MODULE 08

CHARACTERISTICS OF LASER LIGHT

1. GOALS

1.1 Understand the difference between lasers and ordinary light,
1.2 Understand the physical events that can occur in the light of light: scattering, polarization, diffraction,
1.3 Understand the basic principle of diffraction by lattice,
1.4 Understand diffraction events on CDs and can estimate their capacity using the concept of diffraction.

2. TOOLS

2.1 Laser source (1 piece),
2.2 Roll meter (1 piece),
2.3 Screen (1 piece),
2.4 Polarisator- Analisator (1 piece),
2.5 Grating (1 piece),
2.6 CD (1 piece),
2.7 Arc degree (1 piece),
2.8 Ruler (1 piece),
2.9 Millimeter blocked paper (1 piece),
2.10 Laser statif (1 piece), and
2.11 Regular statif (1 piece).

3. BASIC THEORY

Laser (*Light Amplification by Stimulated Emission of Radiation*) is an electromagnetic wave that has a very strong intensity and has special properties, namely:

a. Coherent. The light (photon) produced by the laser always has the same phase so that the resulting waves strengthen each other.
b. Monochromatic. Laser light consists of only one type of color spectrum/wavelength resulting from atomic excitation at the same specific energy level.
c. Consolidated. The intensity of the laser light does not decrease much despite traveling a long distance. This event is indicated by the distribution value of the laser light.

Lasers are produced from strengthened light due to stimulation from the emission of photon radiation.

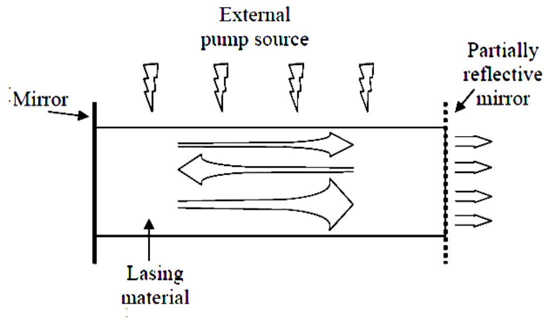


Figure 8.1. Laser process.

The laser used in this experiment was a semiconductor laser. P-type semiconductors with n-type semiconductors (PN connection or PN junction). Therefore this laser is a diode with a regular forward bias. The process of forming this type of laser is similar to the usual LED work where the photon light is caused by the recombination of electrons and *holes* (recombination) in the PN connection area. This laser is also called an injection laser, because the stimulation is done by injection of an electric current through its semiconductor PN connection.

Diffraction is a light curvature event due to narrow gaps, disturbances/ obstacles, or different mediums. If the width of the narrow gap is proportional to the wavelength of the light coming, then a dark light pattern will be formed captured on the screen. In this practicum, diffraction will be discussed in many gaps (lattice). The general formulation of diffraction on many gaps is:

$$m\lambda = d\sin\theta \tag{8.1}$$

Where λ is the wavelength of light, d is the distance between the fissures, is the angle of difference of phase and θm expresses the order of light.

Diffraction events can be observed in narrow gaps and grids, as we can find in most textbooks. In addition to the consequences through a narrow gap, diffraction can also be caused when light hits a barrier. The babinet principle states that if light or light through pounding the barrier with a width proportional to the wavelength of light then the width of the barrier can be likened to a gap.

CD pieces are made of a number of *layers (multi-layered disks*) of plastic material, which are coated with a thin layer of aluminum or silver thus making the data layer highly reflective. Each layer consists of a series of very small "pits" (about 500 nm in diameter) arranged spiraling from the center of the disk outwards. Due to the regularity of the arrangement of these pits and their size in the order of light wavelengths, CD pieces can serve as a diffraction lattice.

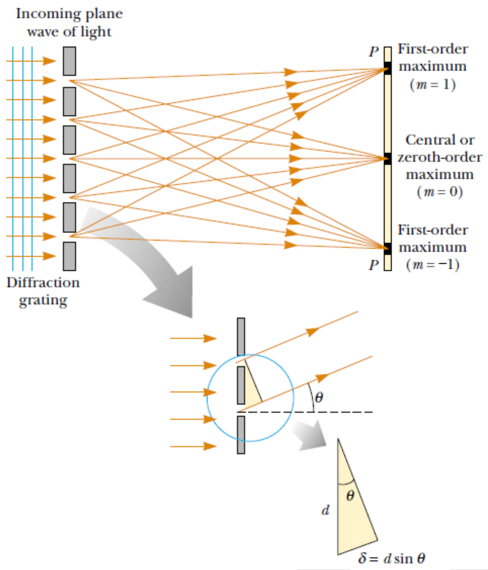
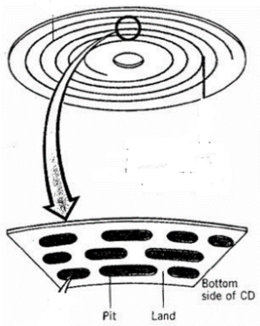


Figure 8.2. Diffraction mechanism on the grid.



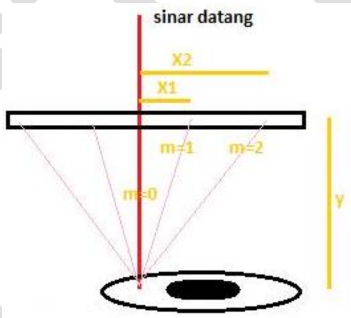


Figure 8.3. Pits on CD Figure 8.4. Diffraction experiments on CD.

