UNIVERSITY OF BIRMINGHAM

Lecture 6 – X-ray Spectra

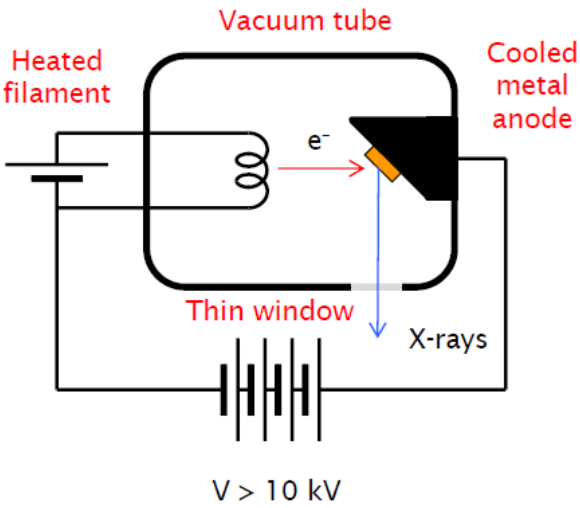
Recap of Lecture 5

- How to produce X-rays – fire high voltage electrons into metal target in vacuum
- It’s hard to measure the wavelength (‘to disperse’) X-rays – prisms don’t work, and they are the size of atoms, so gratings seem hard..
- But we can use solid materials with periodic crystal structure as 3D gratings
- 2 Bragg conditions, $\theta_{in} = \theta_{out}$ & $n\lambda = 2d\sin\theta$ for constructive interference
- Fire X-rays at an angled crystal of known lattice plane spacing to measure/select a wavelength
- Or Fire known monochromatic X-rays at an unknown crystal, changing angle, to measure the crystal

In this lecture

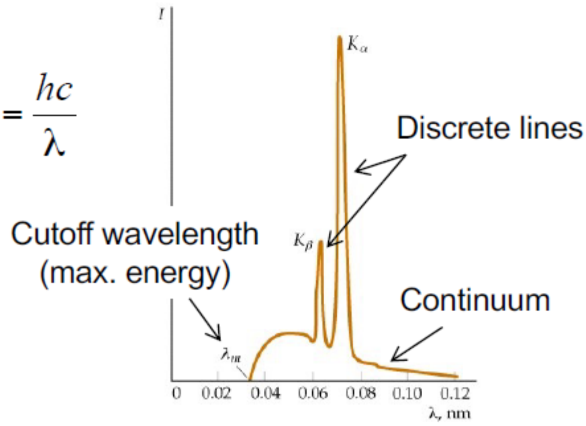
- The production of X-rays – the spectrum created
- Attenuation of X-rays in matter
- Absorption of X-rays in materials & ‘absorption edges’

X-Ray spectra



- Typical energy spectrum
  - Plot as a function of wavelength

$$E = \frac{hc}{\lambda}$$



Bremsstrahlung

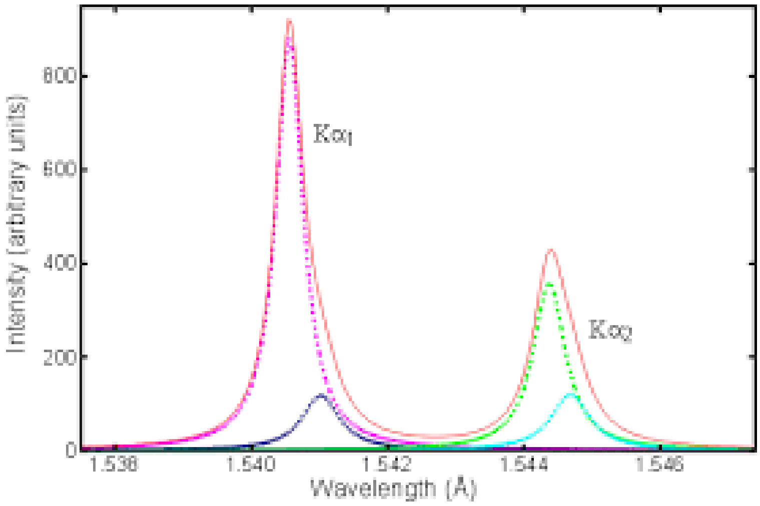
K alpha/beta in Cu and Mo

Just for interest..

