WAVE OPTICS

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Lecture - 66: Babinet Compensator

Hello, student, welcome to the wave optics course. Today we have lecture number 66, where we will discuss a specific component called Babinet Compensator and probably this is the last class we are having for this particular course. So lecture number 66 today, before going to the Babinet Compensator, let us go back and check the production of the polarized light using Jones matrix representation. So for example if I launch a circularly polarized light and if I put a lambda by four way plate then the outcome what we get is a plane polarized light that is one. So that means the field I launch is circularly polarized light is defined by this matrix form and this halfway plate I can represent it in the matrix form in this way. That we have done already in our course. Then what happens if this operator operates on that. That is 1-0-0-I, that is operating on the circularly polarized light. Then what we get is simply 1 minus 1, which is nothing but a linearly polarized light. So linearly polarized light can be obtained from a circularly polarized light as well by using a half wave plate. Similarly, from elliptical polarized light we can get a linearly polarized light as well. So this is elliptically polarized light again we have a halfway plate and what you get on the outside is plane polarized light. Similarly in the previous case the way we have the elliptically polarized light field is simply given as the most general form one can have in this matrix, which is a-ib and halfway plate is already written here. So the production of this system is this. So what we get is A minus B, this is again a linearly polarized light. So we can see that by just using this lambda, four plates from elliptically or circularly polarized light planes can be generated. Now go back to the topic that we were supposed to complete today is this babinet compensator.

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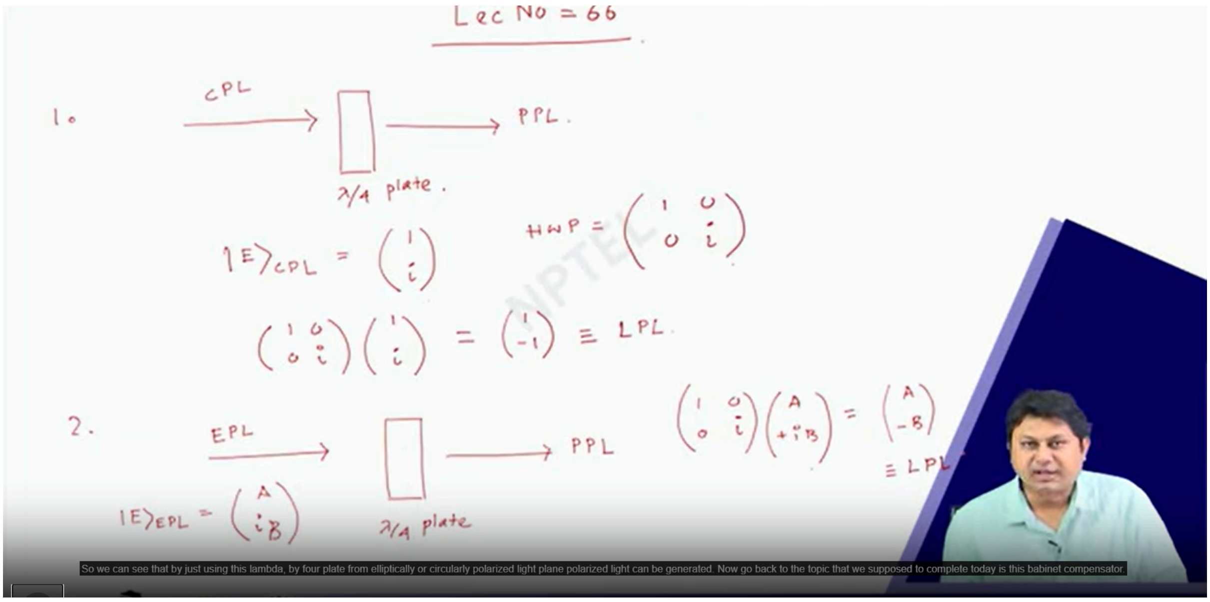

So, in this Babinet compensator instrument we have two sections like this. So this is a q, this is r, this point may be p and this is s, so here this is the direction of the optic axis, this straight line shows for this particular portion, this is the direction of the optic axis, on the other hand for this case the direction of the optic axis is given by this dot that is, that means perpendicular to the plane. So the direction of the optic axis is perpendicular to this plane and in this case it is parallel. So here the optic axis is perpendicular to the plane of paper and here in this case the optic axis is parallel to the plane of paper. Now for this particular system if I launch a light perpendicular to this from this direction then this is A here it is B then it moves here say this is B prime or B1, this point it is b2 and finally it is b3. So AB for example is the incident ray. Let me draw this x axis, this y-axis and this is the incident ray, incident beam which is polarized. So AB is an incident ray, which is plane polarized and making an angle 45 degree with an optic axis. Now, let this distance b b 1 is d 1 and b b 2 is d2. So note that the incident light will be broken into e ray and o ray, whose vibration will respectively be in the parallel and perpendicular to the axis of oa. So this is made of quartz crystal and that's why what we have that NE is greater than NO here, N this condition. Now the path difference because when the light will be launched here because the two rays will travel two different speeds, there should be a path difference and in the length of B1 the optical path difference one can figure out in this way. So in the length BB1 what happened is the length BB1 the optical path difference will be simply delta l 1, which is d 1, which is a physical length multiplied by n e minus n o. So, when the ray enters in the other part that is this, PRS this triangle then E ray. Now the optic axis is perpendicular to the plane, so E ray becomes O ray and O ray becomes E ray vice versa. So in that case, let me see that when the ray enter in the section PSR what happened that the e ray becomes o ray and vice versa, then the path difference will be minus of d 2 n e minus n o, the negative sign because in now these things will change o ray become e ray and e ray become o ray. So the total path difference during this process delta L will be delta L1 plus delta L2 and I can write this is d1 minus d2 multiplied by ne minus no.

