بسم الله الرحمن الرحيم
وَمَا أُتِيتُم مِّنَ ٱلْعِلْمِ إِلَّا قَلِيلًا
صدق الله العظيم

PHYSICS (3)
Distribution of Marks

Total Marks (100)

Thirty	Twenty	Activities	Final exam
30	20	10	40

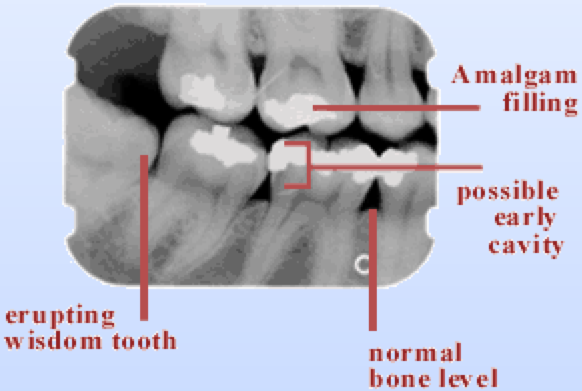
Course contents

- X Ray
- Polarization
- Insulators
- Laser
- Nanomaterials

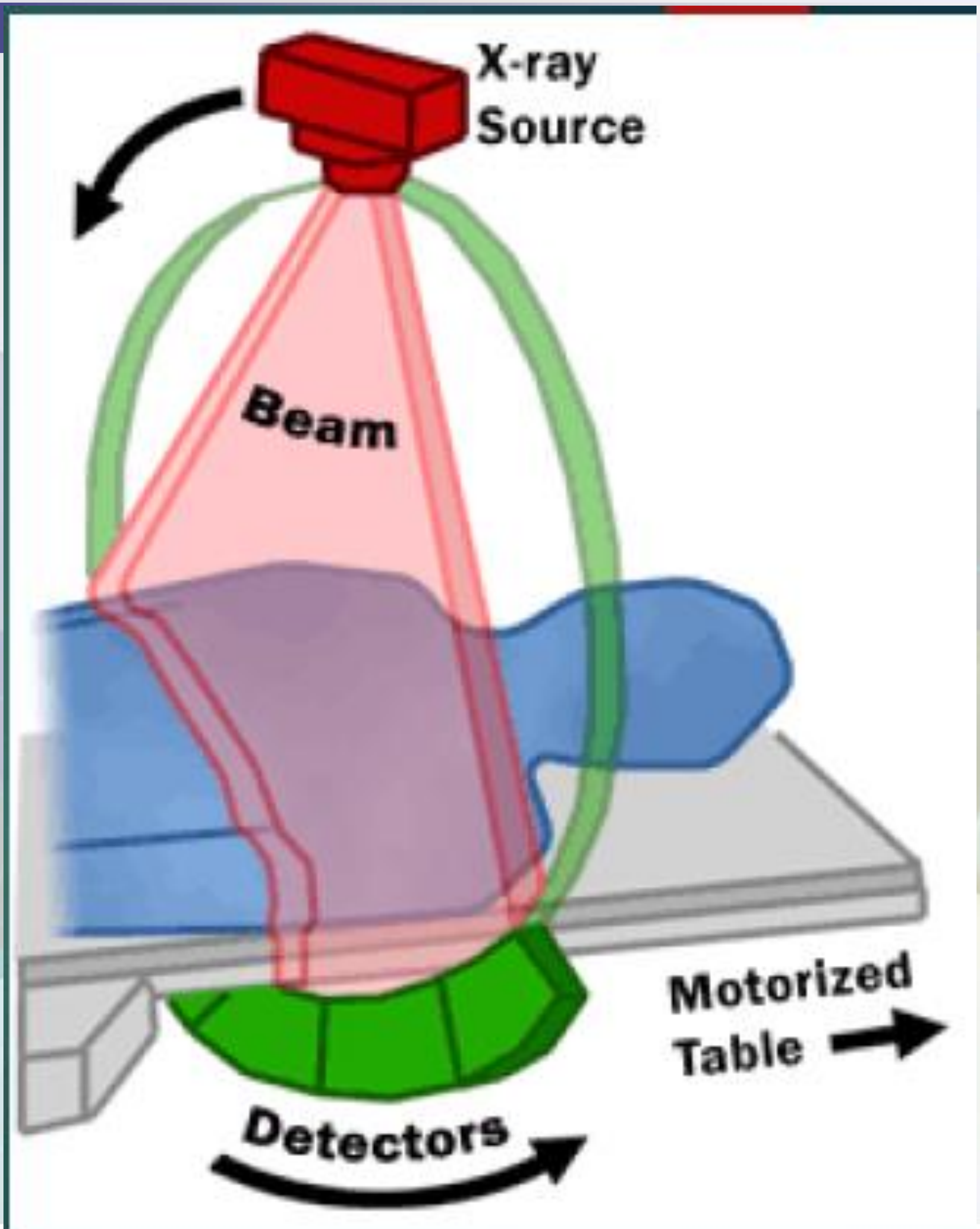
X

X-Rays

X-Rays Medical Applications



- X-rays are used in medicine for medical analysis. Dentists use them to find complications, cavities and impacted teeth.
- Soft body tissue are transparent to the waves.
- Bones and teeth block the rays and show up as white on the black background


X-ray
Source
Beam
Motorized
Table
Detectors

Below are some x-rays showing objects which have been swallowed by people. The examples show an open safety pin and a child's stomach with all the pieces of a magnetic toy re-aligned after he's swallowed them…one by one!

"Your x-ray showed a broken rib, but we fixed it with Photoshop."

History of X-Rays

x-ray technology was invented completely by accident. In 1895, a German physicist named Roentgen made the discovery while experimenting with **electron beams** in a **gas discharge tube**. Roentgen noticed that a fluorescent screen in his lab started to glow when the electron beam was turned on.