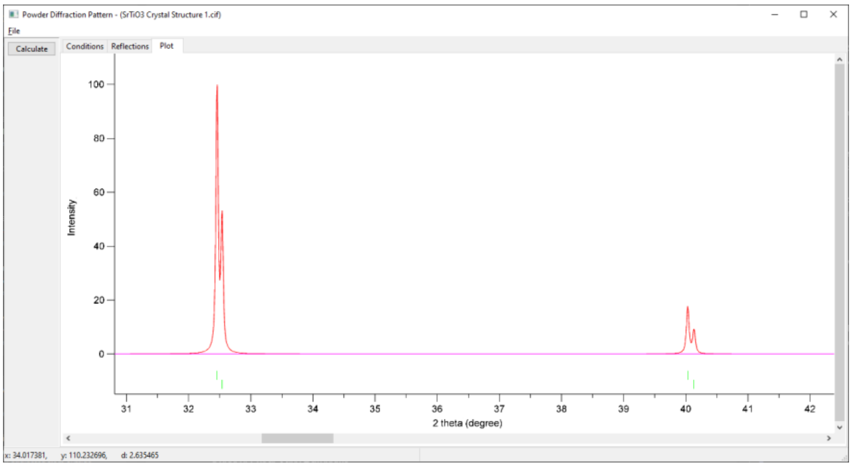
Common lab X-ray sources:

Cu: K_α = 1.54 Å
K_β = 1.39 Å

(In fact, as always in atomic physics, there is more complexity and another splitting and the K_α is actually two lines, $K_{\alpha1}$ and $K_{\alpha2}$ very close together..)



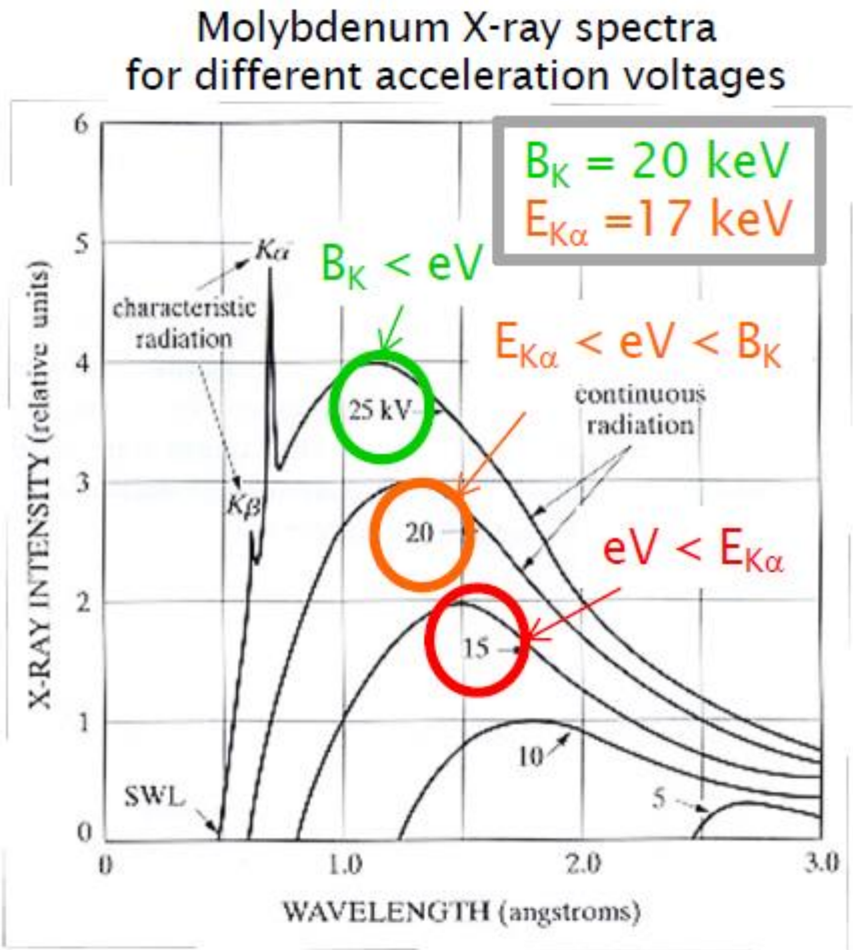
So if use this for crystallography, every peak from a crystal's d-spacing becomes 2:



