X-Ray Crystallography
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Lecture - 10
Intensity of Diffracted Beams

In this lecture, I will discuss how X-rays are produced and how X-rays are detected. You see the first X-ray tube was the gas tube.

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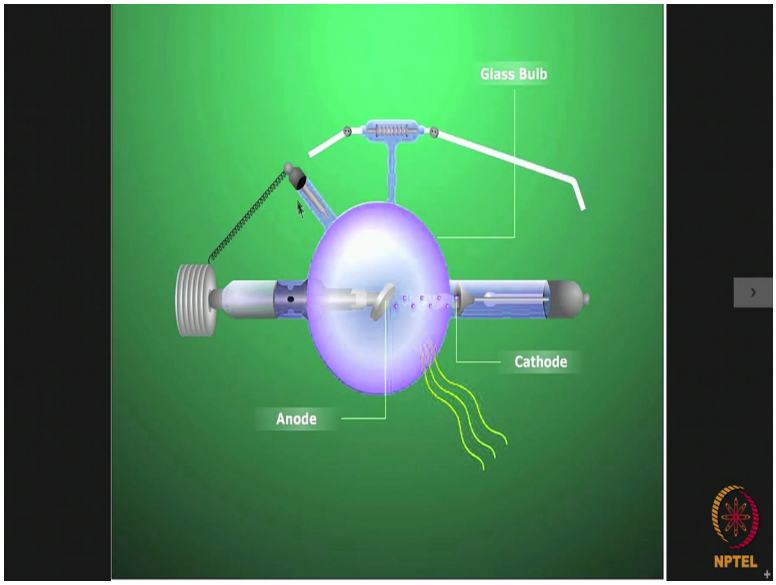

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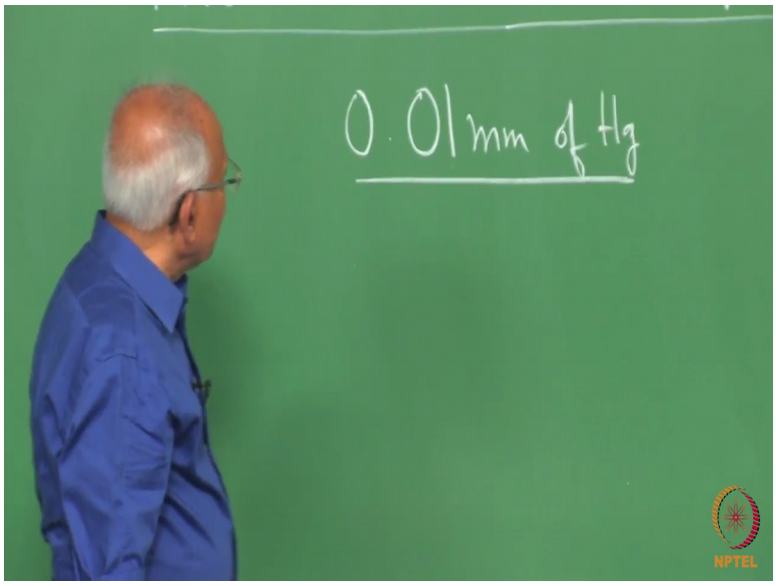

Now, in the gas tube we have a tube in which we put a gas pressure of the order of 0.01 millimeter of mercury. So, we have a gas pressure as low as 0.01 millimeter of mercury. Now what are the gases preserved over there its ordinary air.

