Experimental Physics - II
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Lecture – 20
Basic discussion on spectrometer and prism

You are welcome to the undergraduate laboratory of Department of Physics IIT, Kharagpur. this is second year lab of optics. today I will discuss about the spectrometer., prism spectrometer we used in our teaching laboratory. There are various kinds of spectrometers; spectrometers are there like XPS, X-Ray photoelectron spectrometer, mass spectrometer, etcetera, etcetera. But today the spectrometer I will discuss, this we tell optical spectrometer or prism spectrometer. This is the spectrometer we frequently used in our teaching laboratory.

let us see the spectrometer first, then I will discuss about the different components of the spectrometer.

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this is the spectrometers optical spectrometers. here is we have set this spectrometer.

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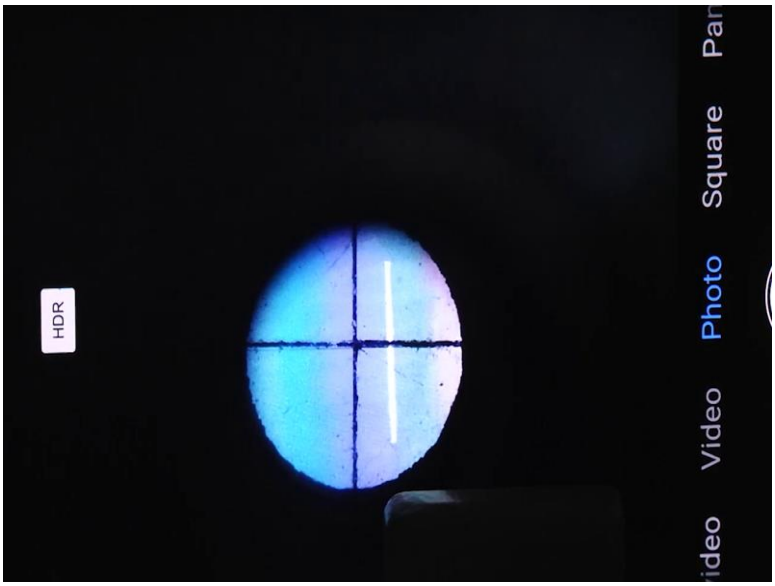

here you can see; you can see that this is the spectrometer. what are the components in spectrometer? Let us see. here this is the light source, it is the sodium vapor light source. There are different kind of.

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These are mercury, these are mercury vapor source. There is other source like cadmium source, sodium.

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Sodium. this one sodium vapor source. different kind of source we use. here it is a just one of them we have used, but not important at the moment. this is the light source. Now, this light is coming through this tube. this tube is called collimator. This tube is called collimator.

Now, here this is a prism table. On this prism table, so you have kept prism. Now, light is falling on this prism and from prism this light is reflected, at the moment it is the reflected. this reflected light coming through this tube, though this tube, so this tube is called telescope. now, in telescope there we are seeing the image at the moment, we are seeing the image of the source. here this is a line source is there, now here in telescope we are seeing the image of the source, line source. Now, in telescope there is a cross

wire, horizontal and vertical cross wire, perpendicular cross wire, perpendicular cross wire, and that slit that line, spectral line one can see through this telescope.

Now, to show the inside, so we have set camera here, in this camera whatever inside we will see, so to show we have used this camera. Now, here whatever seeing here we see this crosswire and these this one line which is source line, this is source line, this source image we are seeing. whatever the image will found depending on the experiment whatever the image will found, so that image we will see in this telescope and that what we see in this telescope that that I cannot show in camera directly, so we have used as another camera to magnify it,

at the moment what you are seeing? You are seeing the cross wire as well as the image of the source. that image can be of different kind if you use different color, so because of dispersion you can see the image of different color, so this is because of dispersion property of the prism. one can separate the different colors, and measuring the separation; measuring the separation of the different colors one can calculate this refractive index of the prism material,

that experiment we will demonstrate later on. At the moment what we want to know, we want to be familiar with the different components of the spectrometer, and how to handle the spectrometer, what is the function of different components, that I want to discuss.

this is the spectrometer; let me take out this prism from here. Now, let me move the source, later on I am not going to use at the moment this source, I am just want to discuss about the spectrometer, as I told this in spectrometer there are major three parts, one is collimators, another is prism table and this third one is telescope,

here you see in telescope you can see a knob; you can see a knob; in telescope you can see a knob here. if you rotate this knob you can take this part, this tube, this part is move in and move out, And other one in collimator also there is knob, if you rotate this one you can also take this part is in and out, this is the function of these two knobs to take these parts and to take this part is move in and move out, what is there? What is there that I will discuss, what we are moving that I will discuss.

