ECE 434 Biophotonics Project

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A Project Report on optical trapping
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Theory

The Ray Optics Model

TODO

The Electric Dipole Model

$$\mathbf{F} = (\mathbf{p}\ \cdot \nabla)\mathbf{E} + \frac{d\mathbf{p}}{dt} \times \mathbf{B}$$

$$\mathbf{F} = \alpha \left[(\mathbf{E} \cdot \nabla)\mathbf{E} + \frac{d\mathbf{E}}{dt} \times \mathbf{B} \right]$$

$$\mathbf{F} = \alpha \left[\frac{1}{2}\nabla \mathbf{E}^2 + \frac{d}{dt}(\mathbf{E} \times \mathbf{B}) \right]$$

$$\mathbf{F} = \frac{1}{2}\alpha \nabla E^2$$

$$\mathbf{F}_{\text{scat}}(\mathbf{r}) = \frac{k^4\alpha^2}{6\pi c n^3 \varepsilon_0^2}\mathbf{I}(\mathbf{r})\hat{z} = \frac{8\pi n_0 k^4 a^6}{3c}\left(\frac{m^2-1}{m^2+2}\right)^2 \mathbf{I}(\mathbf{r})\hat{z}$$

Harmonic Potential Approximation

$$\nabla \mathbf{E}_{\text{AC Stark}} = \frac{3\pi c^2 \Gamma \mu}{2\omega_0^3 \delta}\mathbf{I}(\mathbf{r}, \mathbf{z})$$

$$I(r,z) = I_0 \left(\frac{\omega_0}{\omega(z)}\right)^2 e^{-\frac{2r^2}{\omega^2(z)}}$$

$$\omega(z) = \omega_0 \sqrt{1 + \left(\frac{z}{Z_R}\right)^2}$$

$$Z_R = \frac{\pi \omega_0^2}{\lambda}$$

$$P_0 = \frac{1}{2}\pi I_0 \omega_0^2$$

$$\frac{1}{2!}\frac{\partial^2 I}{\partial z^2}\bigg|_{r,z=0} z^2 = \frac{2P_0\lambda^2}{\pi^3\omega_0^6}z^2 = \frac{1}{2}m\omega_z^2 z^2$$

$$\frac{1}{2!}\frac{\partial^2 I}{\partial r^2}\bigg|_{r,z=0} r^2 = \frac{4P_0}{\pi\omega_0^4}r^2 = \frac{1}{2}m\omega_r^2 r^2$$

$$\omega_r = \sqrt{\frac{8P_0}{\pi m \omega_0^4}}$$

$$\omega_z = \sqrt{\frac{4P_0\lambda^2}{m\pi^3\omega_0^6}}$$

$$\frac{\omega_r}{\omega_z} = \sqrt{2}\frac{\omega_0 \pi}{\lambda}$$

Want to go over time dependent perturbation theory
Then add sinusoidal perturbations
Then derive Einstein's A and B coeffs
Ultimately get Fermi's golden rule and lasers

Applications

References