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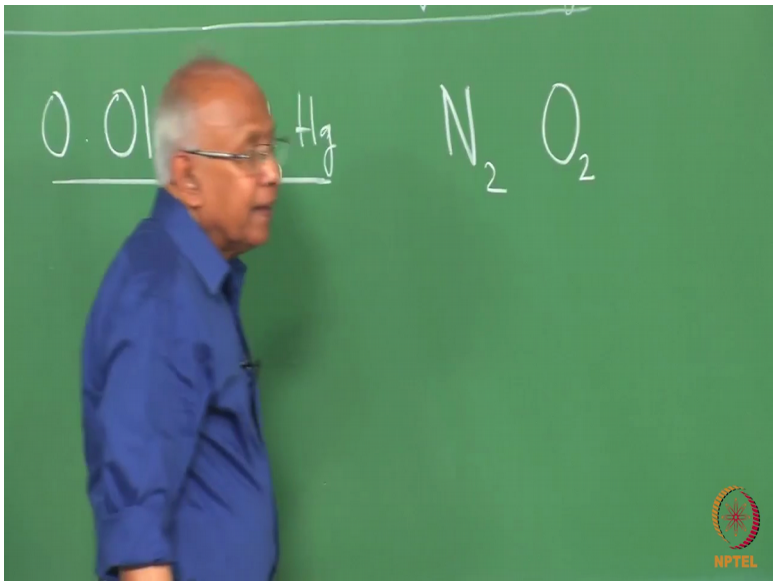

So, we will have nitrogen and oxygen mostly. In fact, how the gas tube operates that is not very clear till today, but you know let us try to give an idea of what might be going on in this kind of an equipment.

So, here we have an aluminum cathode and an anode and we have as I always said some amount of gas present the gas pressure maintained is of the order of 0.01 millimeter of mercury. So, how we do it? This is done by connecting the tube to a mechanical vacuum pumping machine and which is connected to a needle valve. So, using the needle valve we can maintain a constant kind of a pressure more or less constant kind of a pressure inside the gas tube. In fact, when we talk about the gas tube in order you know and once you have the gas inside the tube. So, nitrogen and oxygen atoms many of them will be in an ionized form and there will be some electrons also. So, when we apply a potential between the anode and the cathode here then we will find the electrons will run towards the positive side and positively charged gas ions will run towards the negative side.

So, when the gas ions go to the cathode side they bombard the cathode there will be more electrons produced and once these electrons are produced when they pass through the gas they will ionize the gas more and more. So, more and more ionization of the gas will occur more and more electrons will be produced inside the tube. So, it practically needs quite a bit of jugglery in order to get more or less a constant amount of the you know gas pressure and a constant amount of x radiation to be produced from this tube you know by manipulating the voltage across the anode and cathode and by manipulating the position of the needle valve in the vacuum system. So, when these electrons produced they will go and strike the anode here X-rays will be produced.

Now, this kind of a machine now it is practically do not exist except in a few laboratories the more modern X-ray tube nowadays its perfection looks similar to this figure.

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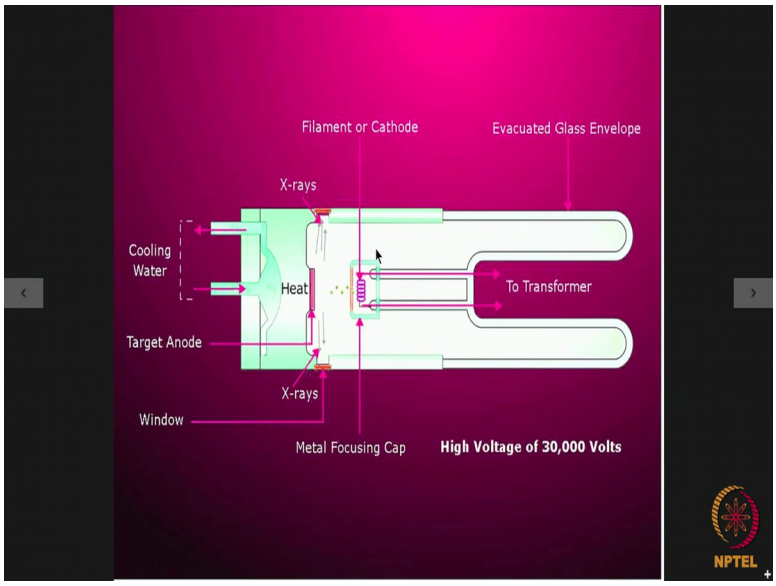