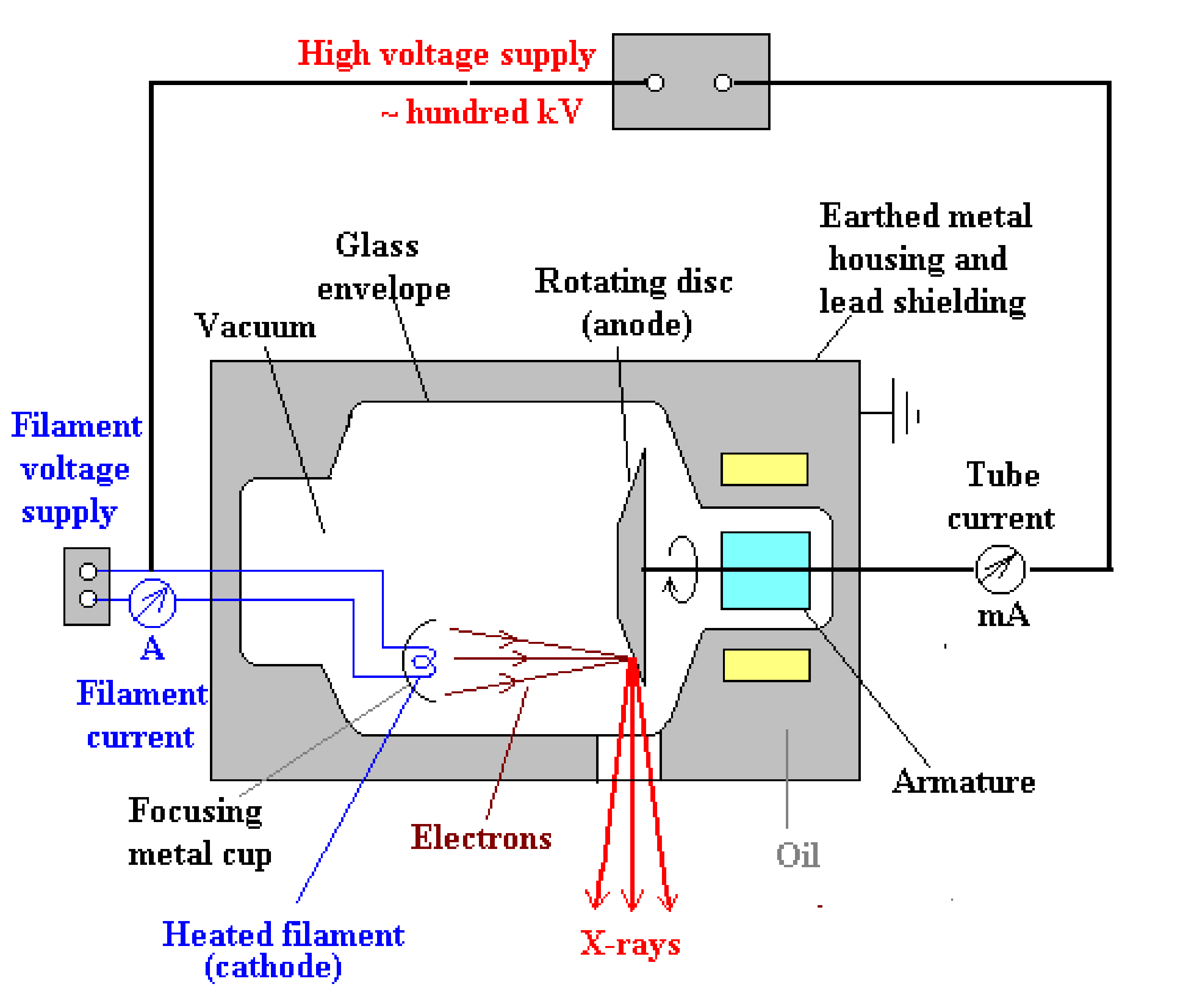
Wilhem Roentgen, The discoverer of X-Rays

Roentgen placed various objects between the tube and the screen, and the screen still glowed. Finally, he put his hand in front of the tube, and saw the silhouette of his bones projected onto the fluorescent screen.

So he not only discovered x-rays but also, their most beneficial application.

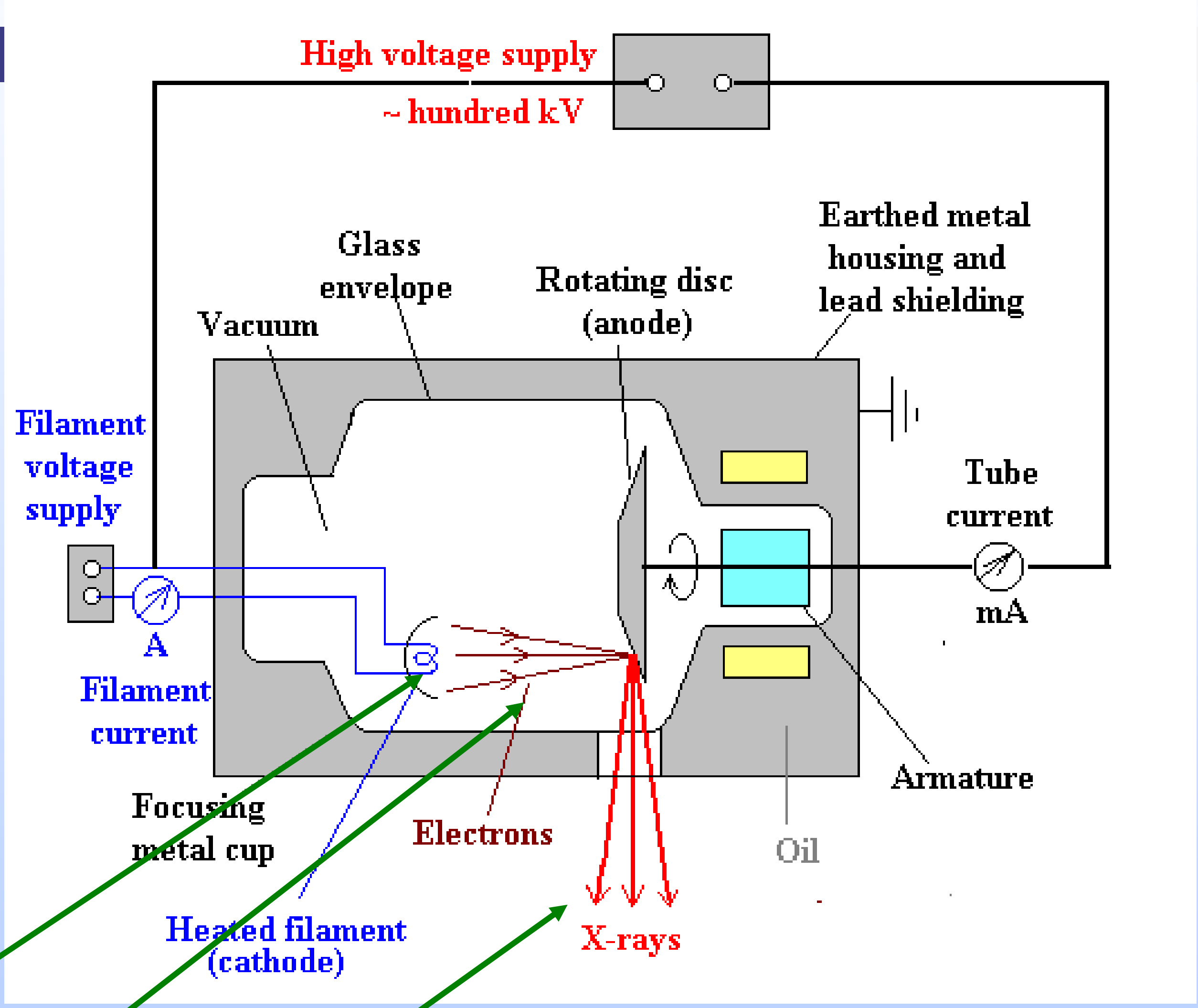
One of the very first x-rays: The picture above shows an x-ray taken of Wilhem Roentgen wife's hand. You can see her wedding ring is clearly visible.

How are X-Rays Produced?



X-Rays are produced in a special type of tube called… "An X ray Tube!!"