Constructive superposition occurs when:

$$m\lambda = d(\sin\theta_m - \sin\theta_i) \tag{8.2}$$

Where λ is the wavelength of light, *d* is the distance between the pit path or pit diameter, is the angle between the normal line of lattice and the order of the nth diffraction θ_m, and is the coming angle of the laser light (against the normal line of lattice/CD). θ_i

4. TRAINING MATERIALS

4.1 Explain the properties of laser light and what are the advantages of those properties!

4.2 Name a few types of lasers and what are the fundamental differences between each other!

4.3 Explain what is meant by polarization of light and what its benefits are in everyday life!

4.4 Explain what the difference between diffraction and interference is!

4.5 Explain why interference events can only occur when the wave light is coherent and monochromatic?

4.6 How can data be stored on CD pieces?

5. EXPERIMENTS

Note:

For safety, although the laser used is low energy and does not damage clothing or skin, laser light should not be seen directly or from its reflection by a shiny mirror/surface because it can damage the cornea of the eye. Keep the laser light from hitting your eyes or your friends.

5.1. Laser Light Deployment

1. Prepare the tools that will be used in the experiment. Stick millimeter blocked paper on the screen. The liver at the time of using laser light and for safety should not be directed to the eye.
2. Set the laser on the laser statif, and set the distance between the screen and the laser as far as 2 m and draw a circle pattern formed on the screen.
3. Measure the diameter of the circle of laser lights formed on the screen and then record them.
4. Repeat the experiment for distances of 4 m, 6 m, 8 m, and 10m.

5.2. Polarization of Cahaya

In theory, the light of laser light is not polarized, meaning that light consists of waves that vibrate in various directions. However, in lasers there is actually a polarizing effect, i.e. vibration in a certain direction, its amplitude and intensity are greater than in any other direction.

1. Place a polarisator piece in front of the laser source,
2. Use the screen to observe the laser light. Place the paper/screen not far in front of the lens and observe the laser light,
3. Change the direction of the transmission keeping polarisator (arrow on the edge of the piece) and observe the laser light on the screen note if there is a change in intensity,
4. At the polarisator position that gives the most intensity to the screen, try to leave a few minutes while still observing the laser light on the screen, note if there is a change, then investigate whether the direction of polarization that produces the maximum intensity has changed,
5. Change the direction of polarisator transmission and note the change in the intensity of the laser light on the screen, note the relative position of the polarisator transmission direction when the laser light intensity is maximum and minimum.

5.3. Diffraction by Grid

1. Take the available grid,
2. Place the grid in front of the laser source and the screen behind it as far as possible. The light of the lattice,
3. Measure the distance between the laser and the screen and the distance between the 2 bright diffraction patterns,
4. Determine the wavelength of the laser used!

5.4. Determine CD Capacity

1. Place the CD with the reflective part of the CD facing the screen,
2. Give a small hole on the screen according to the diameter of the laser source hole and attach the screen on the statif,
3. Attach the laser on the statif for the laser,
4. Point the laser light at the CD at an angle perpendicular to the reflekti part of the CD,
5. Give a mark by using a pen / marker at the point where the diffraction light is seen on the screen (millimeterblok),
6. Note the distance between the central light and the diffraction light,
7. Measure the distance between the screen and the CD and the distance between the order from the diffraction formed,
8. Perform the above experiment twice with different laser light drop points,
9. Tabulasikan data obtained in Table 8.1 and Tabel 8.2.

Table 8.1. Diffraction on CD.

y(m)	M	x(m)	sin θ	*d* (m)

Where y: distance of CD to screen, m: bright order, x: distance between bright order, p: distance of light order m to the center light, sin θ = 1, d: many lattice gaps.

Table 8.2. Calculation of CD capacity.

y(m)	d (m)	Square Assumptions		Circle Assumptions	
		Pit area (m2)	Capacity (MB)	Pit area (m2)	Capacity (MB)

where Density = and 1 Pit = 1 bit = bytes. Use byte $\frac{\text{Luas CD/DVD}}{\text{Luas 1 Pit}}$ $\frac{1}{8}$*units*, where 1 *byte* = 8 bits, and MB units, where 1 MB = 1 *megabyte* = 106byte.

6. ANALYSIS

6.1 Why is there a laser light spread?
6.2 What laser properties are related to the event of the spread of the laser light light?
6.3 Why does the angle of polarization obtained have different results with references (~90°)?
6.4 Compare reference wavelengths and experiments! Explain if there is a difference!
6.5 Is there interference and diffraction simultaneously in the lattice experiment? Why?
6.6 Compare the capacity of reference CDs and experiments! Explain if there is a difference!
6.7 Explain the incorrect assumptions used in the diffraction experiment on the CD!

7. REFERENCES

Halliday, D., Resnick, R., Walker, J. (2006): *Fundamentals of Physics 6th Edition*, John Wiley & Sons, 909 – 910.

Lenda, Andrzej. (2000): *Physics Laboratory*, International School of Technology of Cracow, 71-1 – 71-4.

Using a laser pointer to measure the data track spacing on CDs and DVDs (2008), http://www.sciencebuddies.org