Now, as you can see here we have got a filament maybe a tungsten filament which acts as a cathode and then you have a target which is a metallic target this is the anode. Now as I already described a small current about 3 ampere current is passed through the filament as a result of which the filament gets heated up and there is a turbinic emission of electrons. Now if a high potential difference is kept between the target and this filament the negatively charged electrons will strike against the target at a very high speed and from the point of impact x radiation will be produced and those x radiation will be taken out through some windows.

Now, the entire tube here is an evacuated glass envelope. So, the level of the level of evacuation is pretty high. So, these windows through which the X-rays are let out are made up of low atomic number material such as aluminum beryllium or even mica now this target gets heated up due to the impact of the striking electrons. And there must be their method by which this can be cooled down by passing cooling water to the system the voltage applied can be 30000 volt can be less can be even higher. So, depending on what is the accelerating voltage used we can control the amount and intensity of x radiation which is produced.

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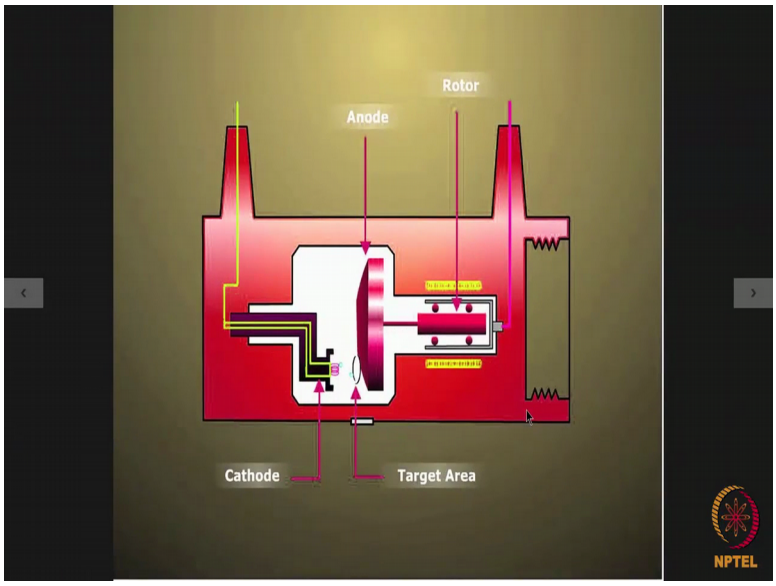

Now, that can be another type of x-ray tube also you see in the previous case the target is fixed here the entire tube is sealed in the factory and comes to the laboratory as such. So, if I want to have the provision to have a copper target a molybdenum target and the chromium target. Say, then I will have to buy 3 such tubes one with a copper another with a chromium another with a molybdenum target, but there is a possibility that we have what is known as a demountable x-ray tube as shown here.

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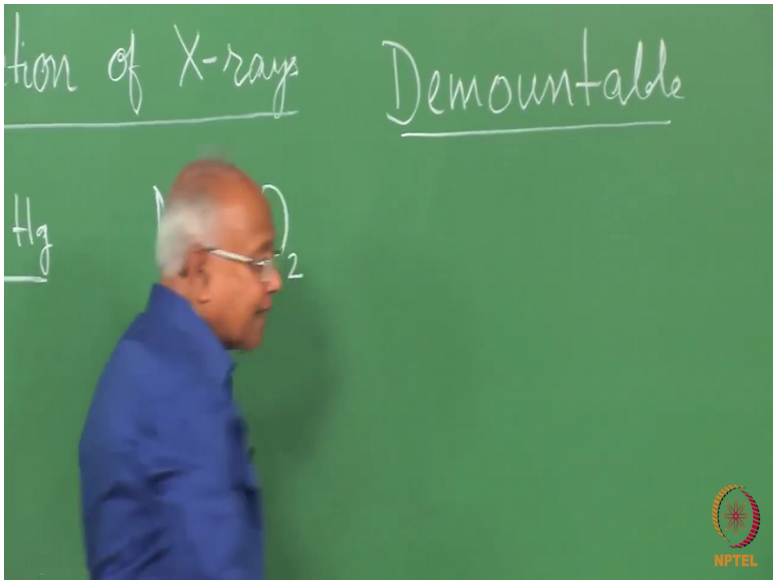

