University of technology
Laser and optoelectronics eng. Dept.

LASER APPLICATION COURSE
4TH YEAR
LEC.2

LASER PARAMETERS

- Laser parameters relate to both the ***laser beam*** and to the ***laser power output as a function of time***. Normally, lasers are either operated ***CW*** or ***pulsed***. The parameters of the beam that affect processing are as follows[2]:
- ***Wavelength***: Is the distance over which the wave repeats itself and is represented by the Greek letter λ (lambda). Each color of visible light has it's own characteristic wavelength.
- ***Focused Spot Size.***
- ***Mode Structure (CW or Pulse).***
- The ***wavelength*** affects ***absorption*** and ***reflection*** characteristics, and ***spot size*** & ***mode structure*** affect ***average irradiance*** & ***irradiance distribution*** in the spot.

CONTROLLING THE BEAM AFTER IT IS EMITTED OUT OF THE OPTICAL CAVITY

- A known rule in optics is that the product of the beam diameter (d) and its divergence angle (θ) is a constant. Thus, when the beam divergence needs to be reduced, the beam diameter must expand. The following pages describe the beam expander[1].
- ***1.3.1 Beam Expander:***
- *Optical device increasing beam diameter and reducing divergence. Result a smaller focused spot for more distance between lens and workpiece.* We saw the basic equations describing the beam divergence[1]:

$$\theta = \frac{1.27 \cdot \lambda}{d} \quad \ldots(1.5)$$

Increasing the beam diameter (**d**) causes a decrease in the beam divergence angle (**q**). Beam expander is based on the telescope developed by Kepler in the 17 century (see figure 1.1).

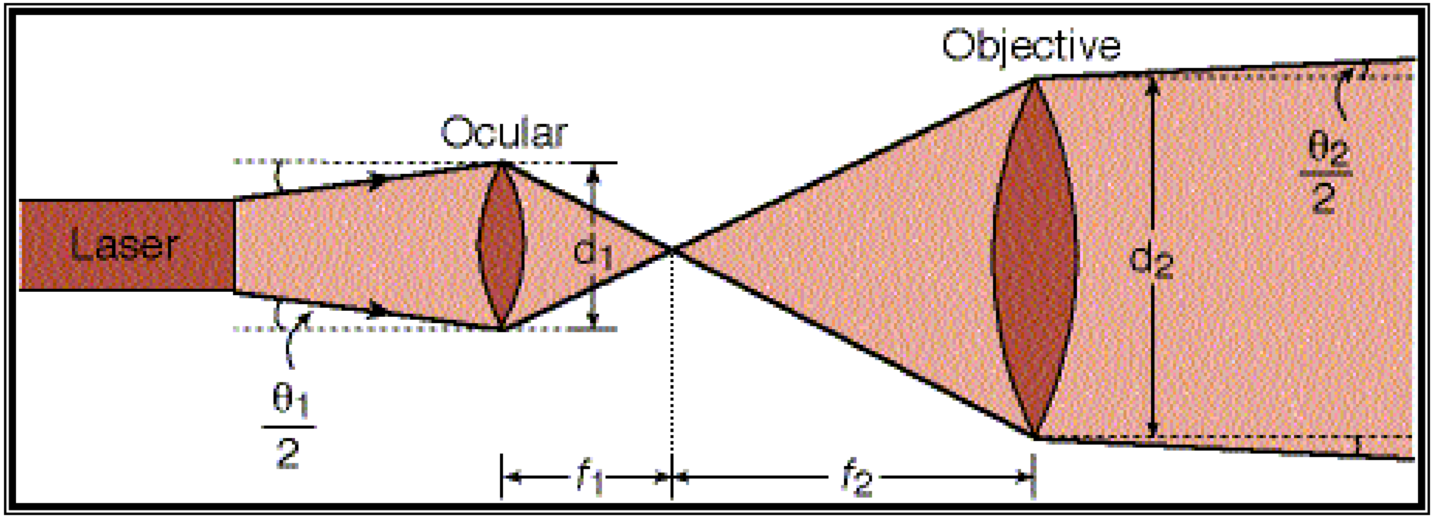

Figure 1.1: Beam expander based on the Kepler telescope[1].

