Physics 312 Set up
April 15

Lab 11: Birefringence

Goals: To use birefringence 1) to create circularly polarized light via a quarter waveplate 2) see stress in materials and 3) to understand 3D projection glasses.

1. *Creation of circular polarization*

As was shown in homework, you can easily find the 45° orientation of the λ/4 film (i.e. the midpoint between the fast and slow axis): You place the film between the two perpendicular polarizers as shown in Fig. 1 and look for a transmission maximum.

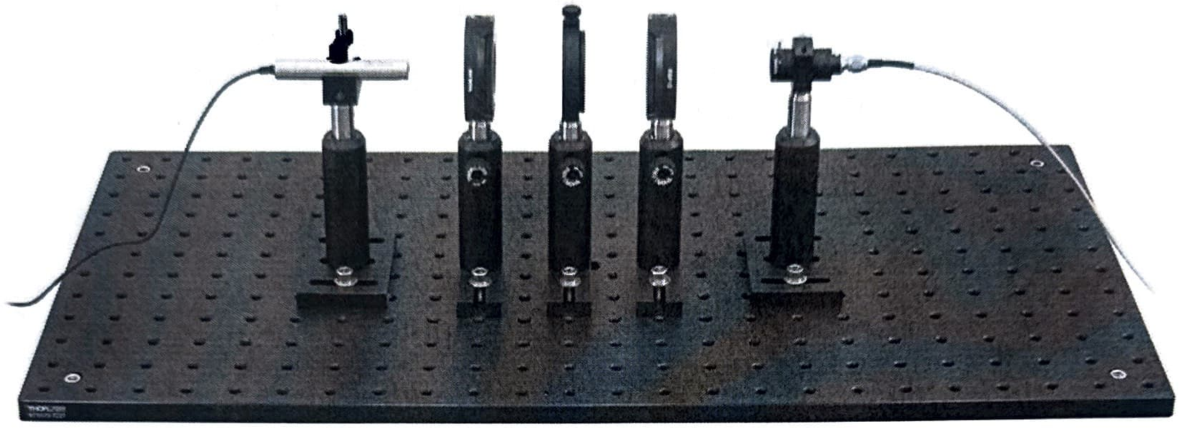

Figure 1. The laser strikes a linear polarizer, behind which the λ/4 film is placed. After that, the second linear polarizer is aligned with the transmission axis perpendicular to that of the first polarizer. The photodetector measures the intensity of the light transmitted through the wave plate and polarizers.

Once the 45° orientation of the λ/4 film has been found, rotate the rear polarizer and record the voltage values from the photodector. To avoid a non-linear signal, the iris in front of the photodiode should be adjusted so that the output of the photodetector remains below 220 mV. Make a polar plot of your results: https://www.mathworks.com/help/matlab/ref/polar.html. Comment on whether the light is circularly polarized.

2 *Stress-induced birefrigence*

Stress-induced birefringence can be observed by placing an object, say an optics box, between a linearly polarized source and a perpendicular linear polarizer. A computer screen can be used as a linearly polarizer. Without the object no light should be transmitted through the polarizer; with the object, the polarization state of the light is changed due to stress-induced birefringence. Take a picture of the stress-induced birefringence and include in the report. Comment on why you see different colors.

3. *RealD 3D projection glasses*

3D glasses have both a linear polarizer and a quarter wave plate. The transmission axis of the polarizer is set to be at a 45 degree angle with respect to the slow or fast axis of the λ/4 film. Determine the position of the polarizer, by rotating the glasses in front of a linearly polarized light sources with the ear pieces towards you and then again with the earpieces away from you. Describe what you see and your conclusions about the position of the polarizer.

Now put on the RealD glasses and look into a mirror. Close one eye. Describe what you see and explain the result. Keep in mind circular polarization reverses direction upon reflection.

*4. **Extra credit only**: create a 3D projection with the RealD method.*

To achieve the optimum 3D effect, the orientation of the polarizers and the $\lambda/4$ film must be aligned with the films in the glasses during the set-up. The glasses themselves consist of two films that are glued together, a $\lambda/4$ film in the front and a polarizer closer to the eye. The polarizers in front of both eyes have the same orientation, while the fast axes of the $\lambda/4$ films are offset with respect to each other by 90°. First, we have to align our polarizers to the polarizers in the glasses in the set-up. Here it is best to use a laser as an aid. Arrange the glasses, laser and polarizer as shown in Figure 2.