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And this part is a prism table, here as you have seen that we are putting prism or grating early on this table, here this table, this there is a knob here, you can adjust the height of the table, you can adjust the height of the table, others here this three knobs are there, this three knobs are there here, These three knobs actually I can show you this other three knobs, this, this and this, because this three knobs is we used to used to level this, this prism table, I will explain how to do that.

this is the three knobs for leveling, this is the knobs for adjusting the height, and you can see here this another knob if you lock this knob, so this is the another part, so you can rotate the prism table, you can rotate the prism table, I think this you can if I tighten this one, then let me see what is happening,

the similar type of these two knobs are there this one, if I cannot rotate this now, is very tight, if I rotate, I cannot rotate if I loosen it, ok, so I can rotate easily. I think I have to see which one for what. two rotations here you can see, this one is for prism table, another is for this telescope, another is for rotating telescope,

for this telescope if you tighten this one, so then you can rotate this one, this knob is to tighten this telescope, rotation you can stop, no more it will rotate, and this prism table is you can rotate. Now, if you tighten it then you cannot rotate, after tightening for fine movement of this prism table, for fine movement of the prism tales there is a knob, I think this is the knob. you can see for fine movement, I do not know whether you can

see or not, if I rotate this one, you can see this fine movement of this prism table, fine movement of the prism table this is possible, this knob is for fine movement of the prism table and this knob is for fine movement of the telescope. You see, this knob is fine movement of the telescope,

for coarse movement you have to loosen this two knob for, one is for prism table, another is for telescope and for after fixing at a particular position you can tighten them and then for fine movement you can use these two screw, , you can use these two screw. this is for the movement of the prism table and this is for the movement of the telescope, and this one collimator, it is fixed, it has no movement horizontal movement, it is fixed,

Now, this whole base is you can see it is on three screw, one is this it is on three screw, ok, this one, this one and this third one is here, third one is here, but this is sometimes in some spectrometer is the screw is there, some spectrometer it is fixed,

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these whole spectrometer is standing on these three screw, on this three screw, one is fixed and other two have you can move them, other screw you can move them, ok; other screw you can move them. Now, these screw what is the purpose of this screw? These are leveling screw; we use initially sprit level. for leveling so we have to make this spectrometer this horizontal. we can put on this base and check whether it is this your bubble is in middle or not. if it is not middle, generally we put here, and then if we see it is if it is not middle, so then we rotate this one, these two screw,

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Now, one should check that if you rotate in clockwise; if you rotate in clockwise height is increasing, ok, if you rotate in anticlockwise height is decreasing, for this also same thing. generally, we tell that for leveling you rotating opposite direction. Why? Because you are rotating this one say to make height higher; that means same thing, same effect you will get if you rotate if you take it down, that is why at a time we rotate in opposite direction, so that this will raise the height and this side we will get down,

your purpose is to make it horizontal, to get this horizontal position we just rotate the this screw in opposite detection, that way mechanical leveling we do and then this tube also we do this leveling, Here this two pieces are there, so one can just adjust, just do the leveling make it horizontal using this two, here is make it horizontal, also here is you should make it horizontal, using these two you can make it horizontal. more or less this tube, these both tubes are mechanically we make it horizontal, this base also we make horizontal,

Now, for prism table to make it horizontal this these three knobs are there. As I told here also generally we put it say this way perpendicular to these two one, and then you have to use this to make it I think keep it horizontal of these two and then see height is a difference is there or not rotate in opposite direction, rotate in opposite direction, take it horizontal and then I think if you put this way keeping this one fixed, now you can adjust this one to take it in middle of this middle of the bubble. this way you are using these

three you have to make it horizontal using this sprit level, this way more or less you are making this spectrometer horizontal, this is the mechanical leveling.