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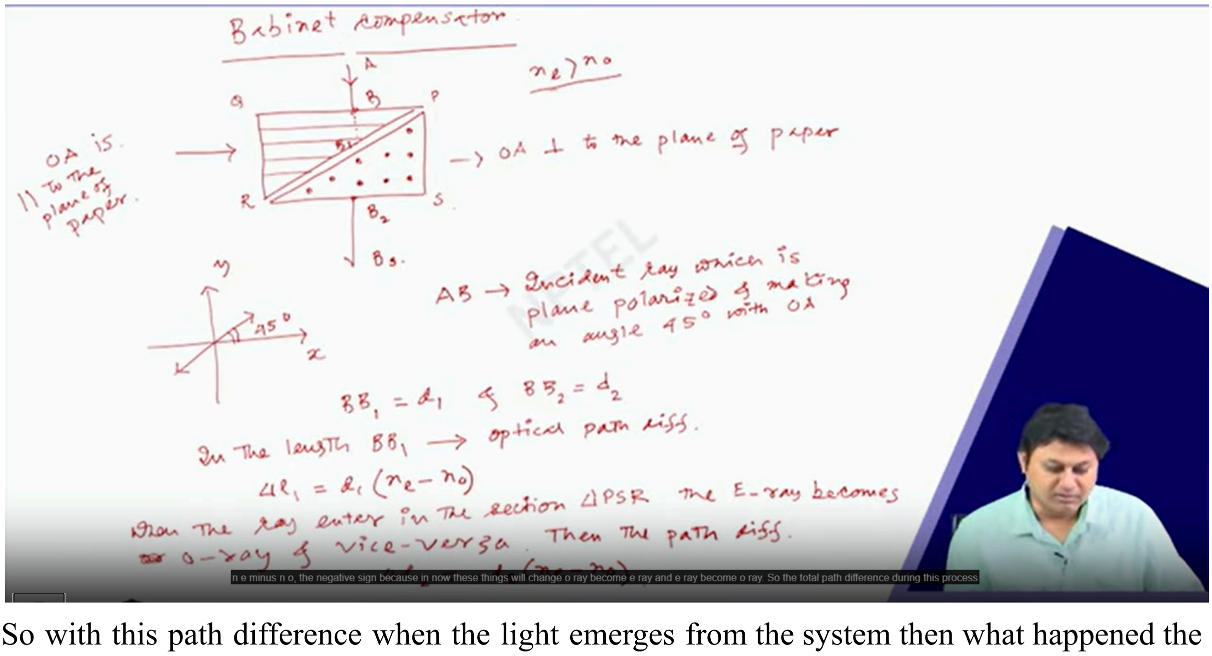

So with this path difference when the light emerges from the system then what happened the resultant phase difference the resultant phase difference will be delta phi and that is 2 pi divided by lambda into delta L or in other words 2 pi divided by lambda then d 1 minus d 2 n e minus n o. Now in this particular system what can we do? We can change these path differences as per our liking because these two portions are movable. So let me draw this in babinet compensator that we have, that we have the screw here through which we can slide these things over each other. So we can move this prism and with this movement one can control the path difference. So, by moving the two prisms on top of each other one can adjust the path difference or the phase difference. Let with the movement of 2B a pi phase difference takes place that for example, we can have. So, we can calculate that. So, let the 2ba 2 pi phase difference take place. So, by moving these two prisms 2 b, we can have a phase difference of 2 pi. So, if that is the case then by moving the x distance we know what should be the path difference. So, once we know this figure then the phase difference by moving x distance we can calculate as 2 pi divided by 2b, this is the phase difference one can have by moving unit distance and some arbitrary phase difference one can generate by moving x distance. So this gives me x multiplied by pi by b. Now it is easy to show that when x is equal to b we can have a phase shift of pi. Similarly, when x is equal to b by 2 we can have phase difference of pi by 2 and so on. So, we have a major that by changing the value of x, we can change by just moving these two prisms on top of each other. So whatever the light will hear we can generate a phase difference in this direction and that phase difference makes the polarized light in so, for example if I launch a linearly polarized light by putting a suitable phase difference we can generate a circularly polarized light or elliptically polarized light according to our choice, so this is the way the babinet compensator will work. Now let us move to our last topic of this entire course and that is called the optical activity which is also related to polarization. In a few cases you have this experiment also. So what is optical activity? So the optical activity is so when a linearly polarized light is incident on an optically active material there are few optically active materials there it emerges as a linearly polarized light but its direction of vibration is rotated.