Figure 2. Adjusting the polarizers to the polarizer films in the glasses.

The laser passes through the glasses, and is then linearly polarized.
> Turn the linear polarizer positioned behind the glasses until no light reaches the screen anymore. Make sure that the glasses actually sit straight in the holder!
> Now read the degree setting on the polarizer and then turn it by 90° in either direction.
> Result: The polarizer is now parallel to the linear polarizer in the glasses, which means that the transmission is now at its maximum. Accordingly, a bright dot is visible on the screen.
> Repeat the same procedure with the second polarizer. It can be done on the same ‘lens’ – the two linear polarizer films in the glasses have the same orientation.

Position the lamps, slides, lenses, and cinema screen as in the previous lab, see Fig. 3. Now place all the polarization optics in the path of the beams, one polarizer and one $\lambda/4$ film per lamp/lens respectively. Adjust the $\lambda/4$ films: Put the RealD glasses on, close your left eye and turn the right lamp on. Now rotate the $\lambda/4$ film until the image on the screen is mostly dark. Perform the same procedure for the other eye (and $\lambda/4$ film): Close your right eye, turn the left lamp on, and rotate the $\lambda/4$ film until the screen is mostly dark.

Put the 3D glasses on and adjust the slides and/or lenses to make the images overlap and see the 3D effect. A schematic diagram of what is happening with this imaging is shown in Fig. 4.

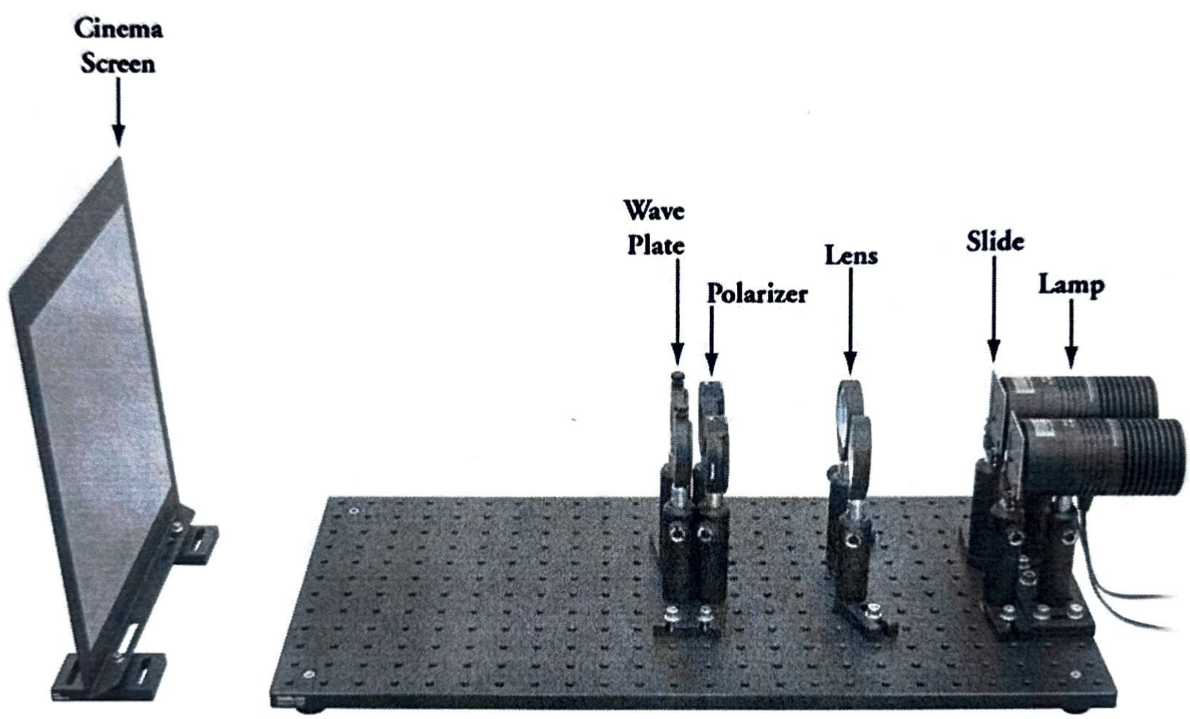

Figure 3 Polarizers and $\lambda/4$ films in the beam path.

