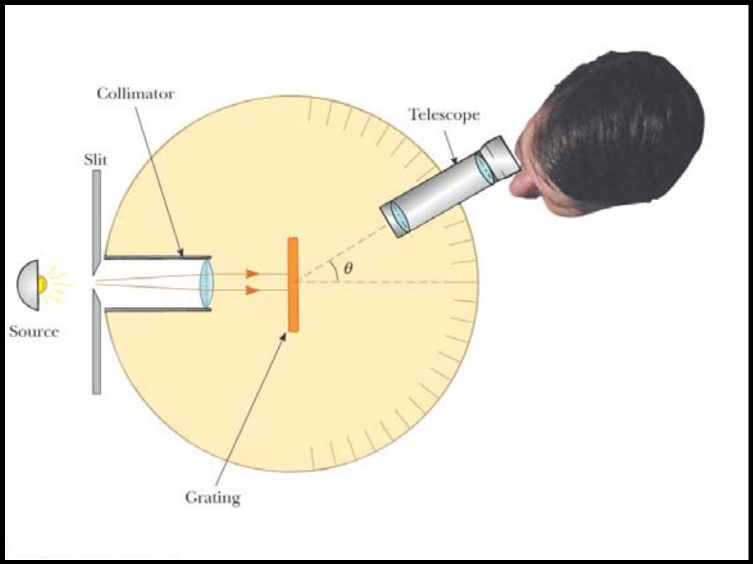
Condition for interference maxima for a grating :

$$\boxed{d \sin\theta = m\lambda} \qquad \text{with } m = 0, \pm 1, \pm 2, \ldots$$



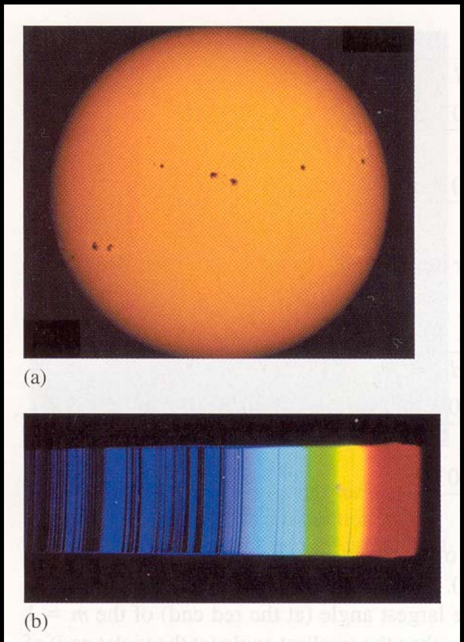


(3) Diffraction grating spectrometer :



The diffracted light leaves the grating at angles that satisfy the condition;

$$\boxed{d \sin\theta = m\lambda}$$

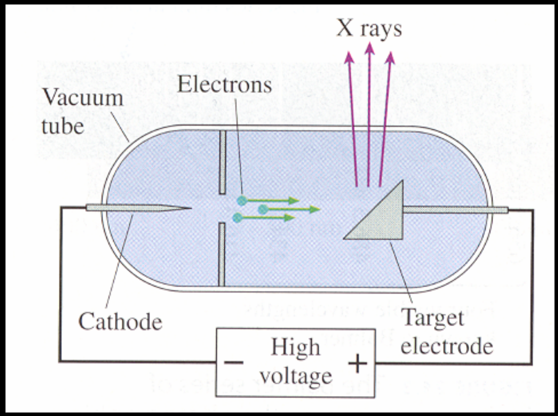


Absorption lines of spectrum :

Specific wavelengths are absorbed as sunlight passes through the sun's atmosphere, leaving dark lines in the spectrum. (Ch. 42, Atomic Physics)

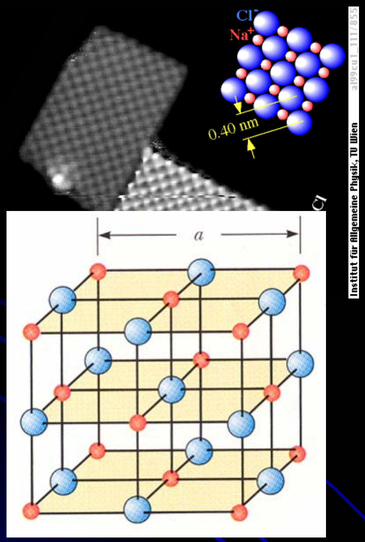
38.5 Diffraction of X-rays by crystals

- X-Ray (Röntgen, 1895 / Nobel prize 1901) :
  - → Electromagnetic waves of very short wavelength (~ 0.1 *nm*).
    (Ch. 42, Atomic Physics)

