



Lecture7 SPDC mechanism

①

a, a^\dagger

$g^{(1)} \rightarrow \langle \hat{E}_2^* \hat{E}_1 \rangle \rightarrow \hat{n}$

$g^{(2)} \rightarrow \langle \hat{I}_2^* \hat{I}_1 \rangle = \langle \hat{E}_2^* \hat{E}_1 \hat{E}_1^* \hat{E}_2 \rangle \rightarrow \hat{n}$

$|K\rangle = \sum |n\rangle$

②

- generation of nonclassical light
(SPDC mechanism)
- Single-mode squeezing

laser 405 nm $|a\rangle$

P-B3O

810 nm 810 nm

SPDC?

$\omega_p = 405\text{ nm}$ $\omega_s = 810\text{ nm}$ $\omega_i = 810\text{ nm}$

$\hbar\omega_p = \hbar\omega_s + \hbar\omega_i$

Poisson distribution





③

$\vec{E}_P \rightarrow \vec{d}(t) \rightarrow \vec{a}(t) \rightarrow \vec{E}'$
Current oscillation

$\vec{d}(t)$ induced dipole moment

$\vec{d}(t) = \chi^{(1)} \vec{E} + \chi^{(2)} \vec{E}^2 + \chi^{(3)} \vec{E}^3 + \dots$

$U = \vec{E} \cdot \vec{d} = \chi^{(1)} E^2 + \chi^{(2)} E^3 + \chi^{(3)} E^4 + \dots$

linear, nonlinear

④

- generation of nonclassical light (SPDC mechanism)
- single-mode squeezing

$W = \int \vec{F} \cdot \vec{v} dt$
 $\omega = 2\omega_0$
 $2\omega_0 - \omega_0, 2\omega_0 + \omega_0$
 $\omega_2 = 2\omega_0$
parametric excitation

$m\ddot{x} = -m\omega_0^2 x - \gamma\dot{x} + eE(t)$
 $\rightarrow \ddot{x} = -\omega_0^2 x$
 $\rightarrow x = A \cos(\omega_0 t) + B \sin(\omega_0 t) + \chi^{(1)} E_1(t) + \chi^{(2)} E_2(t)$





④

$\frac{1}{n_p^2} = \frac{\cos^2 \theta_p}{n_o^2(\lambda_p)} + \frac{\sin^2 \theta_p}{n_e^2(\lambda_p)}$

$n_1 = n_o(\lambda_1)$
 $n_2 = n_o(\lambda_2)$

$n_e(\lambda)$
 $n_o(\lambda) \neq n_e(\lambda)$
anisotropic

ω
 ω_0
 $2\omega_0$

Input $\lambda_p = 605 \text{ nm}$
 $\theta_p = 29.13^\circ$
 $\lambda = 810 \text{ nm}$
birefringence

$n_p = 1.6590$
 $n_1 = 1.6590$
 $n_2 = 1.6592$
 $n_e = 1.6602$

$\lambda_2 = 810 \text{ nm}$
 $\theta_1 = 1.2993^\circ$
 $\theta_2 = 1.2973^\circ$

$k_p' = k_1' \cos \theta_1 + k_2' \cos \theta_2$

$k_p' = 2k_o' \cos \theta$
 $k_o' \sin \theta = k_o' \sin \theta$
 $k_p' = 2k_o' \cos \theta$

$\omega_p = \omega_1 + \omega_2$
 $\hbar \omega_p = \hbar \omega_1 + \hbar \omega_2$
 $\vec{k}_p = \vec{k}_1 + \vec{k}_2$
 $\omega_p = c k_p$
 $= \frac{c}{n(\lambda)} k_p$
 $= c k_p'$

$\frac{\omega_0}{c} \frac{1}{n(\lambda_p)} = \frac{2\omega_0}{c} \frac{1}{n(\lambda_o)}$
 $\cos \theta$
 $n(\lambda_p)$
 $n(\lambda_o)$
 λ_o
 λ

$\phi_1 = 29.13^\circ$
 $\phi_2 = 29.13^\circ$
 $\phi = 29.13^\circ$