Production Of X-Rays.. (continued)

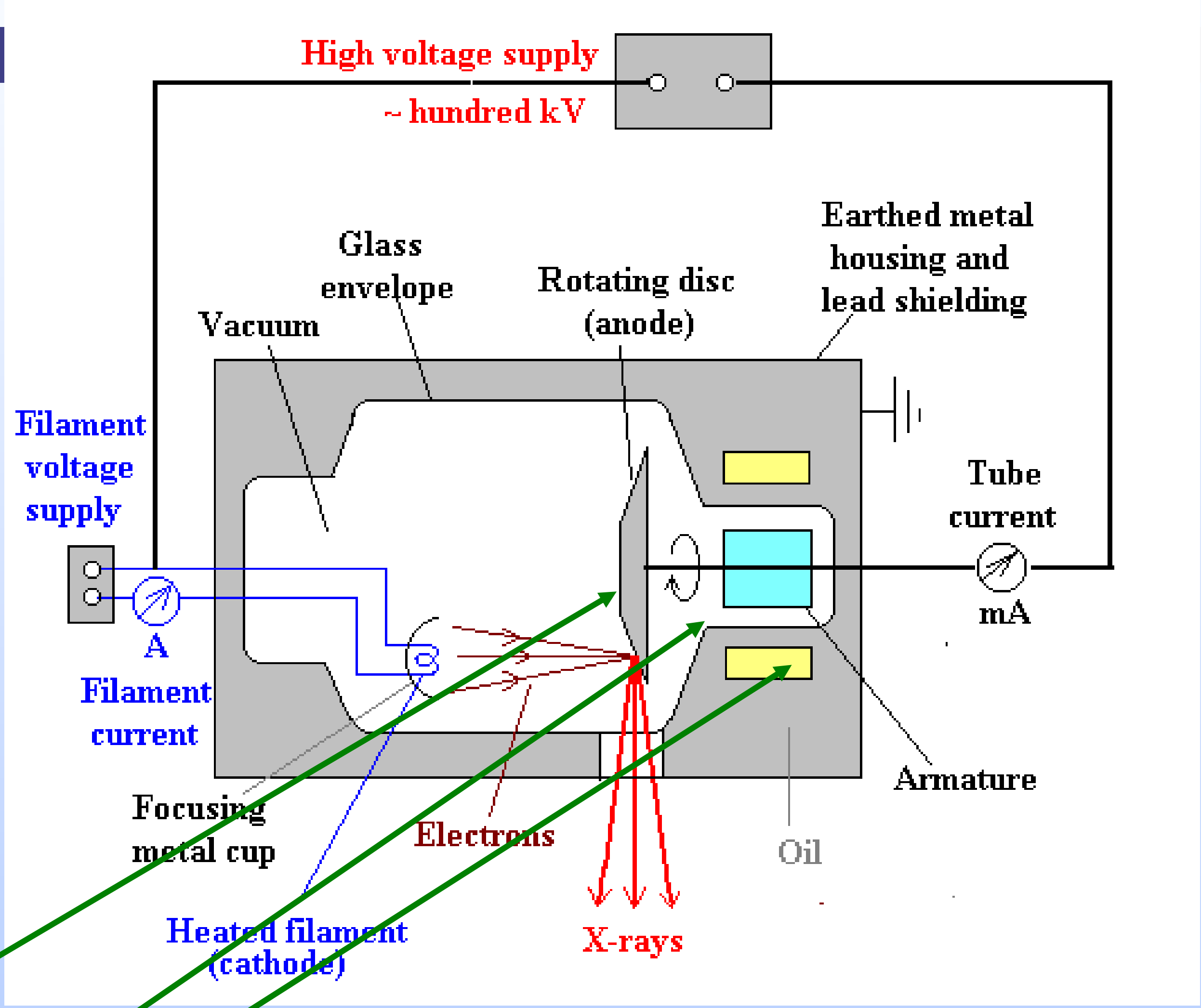


Electrons are first emitted from a heated filament, by a process called thermionic emission.

They are then accelerated across the evacuated X-ray tube, under the action of a large voltage across the tube, the filament forming the negative cathode and the target being positive anode. On striking the target, the electrons lose most (about 98%) of their energy in low-energy collisions with target atoms, resulting in a substantial heating of the target.

The rest of the electron energy (usually less than 2%) reappears as X-ray radiation.

Production Of X-Rays.. (continued)