Then, this more or less ready for your experiment. now, here important things are there this two scales are there you know, vernier scale 1, vernier scale 2.

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here if I show you, I think it is a; I can show you here. this is a let see this main scale; main circular scale is attest with the telescope; attest with the telescope, if I move this telescope; that means, this main scale, main circular scale is rotating, and vernier scale is attest with the prism table. if I rotate the prism table, you're this Vernier scale is rotated,

change of reading, change of angle it may happen because of rotation of the prism table or because of rotation of the of the telescope, two Vernier scales are there, as I told vernier scale 1 and vernier scale 2. we have to find out the vernier constant. And I have discussed how to find out the vernier constant in in experimental physics I course,

you have to find out the one smallest division of the main scale, and what is the value of the smallest division of the main scale, and how many divisions are there in the vernier scale. Here is in this spectrometers I can see there are 60 small smallest division in the vernier scale, yes, 60 smallest division in the vernier scale, and if you coincide if you see this 0 coincide we will say here in vernier in main scale, say if I put at 0 here, so it is. yeah, I can see smallest main scale division is yeah, it is a 0.5 degree.

here I can see the 0, then 10, 20, so 0 and 10 degree between 0 and 10 degree there are 20 divisions, so that means, smallest division is 0.5 degree, and also I can see that 60 division coincide with the 59 division of the main scale, so one can calculate the vernier constant. But simple formula if you use, the value of the one smallest scale division divide by the number of vernier scale division. there is the vernier constant.

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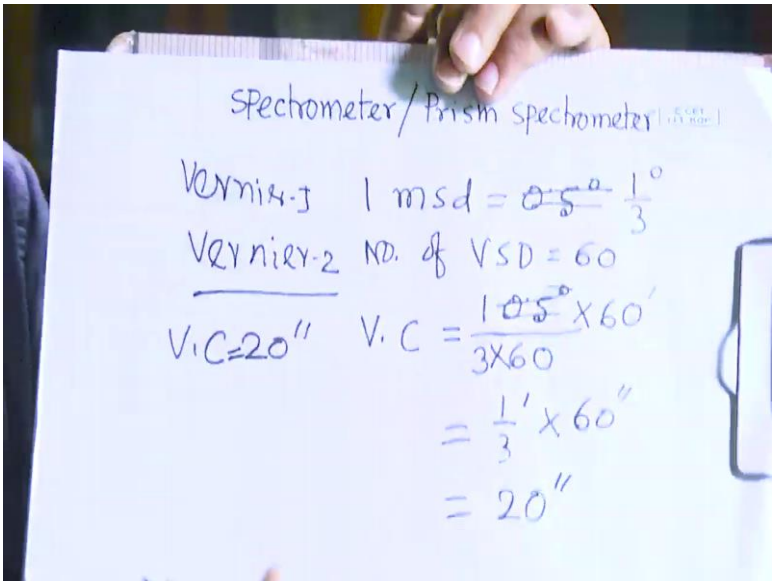

This one main scale division equal to 0.5 degree and number of vernier scale division equal to 60, Vernier constant equal to 1 main scale division 0.5 degree divide by total number of division. this degree if I convert into minute, so I have to multiply with the 60, ok, I have to sorry. no, I think I did mistake. Here, I think yes, 1 degree between, 1 degree, there are yeah 0 to 20, so actually 60 divisions are there, so that means, 1 degree is divided into 2. one smallest division is one-third degree. that, I think it is not one smallest scale division, is not is not is this is the one-third of a degree, this is not 0.5, so this is one-third degree one-third degree.

now, if I degree convert to the minutes, 60 minutes, so then it is becoming, it becomes one-third minute. Again, 1 minute is 60 second, 1 minute is 60 second, so 20 second Vernier scale, Vernier constant is 20 second. that you have to check for vernier 1 and vernier 2. Generally, on the time this vernier constant for both are same, but one should check in this case both are same. vernier constant for vernier 1, vernier 1 and vernier 2,

vernier 2, in both cases this is the vernier constant is 20 second, vernier constant is 20. that you have to find out,