So, we can have what is known as demountable x-ray tube in which the target can be taken out and replaced by some other material; now one disadvantage of this method is every time the target is taken out no vacuum will be lost. And again we have to evacuate it to a very high degree and technically it may not be that easy every time.

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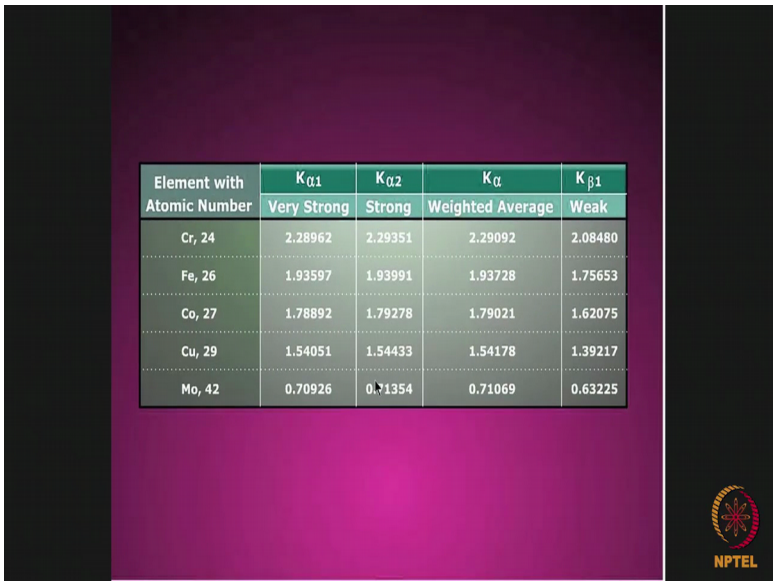

So, from the X-ray target as we have said earlier we can have you know K alpha one K alpha two and weighted K alpha as well as K beta this one you know its meaningless it is a K beta. So, all this characteristic radiations can be produced you know here to the K alpha one wavelength this is the K alpha two wavelength and this is the weighted average of K alpha and this is the K beta. So, depending on which kind of target we are using we can have a host of K alpha and K beta radiations possible then we have to choose the right target for our particular purpose.

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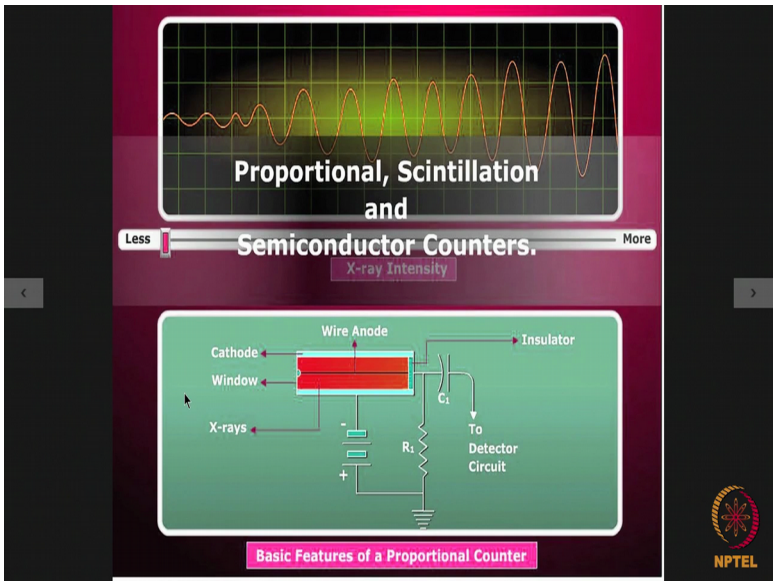