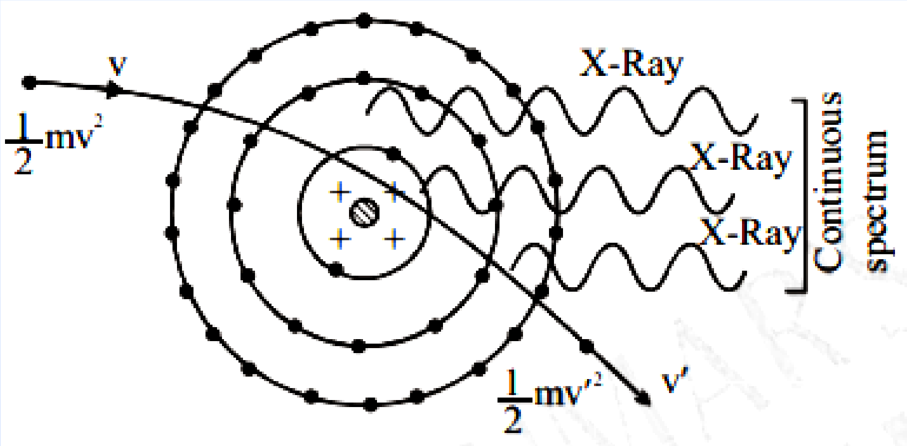


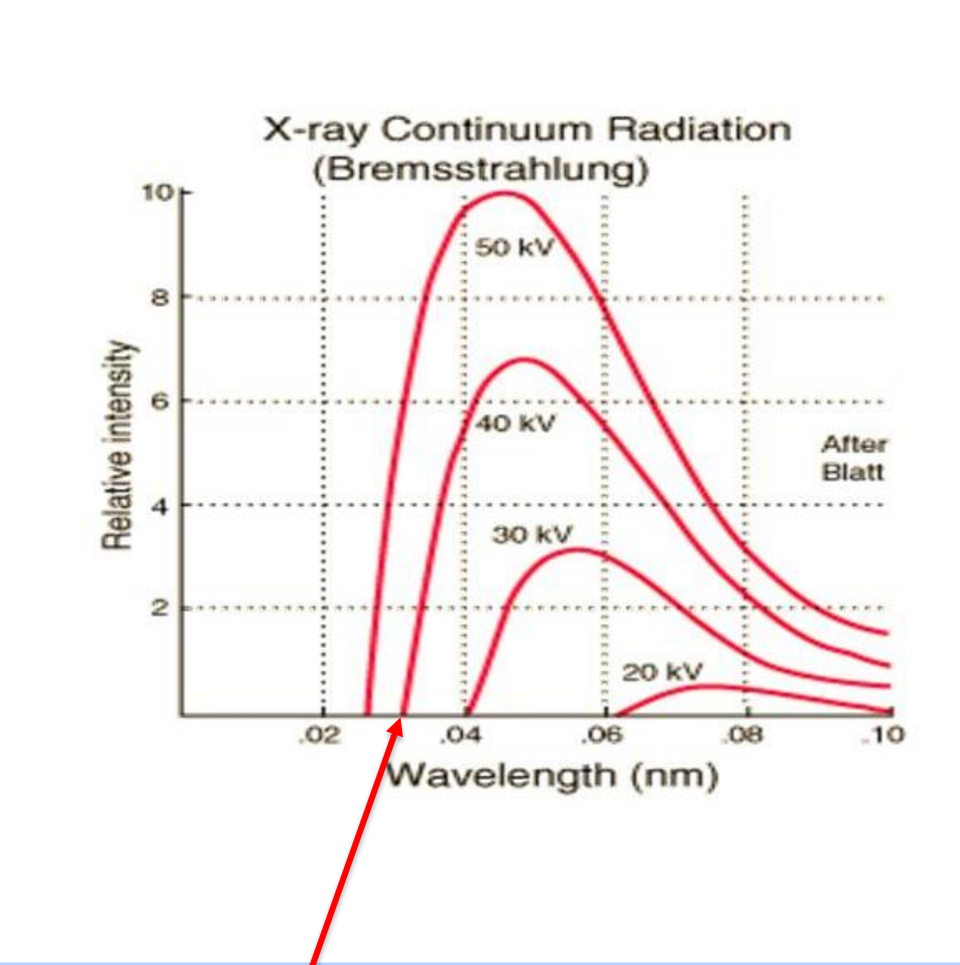
•*A rapidly-rotating anode* is generally used. It forms the (tungsten) target surface on to which the electron beam is focused. The target area under bombardment is constantly changing, thus reducing local heat concentration. (You can often hear the whirring of the anode motor during the taking of an X-ray.

Copper, being an excellent heat conductor, is used to hold the anode in place.

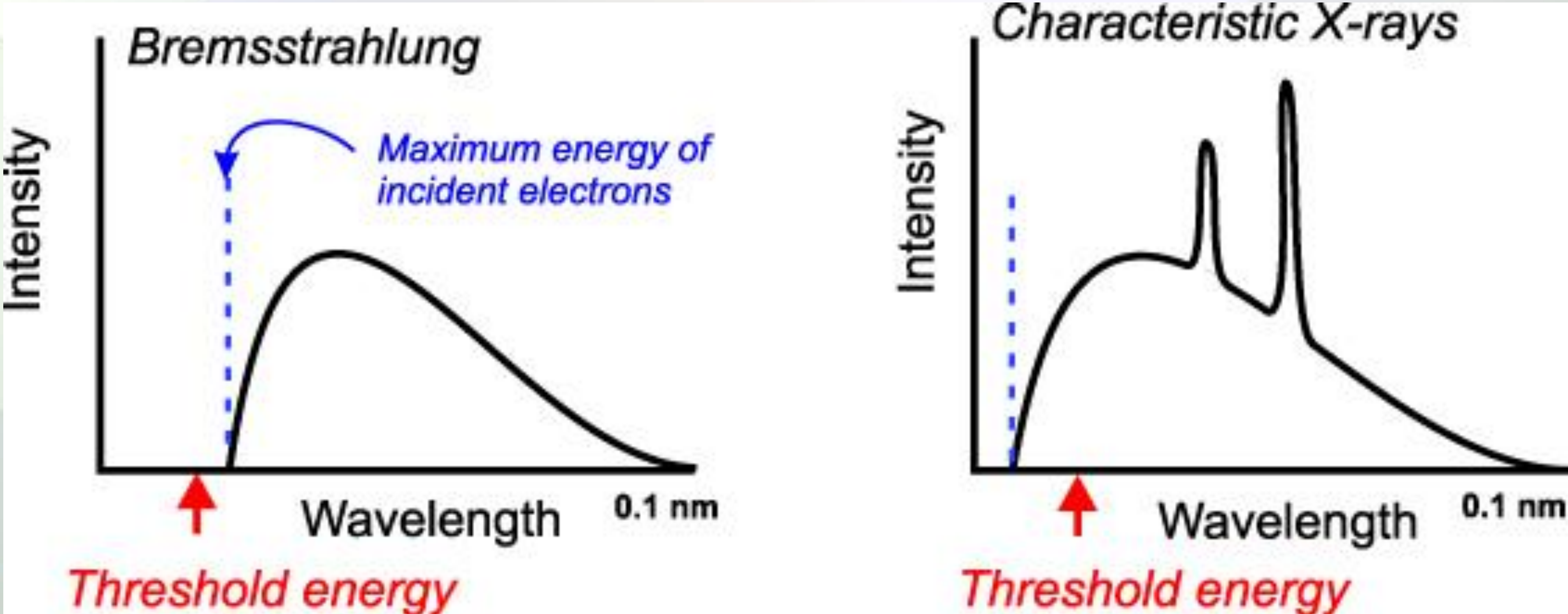
Oil, which circulates in the outer housing,, helps with convective cooling (as well as providing electrical insulation).

Continuous X Ray Spectra





λ_{min} or cut off wavelength


Bremsstrahlung
Maximum energy of incident electrons
Intensity
Wavelength
0.1 nm
Threshold energy
Characteristic X-rays
Intensity
Wavelength
0.1 nm
Threshold energy

- A few fast-moving electrons penetrate deep into the interior of the atoms of the target material and are attracted towards the nuclei by the attractive forces of their nuclei.

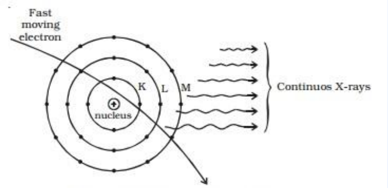


Fig Origin of continuous X – rays

- Due to these forces, the electrons get deflected from their original path. As a result of this, the electrons are decelerated, and hence energy of the electron decreases continuously. This loss of energy during retardation is given off in the form of X-rays of continuously varying wavelength.
- The continuous spectrum is due a rapid de-acceleration of the electrons of the electrons hitting the target and emits energy.

