Dipole Trap

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Dipole trap depth

$\lambda_{dip} = 935.6\ nm$ / wavelenght of the dipole trap laser

$\lambda_{D1} = 894.59\ nm$ / wavelength of D1 line

$\lambda_{D2} = 852.35\ nm$ / wavelength of D2 line

$\Gamma_{D1} = 2\pi \times 4.56\ MHz$ / natural line width of D1 line

$\Gamma_{D2} = 2\pi \times 5.22\ MHz$ / natural line width of D2 line

The potential and the scattering rate of linearly polarized dipole trap from D1 line are calculated as[1][2]

$$U_{dip\ D1}(\mathbf{r}) = -\frac{3\pi c^2}{2}\frac{1}{\omega_{D1}^3}\left(\frac{\Gamma_{D1}}{\omega_{D1}-\omega} + \frac{\Gamma_{D1}}{\omega_{D1}+\omega}\right) I(\mathbf{r}),$$

$$\Gamma_{sc\ D1}(\mathbf{r}) = -\frac{3\pi c^2}{2\hbar}\frac{1}{\omega_{D1}^3}(\frac{\omega}{\omega_{D1}})^3\left(\frac{\Gamma_{D1}}{\omega_{D1}-\omega} + \frac{\Gamma_{D1}}{\omega_{D1}+\omega}\right) I(\mathbf{r}).$$

The same formula can be used for D2 line.

Since the ratio of the transtion strengths from D1 and D2 line is 1:2, the total potential and the scattering rate are

$$U_{dip} = \frac{1}{3}U_{dip\ D1} + \frac{2}{3}U_{dip\ D2}$$

$$\Gamma_{sc} = \frac{1}{3}\Gamma_{sc\ D1} + \frac{2}{3}\Gamma_{sc\ D2}$$

Since the dipole trap wavelength is decided, the only dependency is the laser intensity which is determined by the laser power and beam waist.

$\omega_0 = 1.9\ \mu m$ / the beam waist of guided light inside the fiber HC-800-02[3]

$P = 100\ mW$ / laser power

$I = \frac{2\ P}{\pi\omega_0^2}$ / laser power at the center of the beam

By inserting these parameters, we have

$$U_{dip}/k_B = 12.0\ mK$$

$$\Gamma_{sc} = 323 Hz$$

This calculation process was tested with numbers in the references [2][3].

The temperature in MOT can be assumed near the Doppler temperature $T_D = 126\mu K$.

The average recoil temperature is $T_r = 186 nK$.

The average lifetime of Cs in dipole trap is roughly estimated as

$$T_{\text{life}} = \frac{U_{dip}/k_B - T_D}{T_r\ \Gamma_{sc}} = 190\ s.$$

Notes

1. ↑ R. Grimm, et al. Optical Dipole Traps for Neutral Atoms. arXiv:physics/9902072v1, 1999.
2. ↑ [2.0] [2.1] K. Meyer. An optical dipole trap for a two-species quantum degenerate gas This. Thesis, University of Heidelberg, 2010.
3. ↑ [3.0] [3.1] M. Bajcsy, et al. Laser-cooled atoms inside a hollow-core photonic-crystal fiber. Phys. Rev. A 83, 063830, 2011.