Toward narrow-band heralded single photon source

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Outline

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• Introduction to heralded single photon generated by SPDC
• Experiment setup
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Motivation

About quantum information in optics:

Information carrier

$\text{v} = c$

$\text{atom}$

$\Delta t_d$

$|g_2\rangle$

$|g_1\rangle$

$\text{atom}$

$\text{atom 2}$
Why sub-MHz?

Electromagnetically induced transparency (EIT)

\[ |1\rangle \rightarrow |2\rangle \rightarrow |3\rangle \]

\[ \Omega_p \]

\[ \Omega_c \]

\[ \Delta t_d \]

\[ |g_2\rangle \rightarrow |g_1\rangle \]

\[ \Omega = \left(10^5\right) \text{MHz}; \Delta w = \Omega \left(10^0\right) \text{MHz} \]

\[ \Delta w_{\text{EIT}} = \frac{\Omega_c^2}{\sqrt{OD\Gamma}} \]
Highly Efficient Coherent Optical Memory Based on Electromagnetically Induced Transparency

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Generate bi-photon pair

\[ H_{spdc} = \hbar \kappa (a_s^\dagger a_i^\dagger e^{i(\Delta k \cdot r - \Delta \omega t)} + a_s a_i e^{-i(\Delta k \cdot r - \Delta \omega t)}) \]

\[ |\psi > = e^{i \int_0^t H_{spdc}(t')dt'} |0 > \]

Perfect phase matching: \( e^{i(\Delta k \cdot r - \Delta \omega t)} \sim 1 \)

Small pump: \( |\psi > = C_0 |0 > + \kappa C_1 a_s^\dagger a_i^\dagger |0 > \)

Topica SHG 447 nm laser
Ideal linewidth:
\[ \gamma = (1 - r) \frac{c}{2nL} \times 2\pi, n \sim 1.74, L \sim 4\text{cm (plane mirror)} \]
\[ r_l = 99.99\%, r_r = 99.92\% \]
\[ \Gamma_s = \Gamma_i = \gamma_l + \gamma_r \]
\[ \Delta \omega_{FWHM} = 1.24 \text{ MHz} \times 2\pi \]
Future work
Improve mode matching condition of cavity

$$G_2(0) = \frac{4\Gamma_s \Gamma_i \kappa_1^2}{(\Gamma_s + \Gamma_i)^2} + R_1$$

$$R_1 = \frac{4\gamma_s \gamma_i \kappa_1^2}{\Gamma_s \Gamma_i (\Gamma_s + \Gamma_i)}$$

$$g_2(0) = \frac{G_2(0)}{R_1}, \text{ ideally } = 1 + \frac{\gamma}{2}$$

$$\gamma = 1.9 \times 10^6 \times 2\pi$$