Commonly use a filter to remove the $K_{\alpha2}$

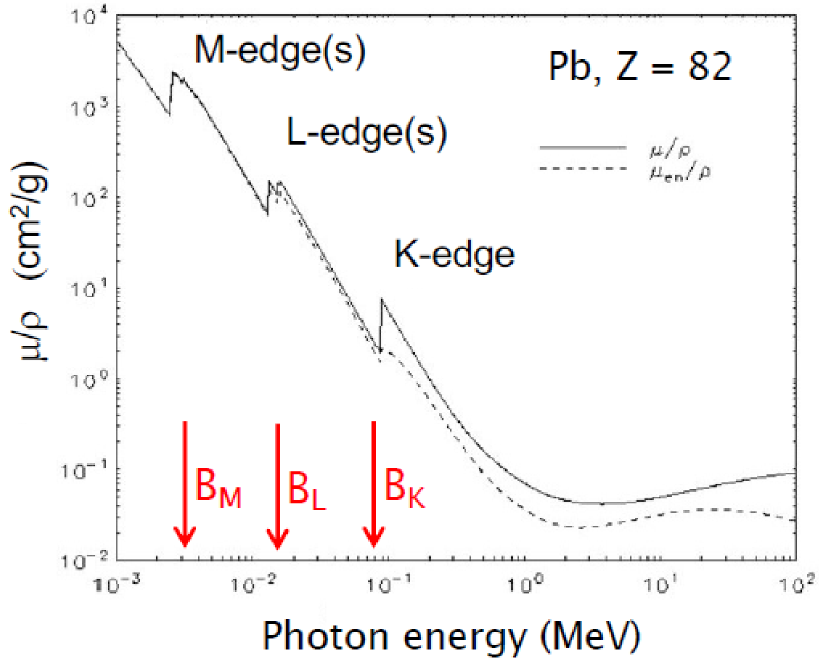
Mo K_α = 0.7 Å
(this wavelength isn't absorbed by diamonds!)

Mo X-Ray spectra



1 angstrom (Å) = 0.1 nm
(useful unit for crystal structures)

Absorption Edges

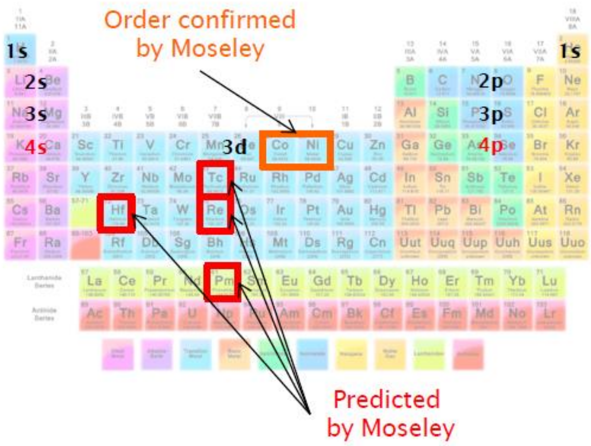


Moseley’s Law

Henry Gwyn-Jeffreys Moseley (1887-1915)

$$f_{K_\alpha} = (2.48\times10^{15}\ \mathrm{Hz})\times(Z-1)^2$$

- This discovery enabled the periodic table to be ordered correctly by atomic number (Z) rather than atomic mass



- Moseley would have almost certainly been awarded a Nobel Prize had he not died in the Battle of Gallipoli (1915)