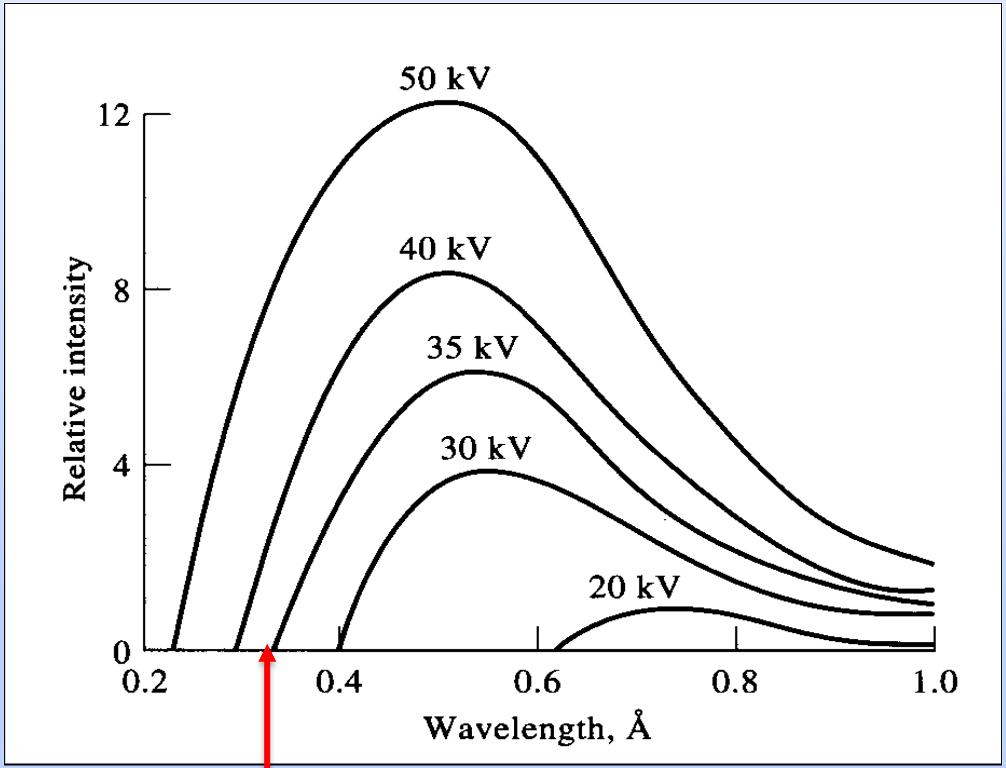
- Not all electrons are de-accelerated in the same way, some are stopped in one impact and give up all their energy (Max freq.) (gives λ_{min})
- While others are deviated this way and that by the atoms of the target successively losing fraction of total K.E.
- The minimum wavelength depends on the anode voltage.

If *V* is the potential difference between the anode and the cathode.

X-ray tube emission

X ray Continuous spectra

Results from rapid de-acceleration of electrons hitting the target.



λ_{min} or cut off wavelength

E = hν

$$h\nu_{max} = \frac{hc}{\lambda_{min}} = eV$$

V: accelerating voltage

e: charge on e⁻

λ_{min} is inversely proportional to V

$$\lambda_{min} = \frac{hc}{eV} \qquad \lambda_{min} = \frac{const}{V}$$

$$\lambda_{min} = \frac{hc}{eV} = \frac{1.24\times10^{-6}}{V} \; m$$

$$\lambda_{min} = \frac{hc}{eV} = \frac{12400}{V} \; A^{\circ}$$

- **Depend on the applied voltage**
- **Independent of material type**

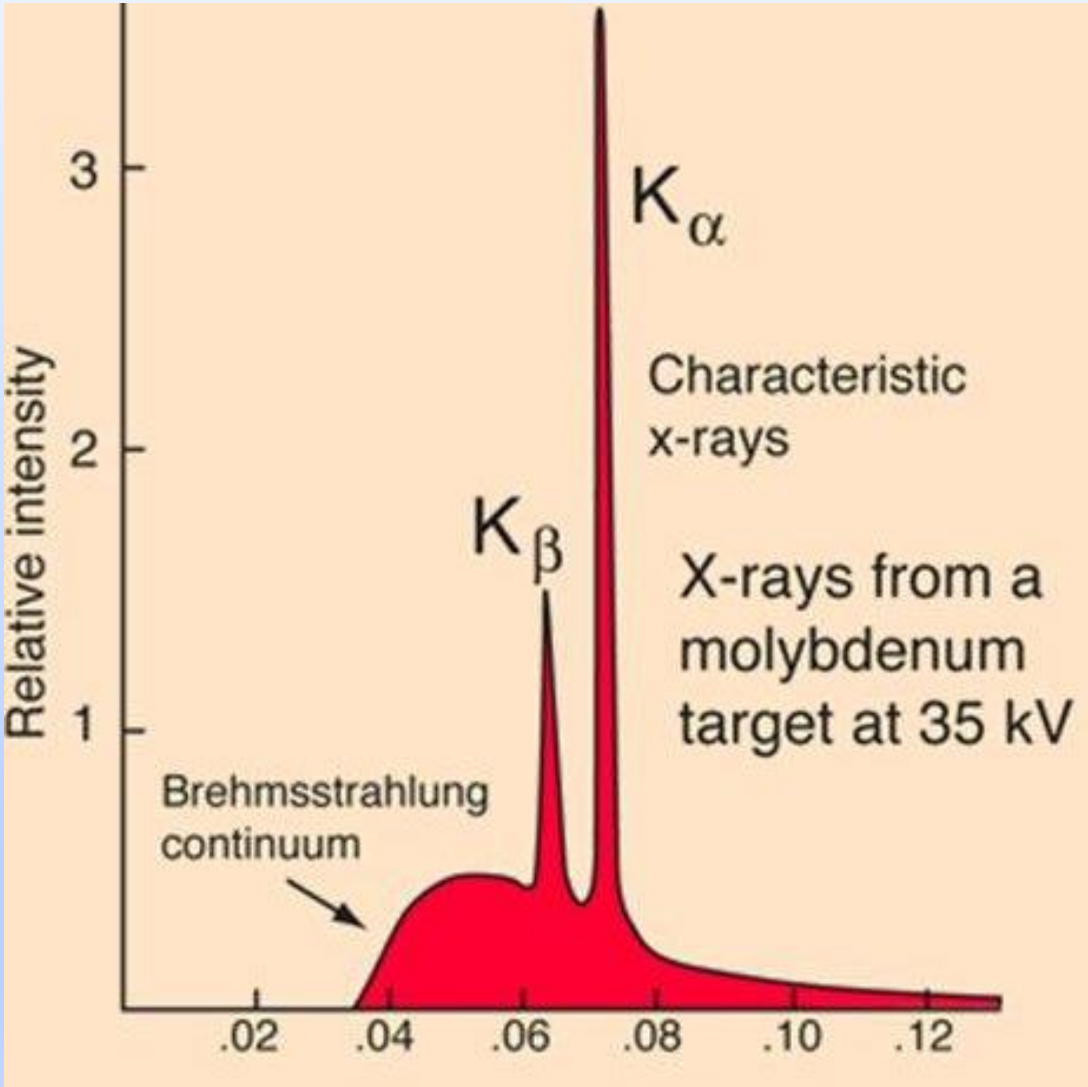
Continuous X ray Spectrum

- X-rays are produced when matter is irradiated with a beam of high-energy charged particles(electrons).

- In an x-ray tube, the interactions are between the electrons and the target. Since energy must be conserved, the energy loss from the interaction results in the release of x-ray photons.

- This process generates a broad band of continuous radiation (bremsstrahlung process, slowdown radiation, braking radiation, polychromatic radiation or white radiation).

X ray Line spectra is possible!



