Helium–Neon Laser

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Abstract

TODO

General laser scheme

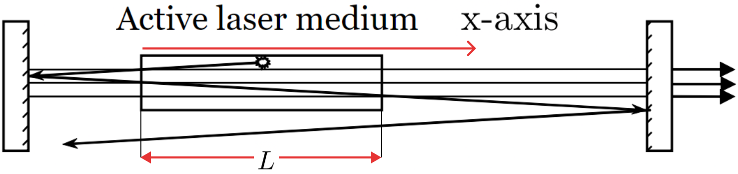


Figure: General laser scheme

Einstein coefficients

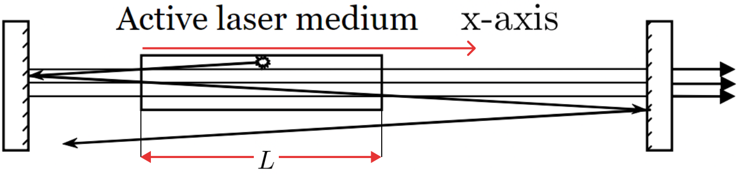
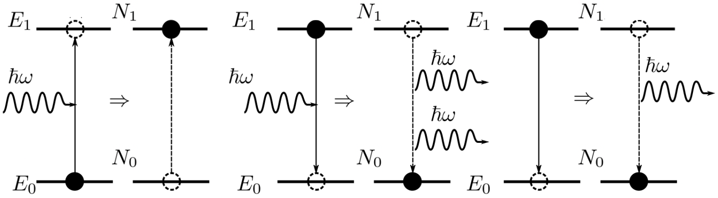


Figure: General laser scheme

Elementary processes



a) Absorption b) Stimulated Emission c) Spontaneous Emission

$\left(\frac{dN_0}{dt}\right)_{\text{abs}} = -B_{01} N_0 \rho(\omega)$

Einstein coefficients are the same $B_{01} = B_{10} = B$

$\left(\frac{dN_0}{dt}\right)_{\text{stim}} = B_{10} N_1 \rho(\omega)$

phase, direction and frequency of emitted and external photons are identical.

$\left(\frac{dN_0}{dt}\right)_{\text{spon}} = -A_{10} N_1$

photons radiate independently in all directions. $\frac{dN_0}{dt}$ **does not** depend on $\rho(\omega)$.

Where $\rho(\omega)$ – spectral energy density of the isotropic radiation field at the frequency of the transition.

Gain

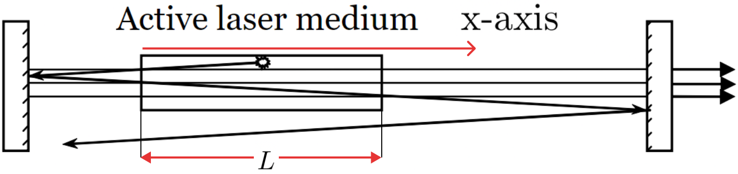


Figure: General laser scheme

Beer–Lambert–Bouguer law states that intensity of light $I(x)$ changes:

$$I(x) = I_0 \exp(\gamma x),$$

where γ – medium gain coefficient. With length L gain per period is called **laser gain**:

$$G = \exp\left(2\gamma L\right).$$

Population inversion

The fact that the number of spontaneously emitted photons does not depend on $\rho(\omega)$ gives us a reason to neglect $\left(\frac{dN_0}{dt}\right)_{\text{spon}}$ term. Number of photons emitted at a time dt:

$$\frac{dN}{dt} = \left(\frac{dN_0}{dt}\right)_{\text{abs}} + \left(\frac{dN_0}{dt}\right)_{\text{stim}} = B(N_1 - N_0)\rho(\omega) \qquad (1)$$

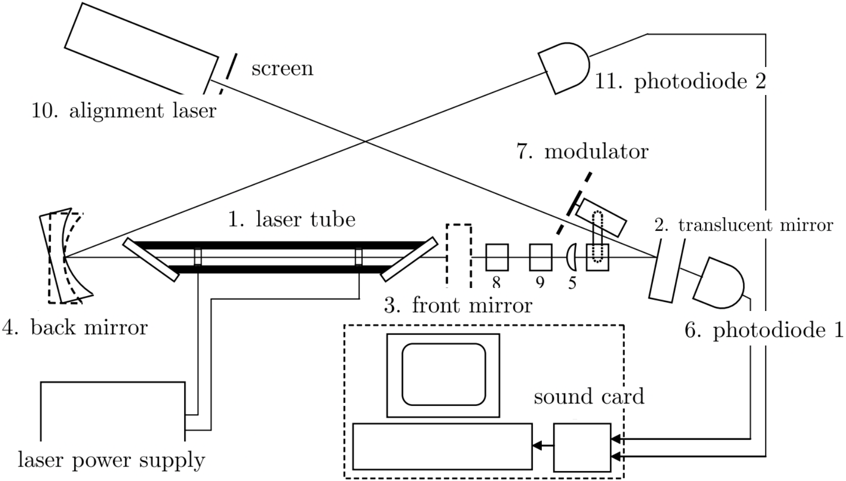
Therefore:

$$\gamma = \frac{dI}{I} = \frac{dN \cdot \hbar\omega}{\rho(\omega)} = B\frac{\hbar\omega}{v}(N_1 - N_0), \qquad (2)$$

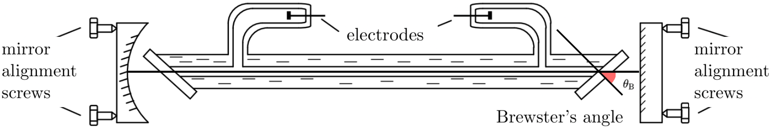
where $v = \frac{c}{n}$ – speed of light inside medium.

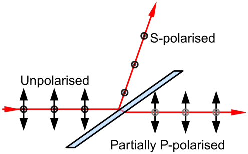
γ is positive if $N_1 > N_0$. This laser principle is called **population inversion**

Experimental setup



Polarization of Laser Emission





To remove reflections from laser's windows the Brewster's angle property can be used:

$$r_p = \frac{E_r}{E_i} = \left.\frac{n_2 \cos\theta_i - n_1 \cos\theta_t}{n_2 \cos\theta_i + n_1 \cos\theta_t}\right|_{\theta_i = \theta_B} = 0$$

Gain

The fact that the number of spontaneously emitted photons does not depend on $\rho(\omega)$ gives us a reason to neglect $\left(\frac{dN_0}{dt}\right)_{\text{spon}}$ term. Number of

1. laser tube

laser power supply

4. back mirror

3. front mirror

sound card

2. translucent mirror

6. photodiode 1

11. photodiode 2

7. modulator

screen

10. alignment laser Brewster's angle

mirror
alignment
screws

mirror alignment screws