The Unusual Properties of Laser and Their Influence on Application

- Monochromaticity
- Directionality
- Special behavior
- Temporal behavior
- Focusing properties
- Coherency
- Brightness
- High intensity
- Tunability
The spacing between two longitudinal modes is $\Delta \nu = \frac{C}{2d}$ (frequency spacing) and equivalent wavelength spacing is $\Delta \lambda = \frac{\lambda^2}{2d}$.

The gain curve has almost the same fluorescent line shape while the loss is constant over small wavelength range. All modes for which the gain is greater than loss can be present. The typical fluorescent line width for the (He-Ne) laser is around $1.4 \text{ Hz (GHz)}$.

To obtain lasers operate with high monochromaticity lasers should be constructed to operate with one longitudinal mode and this involves construction of short laser cavities, so that the spacing between two modes becomes large, but the disadvantage of this way is the limitation of laser output power.

The alternative method for obtaining a single mode involves use of multiple and mirrors the length of short cavity is choosen so that only mode lies within fluorescent line width. The laser operate in the mode which is resonant for both cavity of length $L$ and
In this case, the length of two cavities must be adjusted carefully as this method provides a single longitudinal mode of higher power compared with the previously method.

Particle consideration:

1. Vibration.
2. Temperature Variations.

The width of the mode is affected by the variation in the length of the laser cavity caused by vibration and temperature variation; therefore, the laser system needs stability and isolation.

**B. Directionality (divergence angle)**

One of the important characteristics of the laser radiation is the high directionality (small divergence angle); therefore, the laser beam is collimated in nature. This property is very important for the alignment applications. The laser beam has a very small divergence angle compared to the ordinary light sources and the limitation of the laser beam divergence angle is set by diffraction. The lower limit is given approximately by the Eqn.

\[ \theta = \frac{k\lambda}{d} \]

Where \( k \) is a numerical factor which is nearly \( 1/\pi \) for the Gaussian beam. Thus,

\[ \theta = \frac{2\lambda}{\pi d} \]

Which represent the full divergence angle for the TEM_{00} mode. This value represents the minimum divergence angle for the diffraction limited, moreover, the divergence angle can be written as:
material. While to get effective melting for low thermal diffusivity material like (stainless steel) we should use lower laser power with long pulse duration.

The reflectivity of metal surface is another important parameter. It defines how much of the light that falls on the surface is actually absorbed and can be used for processing. The reflectivity is defined as the ratio of the radiant power reflected from the surface to the radiant power incident on the surface. The reflectivity is a function of wavelength and its value for metal is relatively high for wavelengths longer than (1μm) and becomes high as one goes to long infrared wavelength. For wavelength greater than (5μm), almost all metals have reflectivity greater than 90%.

The amount of light absorbed by a metallic surface is proportional to (1-R) where R is the reflectivity. Thus, at the CO₂ laser (λ=10.6 μm), the absorbed light is very small because R is high and that means only small amount of the incident light will be absorbed. Therefore, most metals absorb amount of laser light greater when Nd:YAG laser is used compared with CO₂ lasers. However, CO₂ lasers can be used effectively with metals because the surface reflectivity reduce during the laser pulse as shown in the figure.

![Figure](image)

Before the boiling begins, the surface must first start to melt. Because of the great rapidity with which the boiling begins, there is no time for much material to melt. Thus,
at high laser power densities ($\geq 10^6$ W/cm$^2$), the dominant physical process is the vaporization. In this case the material latent heat of vaporization is very significant. Metals with low latent heat at vaporization are vaporized with large amount than metals of high latent of vaporization.

![Figure]

There are various regions for laser interaction with material which lead for different potential applications. In the heating region, the laser parameters involve relatively low power density less than $10^4$ W/cm$^2$ with long pulse duration ($10^{-2}$-$10^{-3}$ s). This region involves the surface treatments such as hardening, alloying, doping and glazing .... etc. when we use higher power densities, the temperature rises to values greater than the melting point of most metals.

There one can use such parameters for melting process such as welding. Higher laser power densities with shorter pulses leads to get rapid temperature rising and vaporization occurs. In this region, the hole drilling is dominated. The material removal processing such as “cutting” can be done when higher power density of short pulses is