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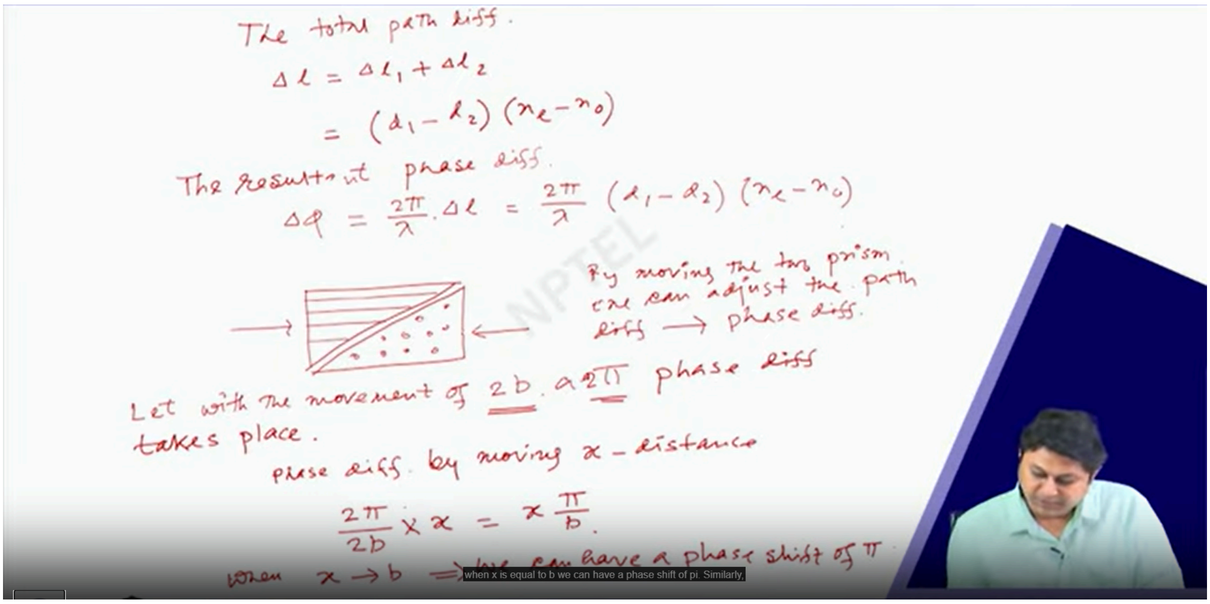

So, it is optical activity, optically active material basically rotates some other polarization. So, if so, when a linearly polarized light is incident on an optically active material, it emerges as a linearly polarized light but its direction of vibration rotates or rotates. So, pictorially if we draw, so this is my x-axis, this is my y-axis, so I launch an unpolarized light for example and then we have a polarizer which makes the unpolarized light polarized. So this is my polarizer with a pass axis, say parallel, this is the pass axis. So when the light emerges, this is the direction of the polarization one can have. So this is the polarized light we are getting from this polarizer. So this is unpolarized light, this is my polarizer and this is the polarized light and here we have the optically active cell and when it passes through, this optically active cell what happened that initially it was in this direction this polarization. Now there will be a rotation of this polarization. Suppose this is the direction, this is the angle at which it rotates. So there will be a rotation. So we also discussed this rotation earlier. So this rotation beta may be this angle beta here, so this rotation beta depends on the wavelength and also the thickness of the cell. So we can define something in this way as the rotation produced by a 1 millimeter plate of say optically active solid material. The rotation produced by one millimeter plate of optically active solid material is typically is called the specific rotation, that is beta is equal to rho L multiplied by D where, L is a light path through an active solution of d gram of active solute per centimeter cube and that is and this is the amount of specific rotation rho L is calculated in terms of decimeters and D is calculated as gram per centimeter cube. So with the knowledge of this quantity one can calculate the amount of rotation for this particular system. So, this behaves like a rotator and we know that in the Jones matrix calculation that what is the matrix element for this rotator we discuss. So, we have almost covered our entire syllabus now. So today was the last class I mentioned. In the last class I covered a specific instrument called Babinet compensator through which you can make the path difference and that path difference allow you to generate the circularly polarized light from a linearly polarized light that we discussed earlier in several time in different classes and also discussed about the optical activity there are materials through which when a polarized light passes, then this optical material rotates its polarization angle. If it is polarized with a certain angle, this angle will rotate. So it behaves like a rotator. So with that note, I would like to conclude. I sincerely do hope that you people thoroughly enjoy this wave optics course and the assignments will be given and over the it's already given to you over the weeks with the solutions and I believe you enjoy these assignments please do this assignment carefully and then I also wish you a good luck for your future endeavor and the exam related to this particular course. So with that note, I will conclude my course today. It was a very good journey for me throughout the course, very nice interactions among the students over these emails and all these things. I also learned many things during this course and I hope that you have enjoyed this course thoroughly. So thank you and best of luck for your future endeavours. See you maybe in some next course. Thank you.