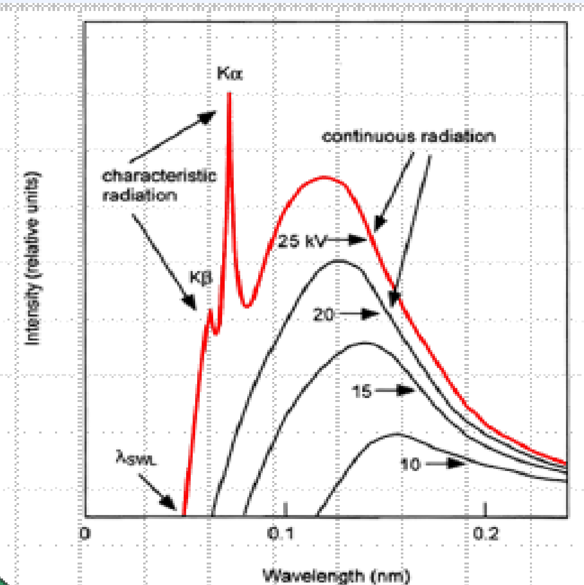
Line Spectrum of a target

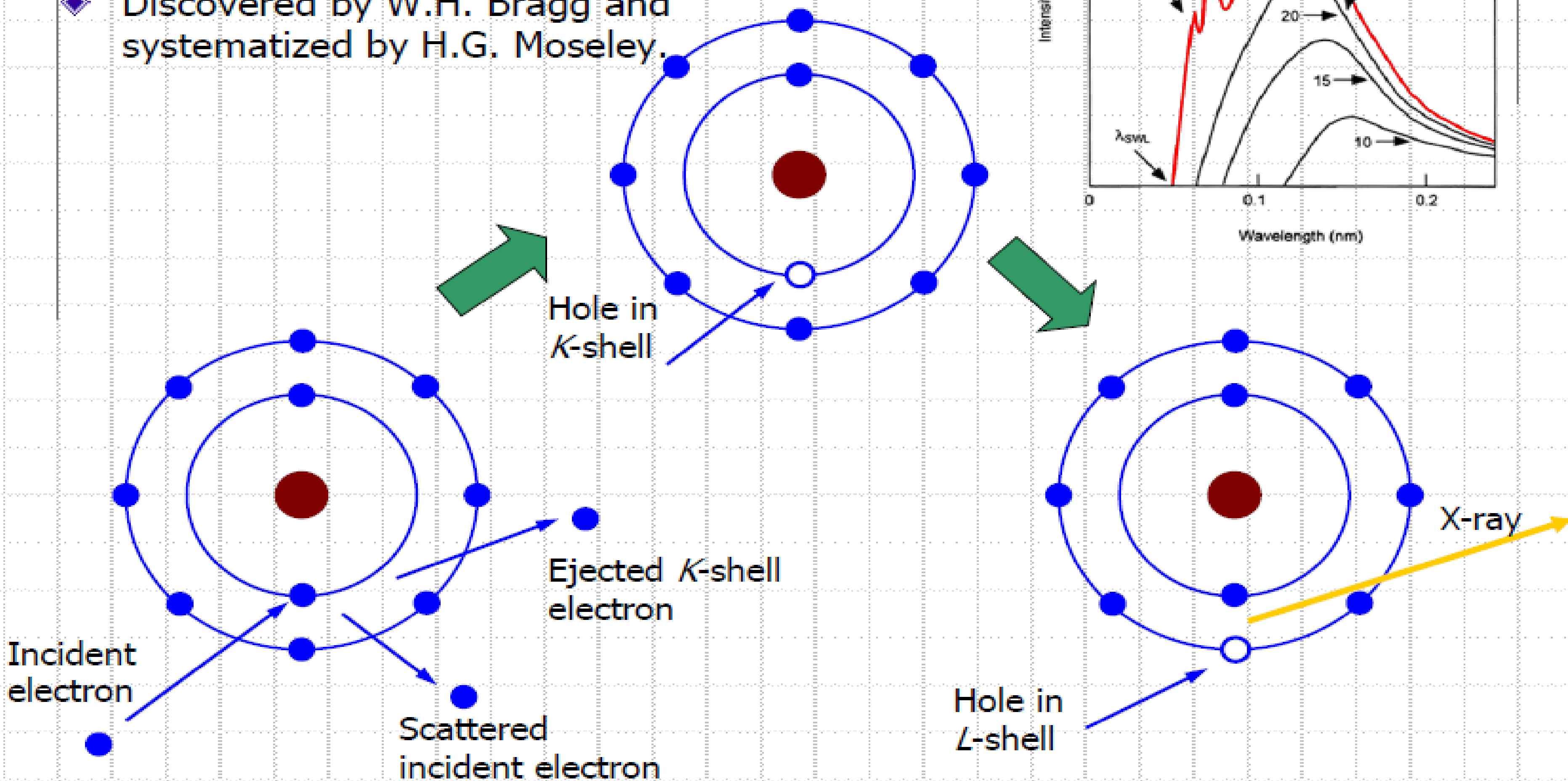
- **An increasing voltage above certain value , the characteristic of the target metal, sharp intensity maximum appear at certain wavelength superimposed on the continuous spectrum Called line spectra.**
- **Depend on the type of target material.**

X ray Line Spectrum

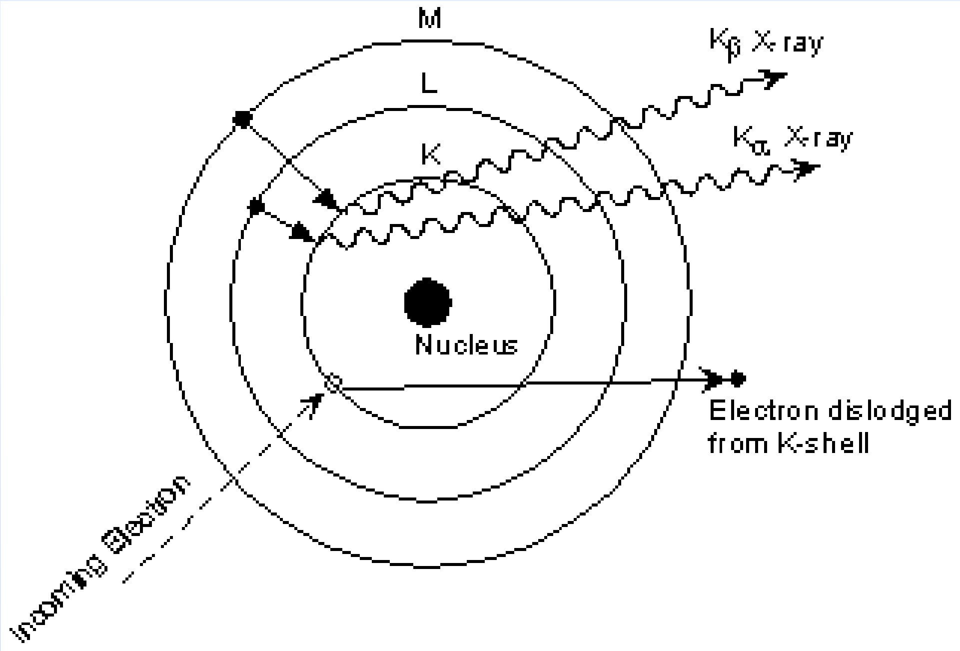
The Characteristic Spectrum

- Discovered by W.H. Bragg and systematized by H.G. Moseley.