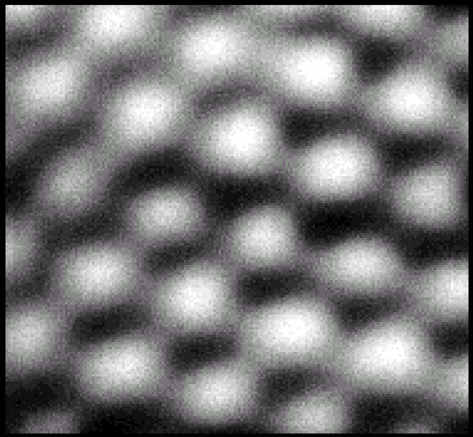


(Bremsstrahlung)

- Crystalline structure : (10^{-10} m = 1 Å)



Crystalline structure of sodium chloride (NaCl). The blue spheres represent Cl^- ions, and the red spheres represent Na^+ ions. The length of the cube edge is a = 0.56 nm.



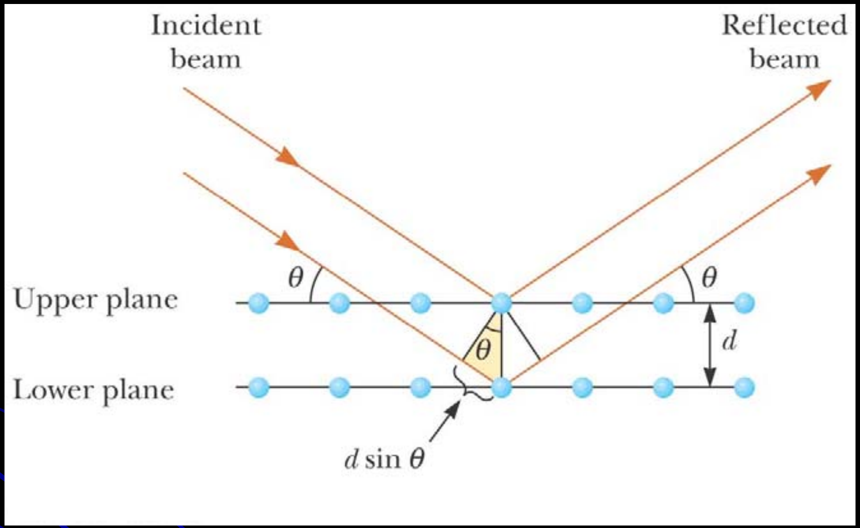
STM image of Ag atoms

- Max von Laue : (Nobel prize 1914, diffraction of X-rays on crystals)
  His idea : the regular array of atoms in a crystal as a three-dimensional diffraction grating for X-rays.

- **Bragg's law :** (Nobel prize 1915, for the use of X-rays to study the structures of crystals).

→ Condition for constructive interference in crystalline planes :

$$\boxed{2d\sin\theta = m\,\lambda} \qquad \text{with } m = 1, 2, 3, \ldots \qquad \text{(Bragg condition)}$$



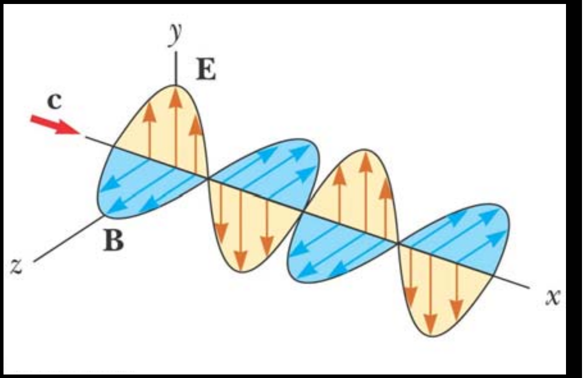
A two-dimensional description of the reflection of an x-ray beam from two parallel crystalline planes separated by a distance d. The beam reflected from the lower plane travels farther than the one reflected from the upper plane by a distance $2d\sin\theta$.

38.6 Polarization of light waves

- Light : Electromagnetic wave ($\boldsymbol{E} \perp \boldsymbol{B}$) → Ch. 34.

