연구

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I. THERMAL EFFECT ON AOM

For 2 qubit gate it is well know thatn[34]

$$\mathcal{F} = \frac{1}{8}[2 + 2(\Gamma_1 + \Gamma_2) + \Gamma_+ + \Gamma_-] \tag{1}$$

$$\Gamma_s = \exp\left[-4\left(\bar{n} + \frac{1}{2}\right)\sum_p |\alpha_{s,p}|^2\right] \tag{2}$$

$$\Gamma_\pm = \exp\left[-4\left(\bar{n} + \frac{1}{2}\right)\sum_p |\alpha_{1,p} \pm \alpha_{2,p}|^2\right] \tag{3}$$

And It is also well know that[34]

$$\alpha_{s,p}(t) = i\eta_{s,p}\int_0^t \Omega_s(t')\cos(\mu t' + \phi_d)\exp(i\omega_p t')dt' \tag{4}$$

Fourier transform makes equation as below

$$\alpha_{s,p}(\omega) = \mathcal{F}\left[i\eta_{s,p}\int_0^t \Omega_s(t')\cos(\mu t' + \phi_d)\exp(i\omega_p t')dt'\right] \tag{5}$$

$$= \frac{\eta_{s,p}}{\omega}\mathcal{F}\left[\Omega_s(t)\cos(\mu t + \phi_d)\exp(i\omega_p t)\right] \tag{6}$$

$$= \frac{\eta_{s,p}}{2\omega}\left[\Omega_s(\omega - \mu - \omega_p) + \Omega_s(\omega + \mu - \omega_p)\right] \tag{7}$$

Rabi frequency Ω has form like below equation.

$$\Omega = \frac{pE}{\hbar} \tag{8}$$

Suppose electric field from AOM has a linearity like below formula.

$$E_{out}(\omega) = \beta_1 E_{in}(\omega) * V_{in}(\omega) \tag{9}$$

Suppose, V_{in} is come from DDS, which has single tone frequency of ω_0 and consider only first order from AOM. Then, it would have thermal noise, and flicker noise. In addition, laser is made from electronic device and it would have thermal noise and flicker noise, so will be written as follow equation.

$$E_{out}(\omega) = \frac{\beta_1}{4}\left(E_0\delta(\omega - \omega_L) + \sqrt{4kTR_L} + \frac{A_1}{(\omega - \omega_L)^{\gamma_1/2}}\right) * \left(E_{DDS}\delta(\omega - \omega_0) + \sqrt{4kTR_{DDS}} + \frac{A_2}{(\omega - \omega_0)^{\gamma_2/2}}\right) \tag{10}$$

$$= \int_{-\infty}^{+\infty}\frac{\beta_1}{4}\left(E_0\delta(u - \omega_L) + \sqrt{4kTR_L} + \frac{A_1}{(u - \omega_L)^{\gamma_1/2}}\right)\left(E_{DDS}\delta(u - \omega - \omega_0) + \sqrt{4kTR_{DDS}} + \frac{A_2}{(u - \omega - \omega_0)^{\gamma_2/2}}\right)du \tag{11}$$

$$\begin{aligned} &= \frac{\beta_1}{4}\Bigg[\Bigg(E_0E_{DDS}\delta(\omega - \omega_0 - \omega_L) \\ &+ E_{DDS}\sqrt{4kTR_L} + \frac{E_{DDS}A_1}{(\omega - \omega_0 - \omega_L)^{\gamma_1/2}}\Bigg) + \\ &\left(E_0\sqrt{4kTR_{DDS}} + 4kT\sqrt{R_LR_{DDS}}\right) + \\ &\left(\frac{E_0A_2}{(\omega - \omega_L - \omega_0)^{\gamma_2/2}}\right)\Bigg] \end{aligned} \tag{12}$$

$$\begin{aligned} &+ \int_{-\infty}^{+\infty}\frac{\beta_1}{4}\Bigg(\sqrt{4kTR_L}\frac{A_2}{(u - \omega - \omega_0)^{\gamma_2/2}} \\ &+ \sqrt{4kTR_{DDS}}\frac{A_1}{(u - \omega_L)^{\gamma_2/2}} \\ &+ \frac{A_1}{(u - \omega_L)^{\gamma_2/2}}\frac{A_2}{(u - \omega - \omega_0)^{\gamma_2/2}}\Bigg)du \end{aligned} \tag{13}$$

So, $\alpha_{s,p}$ would be as follow equation

$$\alpha_{s,p}(\omega) = \frac{\eta_{s,p}}{2\omega}\left[\Omega_s(\omega - \mu - \omega_p) + \Omega_s(\omega + \mu - \omega_p)\right] \tag{14}$$

II. REFERENCE

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