Explanation of Line Spectra by Quantum Theory

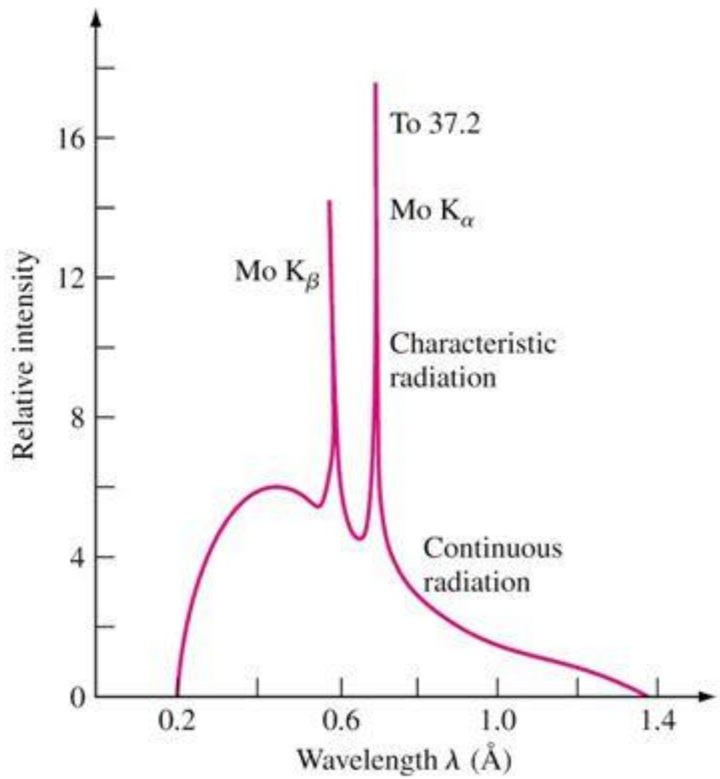


L-shell to K-shell jump produces a $K\alpha$ x-ray

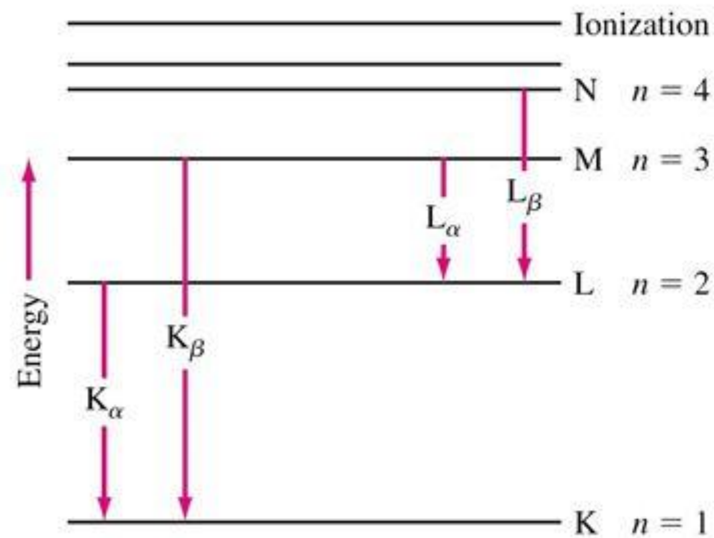
M-shell to K-shell jump produces a $K\beta$ x-ray

- An incoming high-energy electron which bombards the target can knock out a k-shell electron in the target atom,
- leaving a vacancy in the shell and the atom will be in an excited state.
  - An outer shell electron(from L or M shell) "jumps" to fill the vacancy.
  - A characteristic x-ray (equivalent to the energy change in the "jump") is generated.
  - Then the atom return to its ground state.

X-Ray Sources



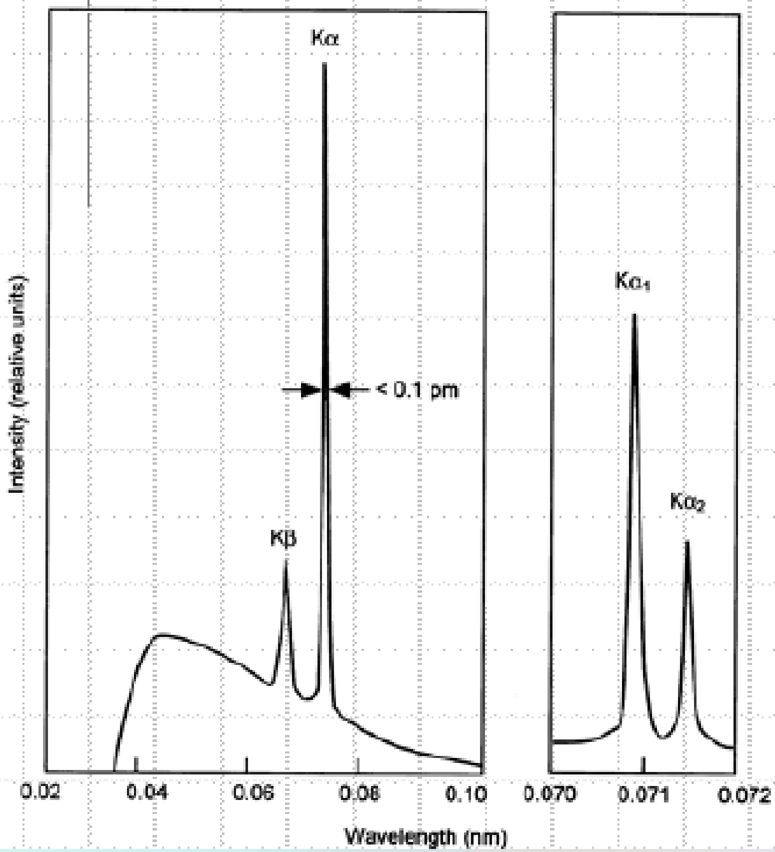
X-ray emission spectrum of Molybdenum which used as target metal in x-ray tube



Origin of K_α and K_β radiation

Properties of Line spectra

- Usually only the *K*-lines are useful in x-ray diffraction.
- There are several lines in the *K*-set. The strongest are $K\alpha_1$, $K\alpha_2$, $K\beta_1$.
- α_1 and α_2 components are not always resolved – $K\alpha$ doublet. $K\alpha_1$ is always about twice as strong as $K\alpha_2$, while ratio of $K\alpha_1$ to $K\beta_1$ averages about 5/1.