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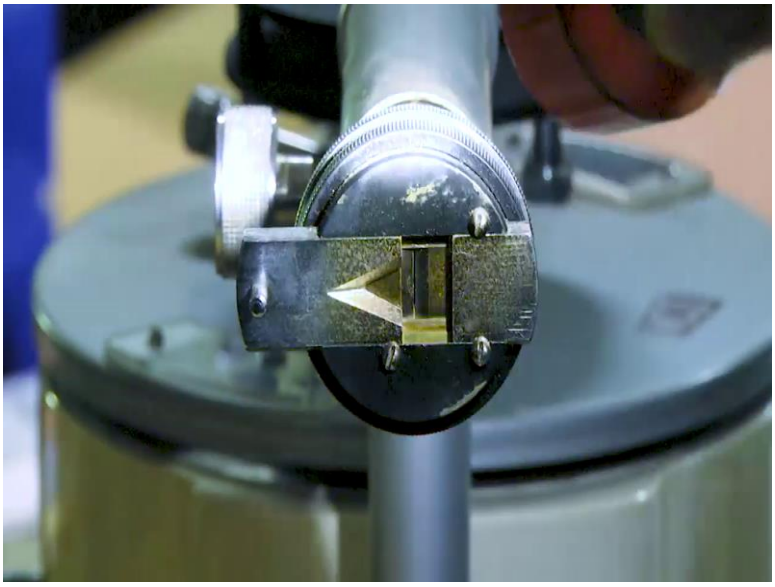

Now, in collimator what is there? In collimator what is there? In collimator, you can see here, there is a slit here, I can there is a slit here I can open it slit. Now, that slit width, you can see this slit, this is the slit, this is the slit here, ok now, that slit width I can reduce using this one, slit width, not slit width slit height I can change using this one, Symmetrically, I can reduce the height of the slit. this is the purpose of this one, and slit width if I open it you can see this is the slit, completely I have opened. Now, you can reduce the slit width it is completely closed now,

just we open it slightly, ok, so that means, this face it is towards the light sources, it is towards the light source, this face is towards the light source that mean light enter through this slit. Now, actually this we tell this is the light source, we tell this is the light source, but in experiment we take this is the source, this slit is source, And this source size, source width and thickness width and height we can adjust using this one, this is the we are reducing the height, we are increasing the height, we are increasing the width of the source, we are decreasing the width of the source, this is the function of this one.

Now, what is the function of this one? What is the function of this one? this one is actually we are moving the source, using this knob we are moving the source, but why

we are moving? What is the use of this one? in collimator there is a lens, convex lens, this type of lens is there, convex lens is there. here, inside here there is a lens,

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you know this convex lens; now, there is a convex lens, and this is the source. Now, if I put this source at the focal point of these lens then we will get other side, we will get parallel rays, this we move, this we move to put this source at the focal point of the lens inside this tube, collimator is make of it has two part, one is lens convex lens it is fixed inside of this tube and it had source, to get the parallel rays we have to put this source at the focal point of this lens. for doing this one we need this movement of the source.

Now, how we will know; how we will know that this source is at the focal point of the of the lens? that there is a method is called Schuster's method. that I will describe later on. here now, this collimator has two parts, two components, one is lens, convex lens fixed inside this tube collimator tube, and the source here. that source we can move. Purpose for movement of the source is to place, the source at the focal plane, focal point of the lens, ok, so that we can get other side, we can get the parallel rays. Now, this parallel rays will fall on the prism or getting whatever, you will put on the prism table, whatever you will put on the prism table,