- The first positive lens has short focal length and small diameter, while the second positive lens has long focal length and large diameter. The distance between the lenses is exactly equal to the sum of the focal lengths of the two lenses. The laser beam enters the short focal length, and is focused to a real image at the focal point of the other lens. This image serves as a point source for the other lens. At the output of the second lens the beam has a larger radius, and a smaller divergence[1].
- ***The relation between the beam diameters and the beam divergence angles is:***

$$\frac{f_1}{f_2} = \frac{d_1}{d_2} = \frac{\theta_2}{\theta_1} \quad \textbf{\textit{...(1.6)}}$$

- f_1: Focal length [m] of the input lens - ocular.
- f_2 :Focal length [m] of the output lens - objective.
- d_1 :Diameter of the input beam [m].
- d_2 :Diameter of the output beam [m].
- q_1:Divergence angle (Rad) of the beam at the input to the beam expander.
- q_2 :Divergence angle (Rad) of the beam at the output to the beam expander.
- From equation (1.6) it is clear that the ratio between the beam diameters is directly related to the ratio of the focal lengths of the lenses. In other ward the beam diameter d_1 expanded to d_2 by , $\dfrac{f_2}{f_1}$

- and we can rewrite equation.(1.6) as below:

$$d_2 = d_1 \frac{f_2}{f_1} \quad \text{...(1.7)}$$

- Where $\frac{f_2}{f_1}$ is the Expansion Factor (***F***).

Example-1[1]

The diameter of a beam emitted from He-Ne laser is 1.2 mm and its divergence angle is 1 mRad. A Kepler beam expander is used made of 2 positive lenses with focal lengths of 1 cm and 6 cm. Calculate:

1. The beam diameter at the output of the beam expander.
2. The beam divergence angle.

Solution

1. The beam diameter at the output of the beam expander is:

$$d_2 = d_1 * (f_2/f_1) = 1.2*10^{-3} \text{ m} * 6 \text{ cm} / 1 \text{ cm} = 7.2*10^{-3} \text{ m}$$

2. The divergence angle at the output of the beam expander (θ_2):

$$\theta_2 = \theta_1 * (f_1 / f_2) = 1\text{mRad} * 1 / 6 = 0.17 \text{ mRad}$$

The beam expander caused a reduction of 6 times of the beam divergence (the ratio of the focal lengths of the lenses).

Beam Transport

- Beam transport is a technique that used for transporting laser beam from the laser to point where the beam is required is to send the beam down a flexible fiber-optical waveguide. Basically they consist of a small diameter (few hundred microns) ***glass*** or ***quartz*** fiber containing a core region where ***the refractive index is higher than the surrounding cladding,*** as shown in figure (1.2).
- A ray is able to travel down the core in a ***zig-zag*** fashion, undergoing ***total internal reflection*** at the core-cladding interface provide the angle it makes with the normal to the interface is greater than the critical angle

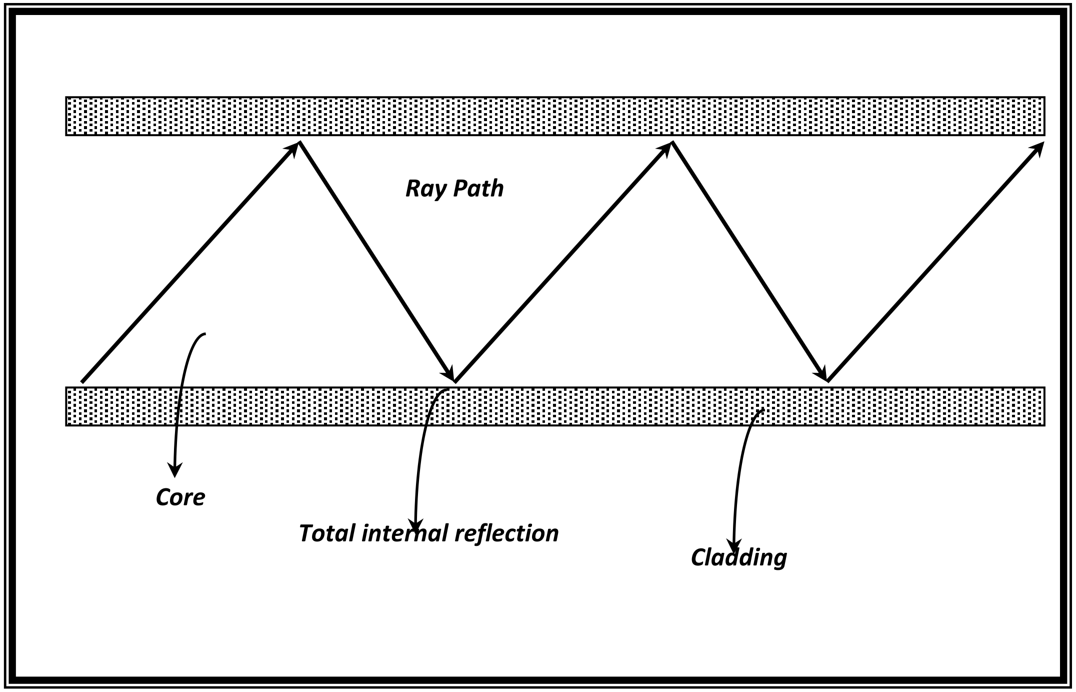

Figure (1.2) Beam Transport down an optical fiber utilizing total internal reflection[4]