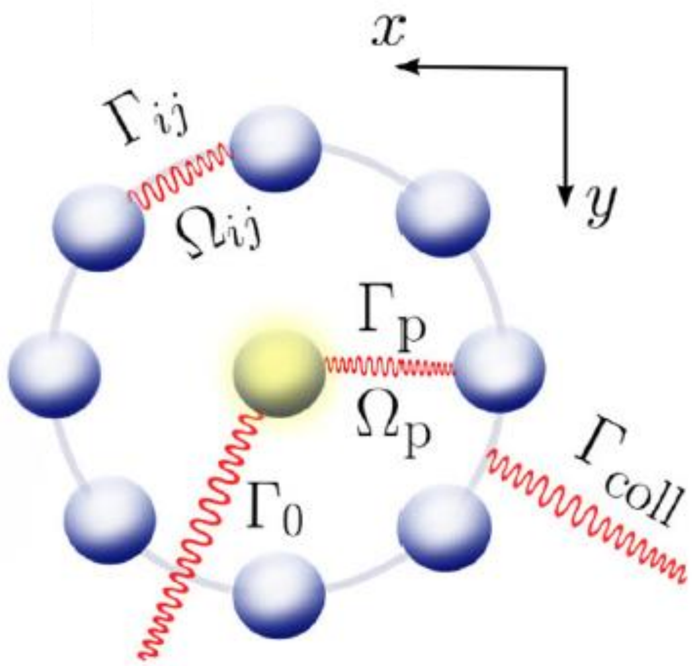
Q & A

Q : Output field is real photon?



Γ_0 : Spontaneous decay rate of a single atom

Γ_P : Collective coupling to center atom with dissipative coupling

Ω_P : Collective coupling to center atom with dispersive coupling

Γ_{ij} : Coupling between ring atoms with dissipative coupling

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Γ_{coll} : Collective decay rate from the symmetric excitation of ring atoms

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- In this paper they computed the emitted field intensity from the modeled system

$$I(\boldsymbol{r}) = \langle \boldsymbol{E}^{+}(\boldsymbol{r})\boldsymbol{E}^{-}(\boldsymbol{r})\rangle$$

- Here the electric field with $\boldsymbol{G}(r, \omega_0)$ is the electromagnetic Green's tensor of an oscillating dipole source in the vacuum :

$$\boldsymbol{E}^{+}(\boldsymbol{r}) = \frac{|\boldsymbol{\mu}|k_0^2}{\epsilon_0}\sum_i \boldsymbol{G}\left((\boldsymbol{r}-\boldsymbol{r}_i, \omega_0\right)\cdot \boldsymbol{\mu}_i\,\sigma_i^-$$

thus, the spontaneous emission of a single atom

$$\Gamma_0 = \frac{|\boldsymbol{\mu}|^2 k_0^3}{3\pi\epsilon_0}$$

- Therefore the paper is showing the photon intensity profile of steady state in Fig.1 at the position of **r**. Since the atomic dipoles are aligned in the same direction almost no intensity profile is shown the direction of dipoles. (look like giant dipole intensity profile)

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- Also the collective coupling rates Ω_{ij} and Γ_{ij} are given as,

$$\Omega_{ij} = -\frac{3\pi\Gamma_0}{k_0}\Re\left(\boldsymbol{\mu}_i^* \cdot \boldsymbol{G}\left(\boldsymbol{r}_i - \boldsymbol{r}_j, \omega_0\right) \cdot \boldsymbol{\mu}_j\right),$$

$$\Gamma_{ij} = \frac{6\pi\Gamma_0}{k_0}\Im\left(\boldsymbol{\mu}_i^* \cdot \boldsymbol{G}\left(\boldsymbol{r}_i - \boldsymbol{r}_j, \omega_0\right) \cdot \boldsymbol{\mu}_j\right).$$

where

$$\boldsymbol{G}\left(\boldsymbol{r}, \omega_0\right) \cdot \boldsymbol{\mu} = \frac{e^{ik_0 r}}{4\pi r}\left[\left(\hat{\boldsymbol{r}} \times \boldsymbol{\mu}\right) \times \hat{\boldsymbol{r}} + \right. \\ \left. + \left(\frac{1}{k_0^2 r^2} - \frac{i}{k_0 r}\right)\left(3\hat{\boldsymbol{r}}\left(\hat{\boldsymbol{r}} \cdot \boldsymbol{\mu}\right) - \boldsymbol{\mu}\right)\right]$$

- In the main slide the decay to bath in the Lindbald operator is indicated (that is the real photons that the author to collect and calculate the intensity profile)

- However, the source does not have the directionality like the ordinary laser