6.2 Estimation of the a.c. Stark shift in a Strontium dipole trap

The magnitude of the a.c. Stark shift can be estimated by

$$\Delta\omega_{light} \approx \frac{\Omega^2}{4\delta} \ , \tag{6.1}$$

where Ω^2 is the Rabi frequency squared

$$\Omega^2 = \frac{I}{I_{sat}} \frac{\Gamma^2}{2} \tag{6.2}$$

with $I_{sat} = \hbar\omega\Gamma \ /(2\sigma(\omega))$ - the saturation intensity that can be calculated from the absorption cross-section

$$\sigma(\omega) = 3\frac{\pi^2 c^2}{\omega_0^2}\Gamma g_H(\omega) \ .$$

Hence, we get

$$\Delta\omega_{light} \approx \frac{I}{8\delta}\frac{3\pi c^2\Gamma^3}{\hbar\omega\omega_0^2} \cdot \frac{1}{\delta^2 + \Gamma^2/4} \tag{6.3}$$

where the Lorentzian line shape $g_H(\omega)$ has been replaced by its explicit expression. For a typical Strontium setup, where

- $\Gamma \approx 2\pi \cdot 7.4$ KHz
- $\omega_0 \approx \frac{2\pi c}{689 \text{ nm}} \approx 2.7 \cdot 10^{15} 1/s$
- $\omega \approx \frac{2\pi c}{1064 \text{ nm}} \approx 1.8 \cdot 10^{15} 1/s$
- $I \approx \frac{2 \cdot 20 \text{ W}}{\pi(50\mu m)^2} \approx 5.1 GW/m^2$

we obtain as a rough estimation for the a.c. Stark shift:

$$\Delta\omega_{light} \approx -5 \cdot 10^{-17} 1/s \tag{6.4}$$