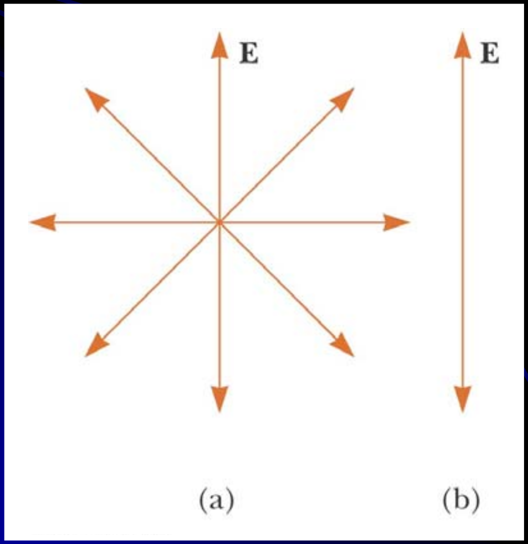
Direction in which the electric field $\boldsymbol{E}$ is vibrating.

$\cong$ *Direction of polarization of wave*.



Schematic diagram of an electromagnetic wave propagating at velocity c in the x–direction. The electric field vibrates in the xy plane, and the magnetic field vibrates in the xz plane.

$\Rightarrow$ A wave is linearly polarized when electric field $\boldsymbol{E}$ vibrates in the same direction at all times. $\rightarrow$ *Plane of polarization*.



(a) A representation of an *unpolarized* light beam viewed along the direction of propagation (perpendicular to the page). The transverse electric field can vibrate in any direction in the plane of the page with equal probability.

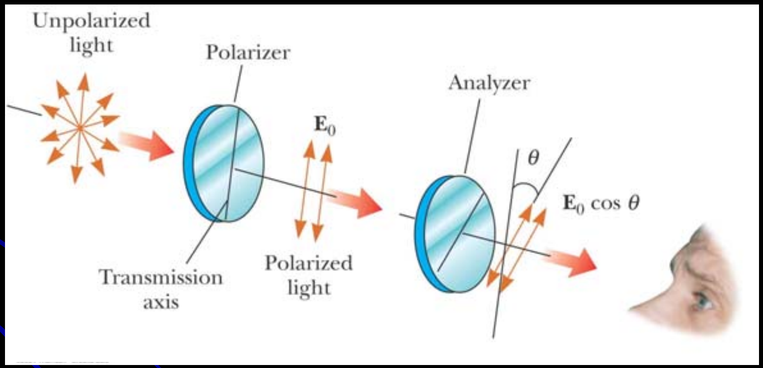
(b) A *linearly polarized* light beam with the electric field vibrating in the vertical direction.

- **Producing polarized light from unpolarized light :**

  1) Polarizer : polarizes light through selective absorption by oriented molecules, *e.g.*, long-chain hydrocarbons (Polaroid; Edwin Land, 1932).

- **Intensity of the polarized beam transmitted through a polarizer :**

$$\boxed{I = I_{max} \cos^2\theta} \qquad \text{(Malus's law)}$$

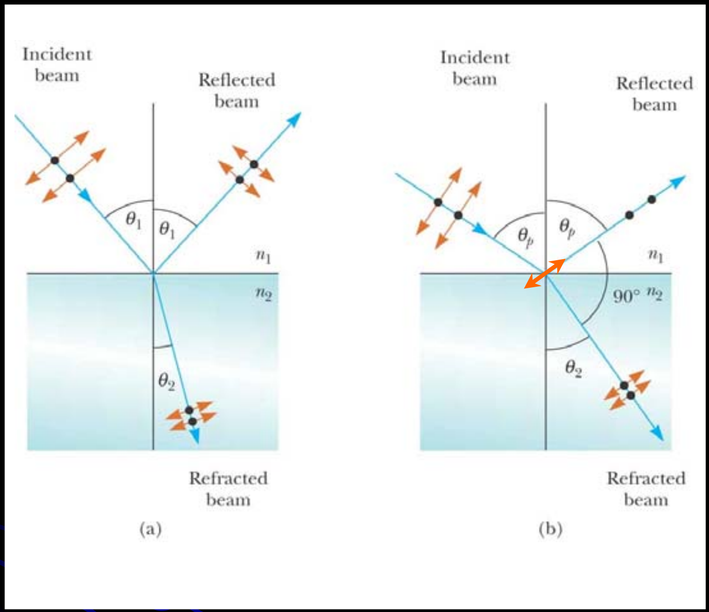


Two polarizers whose transmission axes make an angle θ with each other. Only a fraction of the polarized light incident on the analyzer is transmitted through it.

2) Polarization by reflection at the Brewster angle θ_B :

At a particular angle of incidence, polarizing angle θ_B, the reflected beam is completely polarized (with its ***E***-field vector).

$$\boxed{n_2 = \tan\,\theta_B} \qquad (\text{ Brewster's law })$$



(a) When unpolarized light is incident on a reflecting surface, the reflected and refracted beams are partially polarized.

(b) The reflected beam is completely polarized *when the reflected and refracted rays are perpendicular to each other*.