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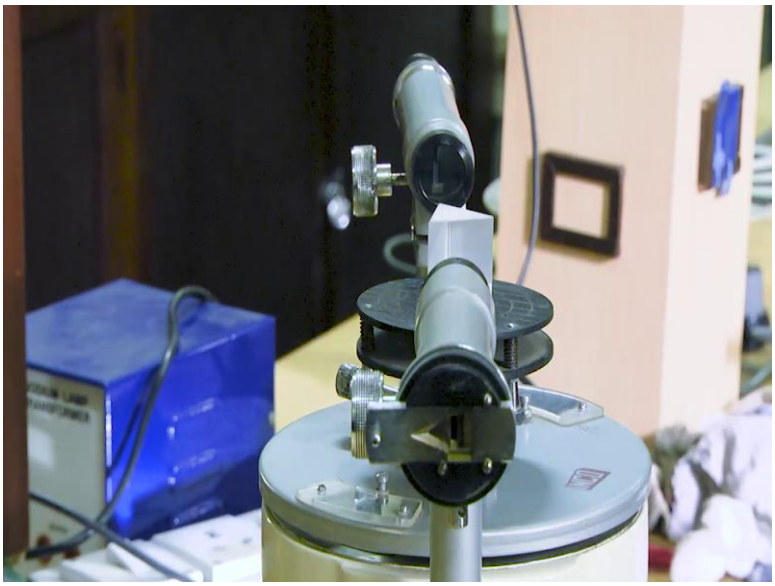

if I put prism table on this, parallel rays will fall on this prism table. Why we need parallel rays? That when we will do experiment I will explain. for grating you need parallel ray because it is a (Refer Time: 32:05) diffraction that I will describe when we will demonstrate the experiment.

parallel rays will fall on the prism. Now, parallel rays will fall on the prism here. Now, there will be refraction or dispersion etcetera or diffraction in case of grating, ok, if you place grating instead of prism. then this parallel rays we will pass through the grating or prism, and then we are getting refracted or diffracted parallel beams, refracted of diffracted parallel beams.

Now, that parallel beams to see the image, ok parallel beam cannot form the image, ok, so that we have to focused. that means, parallel rays now it is passing through this telescope and we are seeing the image. Now, what is the things inside the telescope? here again as I told this we have to focus the parallel rays, so there is another convex lens, another convex lens inside this telescope tube, ok; so, inside this telescope tube, ok S this parallel ray is passing through this convex lens. it is here somewhere,

parallel rays falling on this convex lens of this telescope tube. Now, so they will meet on the focal plane of this lens. Now, on the focal plane there would be image. if you put screen at the focal plane of this lens then you will see the image. screen here I have to put at the focal plane, this screen is this one, it is called eye piece. This this one I can

rotate it and show you, there is a lens here, parallel rays falling on the lens and they will focus on the focal plane of this lens. Now, their image will be formed, so if you have to put screen there then you can see the image, this is the, that screen it is called eye piece in the telescope,

that screen in this eye piece that screen is having the cross wire, this two perpendicular wire whatever I have shown, on that screen there is a cross wire and you have seen the image of the cross wire, there you have seen the image of the cross wire, there, one line this b line you have seen that that is the focal plane, that focal plane, at that focal plane you have to put that screen that screen is having the cross wire, And to locate, so just you have seen this one spectral lines, one lines, but they are may be many lines for different colors, so to know the position of the different colors, so cross wire we use to make them coincide with it one by one. And that is done with the movement of this one, so that means, reading will change and that reading can note down from this spectrometer this vernier 1 and vernier 2,

in telescope what is there? One lens is there, parallel rays are coming and then they will form image at the focal plane. I have to put the screen, eyepiece at the focal plane, I need movement of this eyepiece, I need movement of the eyepiece, so that is why this is the knob for movement of the screen, movement of the eyepiece, ok, movement of the cross wire,

again, how I will know that I have put this screen, this eyepiece at the focal plane of this lens? again, as I told there is a method to put it that is called Schuster's method. that I will explain later on. And there is another way to do that, so that I will explain later on. now I describe about the different parts of the spectrometer, and what are the function of the different parts, how to adjust the height of the prism table, ok, how to rotate, how to lock it, how to move fine adjustment of this one, how to take reading what is the vernier constant, that is what about the prism spectrometer.

in next we will discuss about the how to get the parallel rays for the experiment and we will demonstrate some experiment using the prism. let me stop here.

Thank you.