Some Commonly Used X-ray *K* wavelengths (Å)

Element	$K\alpha$ (av.)	$K\alpha_1$	$K\alpha_2$	$K\beta_1$
Cr	2.29100	2.28970	2.29361	2.08487
Fe	1.93736	1.93604	1.93998	1.75661
Co	1.79026	1.78897	1.79285	1.62079
Cu	1.54184	1.54056	1.54439	1.39222
Mo	0.71073	0.70930	0.71359	0.63229

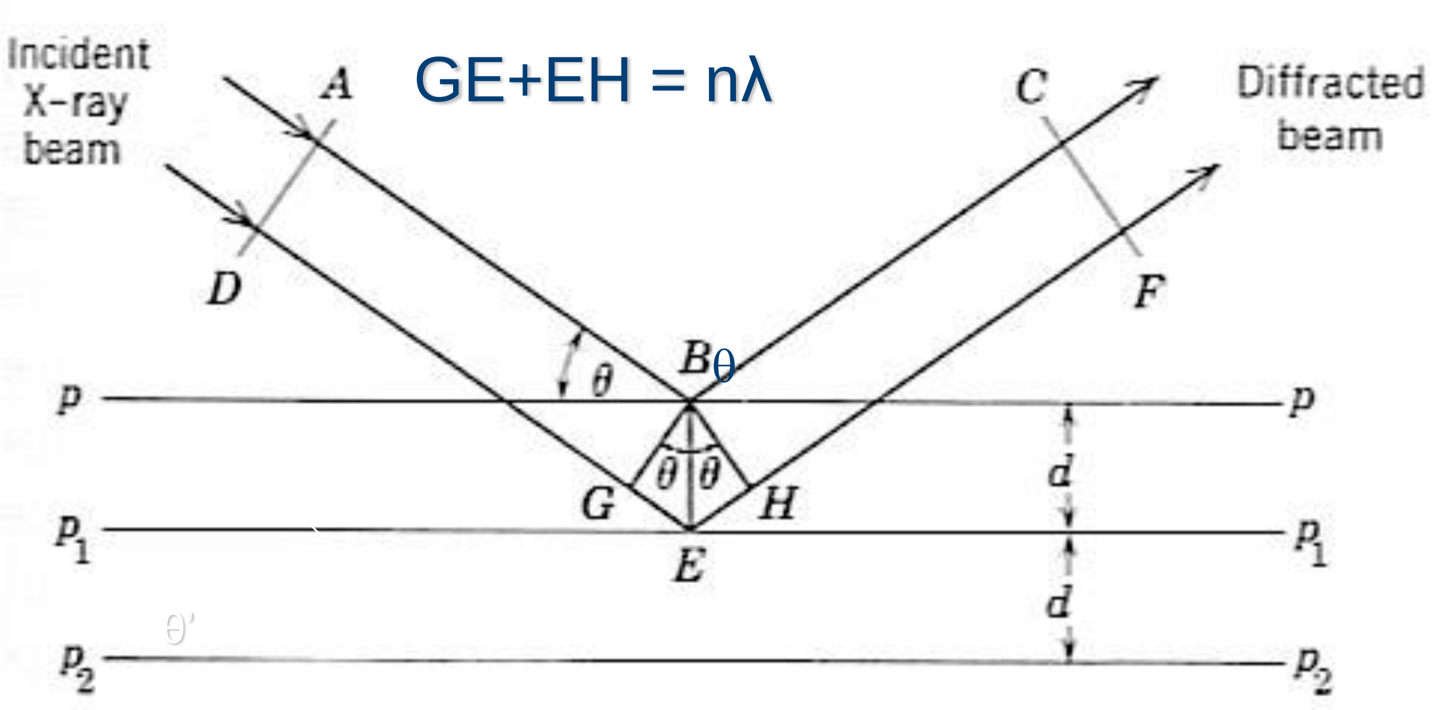
X-ray Diffraction on crystals

(Bragg's Law) $n\lambda = 2d \sin\theta$ BRAGG's EQUATION

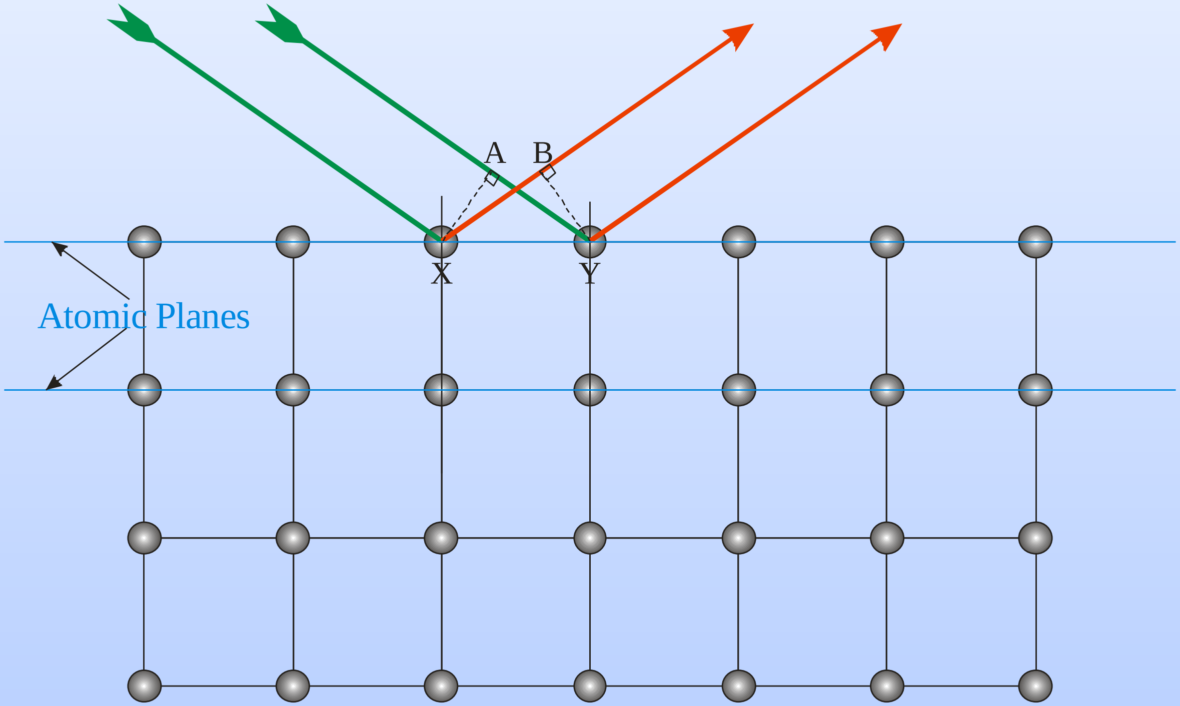
Used to study the fine structure of matter.

The spacing (d) of atomic planes

Incident angle (θ) at which X-rays of a particular wavelength(λ) will reflect in phase (i.e., diffract)



GE + EH is the path difference, waves add if equal to nλ


A
B
X
Y
Atomic Planes

X-Rays

This unit deals with X-rays. By the end of this unit you should be able to explore and explain some of the following ideas

1. Some applications of x-rays in medicine.
2. Some background information about x-rays.
3. Some of the physics ideas behind x-rays.
4. Uses of X-rays in industrial products (Quality control).