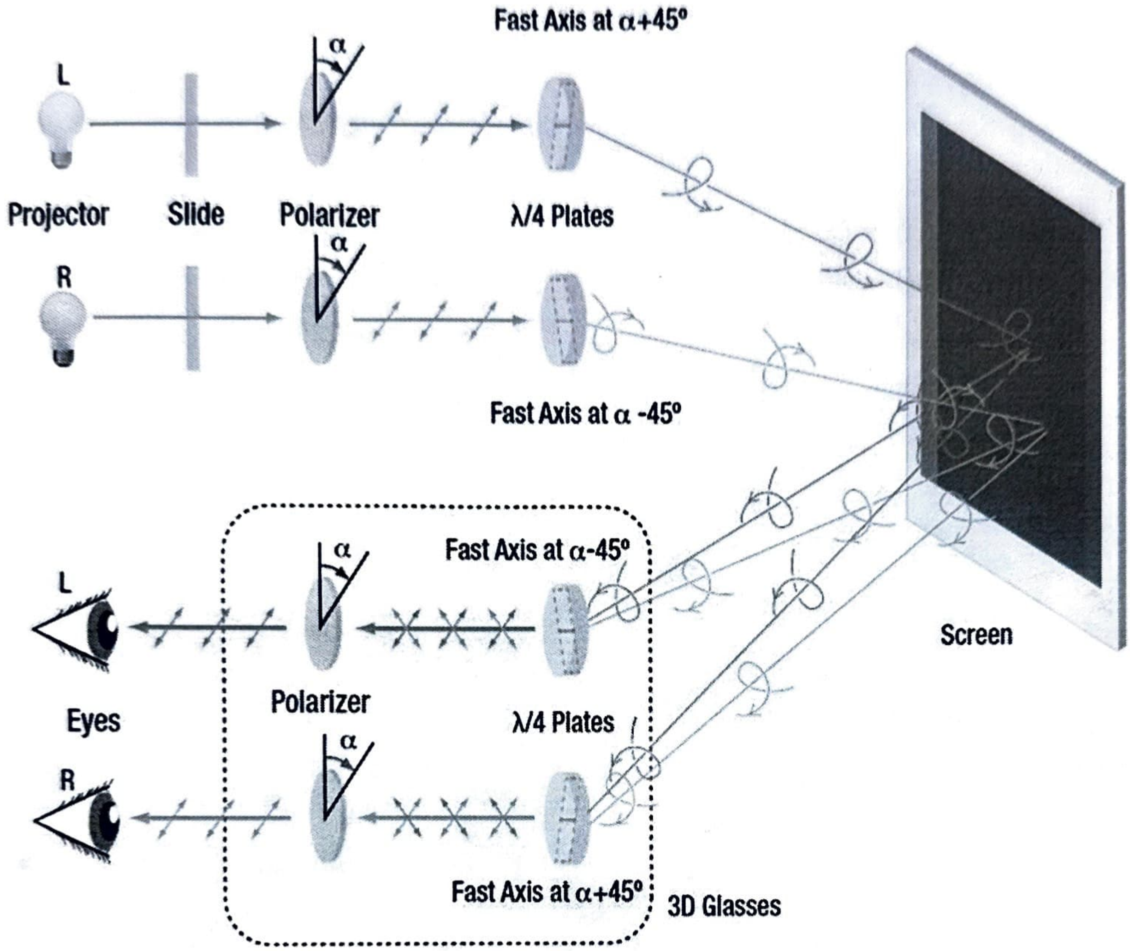

Figure 4 Schematic diagram of the RealD 3D technology. The light from the slide is first linearly polarized via a polarizer and then circularly polarized by passing through a λ/4 plate. After the light is reflected from the screen, the glasses, each consisting of a λ/4 plate and a polarizer, allow only the passage of the left-circularly polarized light to one eye and right-circularly polarized light to the other.