# Solid State Physics
# Lecture 5
Diffraction of Waves by Crystals

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Hello. So, today we are going to discuss the Diffraction of Waves by Crystals. So, why are we interested in the diffraction of waves in a crystal? Because we want to determine the crystal structure and we can do that by putting an X-ray in the crystal that is photons or we can do it by using neutrons the wave nature of the neutrons or the wave nature of the electrons. So, once we put photons or neutrons or electrons that is any kind of wave in a crystal it scatters from the atoms in that crystal. And as a result of that scattering it forms a diffraction pattern and that diffraction of waves from the crystal that is something we need to study in order to find the structure of the crystals. So, how do we study this? The pioneer in this field was Bragg; he devised a very simple theory to find out the diffraction to analyze the diffraction in solids. So, as was mentioned earlier the crystal structure is determined using diffraction of waves and in the simple explanation of the diffraction of beams from a crystal that Bragg presented, instead of considering a diffraction he considered reflection of waves from the crystallographic planes and even though he considered reflection instead of diffraction he got the correct result. So, let us see exactly what he did. He considered crystal planes like this and this, two parallel planes we are considering separated by a distance d. This is distance d and the wave is coming like this falling on here, getting reflected, moving like this and it makes an angle theta with the plane. Remember, the angle theta is with the plane not with the normal unlike what you have learnt in geometrical optics. Another ray comes. So, I am trying to draw a line here another ray comes, falls here at the same angle, gets reflected according to this idea forgive me for the lines being not parallel and not equidistant but, they are supposed to be parallel, ok. Now, the 1st ray and the 2nd ray there is a path difference between them. So, we need to find out this path difference. And, for constructive interference we need this path difference to be equal to integer multiple of the wavelength ok. So, how much path difference do we have? If we consider a line perpendicular to this wave front, it hits here at this point. So, this angle is theta. If we consider a similar line perpendicular to this rays that is parallel to the waveform wavefront, it is theta here. So, this much is the path difference. How do we calculate this path difference? Let us extend it here and this much separation we can find to be $d\sin\theta$. If this is $d\sin\theta$, this other side is also $d\sin\theta$ therefore the path difference that is twice of $d\sin\theta$ and that must be equals to $n\lambda$ where $\lambda$ is the wavelength and n is any integer. So, $2d\sin\theta = n\lambda$; this is the famous Bragg's law that you all are aware of. But, we arrived at this Bragg's law without considering any diffraction just by considering a reflection and it works. But, we would like to approach this in the proper way by considering diffraction. So, how do we go about doing that? Before doing that we need to consider few other things. So, we need to consider that the scattering of waves are from the atoms and to be able to appreciate the use of diffraction in determination of crystal structure we must first learn some Fourier analysis of the crystal that we have.