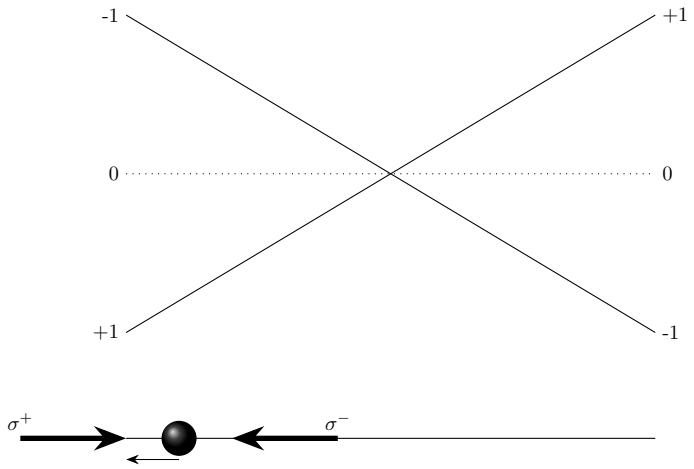
Magneto-Optical Trap(MOT)



Counter Propagation

Force calculation of counter propagation beam in the presence of magnetic field.

$$\vec{F}_{counter} = \frac{\hbar\vec{k}\Gamma_{sp}\Omega^2}{4(\Delta + kv + b'xg_F\mu_B/\hbar)^2 + \Gamma_{sp}^2} \tag{1}$$

$$\begin{aligned} \Delta' &= \omega_L - (\omega_0 - g_F\mu_B B(x)/\hbar)^2 + kv & (2)\\ &= \Delta + kv + b'xg_F\mu_B/\hbar & (3) \end{aligned}$$

where b' is positive.

Consider and put $g_F\mu_B/\hbar = 1$ for simplicity,

$$\frac{1}{4(\Delta + kv + b'x)^2} = \frac{1}{4\Delta^2 + \Gamma_{sp}^2\left[1 + \frac{8\Delta kv + 8b'x\Delta}{4\Delta^2 + \Gamma_{sp}^2}\right]}$$

$$\vec{F}_{counter} = \frac{\hbar\vec{k}\Gamma_{sp}^2\Omega^2}{4\Delta^2 + \Gamma_{sp}^2}\left[1 - \frac{8\Delta kv}{4\Delta^2 + \Gamma_{sp}^2} - \frac{8b'x\Delta}{4\Delta^2 + \Gamma_{sp}^2}\right] \tag{4}$$

$$\vec{F}_{counter} = \vec{F}_0 - \frac{\alpha}{2}\vec{k}v - \frac{\beta}{2}\vec{k}x \tag{5}$$

Co-propagation

Force calculation for Co-propagation beam in the presence of magnetic field.

$$\vec{F}_{coprop} = \frac{\hbar\vec{k}\Gamma_{sp}\Omega^2}{4(\Delta - kv - b'xg_F\mu_B/\hbar)^2 + \Gamma_{sp}^2} \tag{6}$$

$$\Delta' = \omega_L - (\omega_0 + g_F\mu_B B(x)/\hbar)^2 - kv \tag{7}$$
$$= \Delta - kv - b'xg_F\mu_B/\hbar \tag{8}$$

Consider,

$$\frac{1}{4(\Delta - kv - b'x)^2} = \frac{1}{4\Delta^2 + \Gamma_{sp}^2\left[1 - \left(\frac{8\Delta kv + 8b'x\Delta}{4\Delta^2+\Gamma_{sp}^2}\right)\right]}$$

$$\vec{F}_{coprop} = \frac{\hbar\vec{k}\Gamma_{sp}^2\Omega^2}{4\Delta^2 + \Gamma_{sp}^2}\left[1 + \frac{8\Delta kv}{4\Delta^2 + \Gamma_{sp}^2} + \frac{8b'x\Delta}{4\Delta^2 + \Gamma_{sp}^2}\right] \tag{9}$$

Condition for co-propagating beam is $\vec{k} = -\vec{k}$.

$$\vec{F}_{coprop} = -\vec{F}_0 - \frac{\alpha}{2}\vec{k}v - \frac{\beta}{2}\vec{k}x \tag{10}$$

Net force is given by adding equation (5) and (10).

$$\vec{F}_{net} = \vec{F}_0 - \frac{\alpha}{2}\vec{k}v - \frac{\beta}{2}\vec{k}x - \vec{F}_0 - \frac{\alpha}{2}\vec{k}v - \frac{\beta}{2}\vec{k}x \tag{11}$$

Along x-direction, Force is given by,

$$F_x = -\alpha k_x v - \beta k_x x \tag{12}$$