Now, the X-rays coming out of an x-ray tube can be detected using a proportional a scintillation and semiconductor counters now we will discuss those counters later in this course, but the basic features of a proportional counter is given over here, here we have got a cylindrical metallic vessel with a thin wire passing through the centre.

Now, when we have a high potential between the vessel with the cathode and the wire inside is weighed the anode and if we have x-rays getting into this vessel you know through a window as shown here than those x radiation will ionize the gases inside. So, it is basically a gas ionization tube. So, we have got a cylindrical metallic vessel inside which there are some gas present at the centre we have got a wire anode. So, when X-rays enter through this tube by a window then it will ionize the gas. So, some positively charged ions will be produced and they will be charged electrons will be produced and the negatively charged electrons which will be produced will be let out of the tube and it will pass through an external resistance and it will create a current to the external resistance.

So, that current is a measure of the amount of ionization that is occurred within this tube and this again is proportional to the intensity of the x radiation which has entered this counter now x radiation is very harmful to human beings. So, that is the reason why wherever there is an X-ray machine the surrounding region should be you know as far as practical radiation free so, that the operator and other people working on the machine can

roam around. So, there is a you know a maximum level of radiation which the human body can endure without suffering and this level must be maintained around an x-ray machine.

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So, there are radiation survey meters which are nothing, but portable counters and with the help of this portable counters we can sanitize the region around an X-ray machine we can find out you know how good or how bad is the condition so, that human beings can work around the machine.

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Sometimes the workers work even at x-ray machine they have a radiation survey meter which they wear around the wrist like a watch. So, that will also indicate whether the radiation level is harmful or not if it is harmful then the worker must leave that place immediately.

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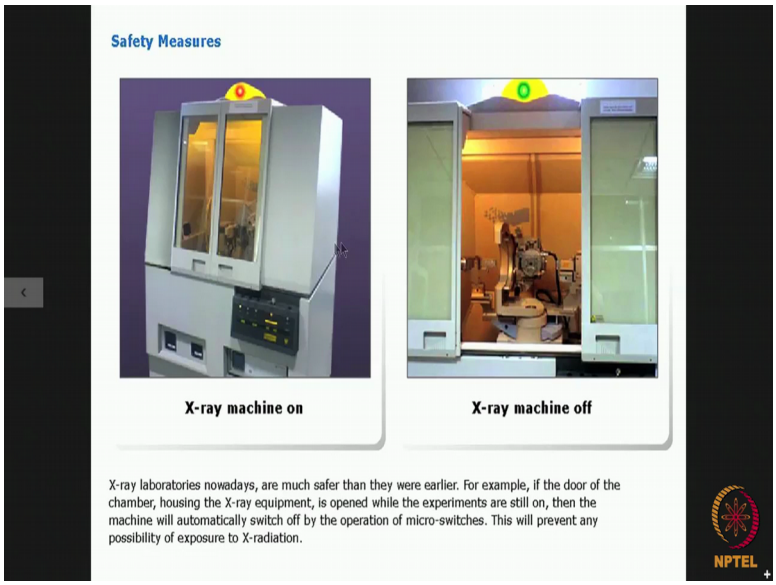

Well, the X-ray laboratories nowadays they are much safer than they were earlier for example, you know nowadays if you have the keep the X-ray machine inside a chamber and you know there are micro switches which are provided in the in the doors to the chambers. So, if the machine is on and say somewhat advertently someone opens the door then there are micro features which will automatically switch off the machine. So, this will prevent any possibility of exposure to the harmful x radiation.