Single photons are important ingredients in quantum information science. We report our construction of a narrowband heralded single photon source based on cavity-enhanced spontaneous parametric down-conversion (SPDC) for the implementation of optical quantum memory based on electromagnetically induced transparency. By putting a PPKTP nonlinear crystal into a high-finesse cavity with proper feedback locking system to lock the cavity length, the coherence time of the signal and idler photons by coincidence measurement is measured to be 80 ns, corresponding to a spectral bandwidth of 2.5 MHz. The continuous timing range of the photon source is above 1 GHz and its frequency can be locked to the F=3 to F′=4 transition of cesium D3 line. The photon bandwidth is below than the natural linewidth of the cesium D3 transition, which allows efficient interactions between photons and atoms. Combining with our cold atom system, this heralded single photon source will be able to accomplish the high-efficiency optical quantum memory, which is a crucial component for the long-distance quantum communication based on quantum repeaters.

**Abstract**

**Introduction**

- Motivation: Atom-photon interaction
- Quantum memory [3]
- Quantum state manipulation
- Electromagnetically induced transparency (EIT)
- High optical density
- Narrowband single photon source
- Heralded single photon source [2]
- Narrow the EIT bandwidth [2](1GHz)
- Electromagnetically Induced Down Conversion (EIDC)
- High finesse cavity enhanced (F ~ 6000)
- Stabilized by beat node method [5]
- $g^{(2)}$ measurement

**Features of our type-II SPDC**

- Biphoton generation from PPKTP crystal
- Signal
- Idler
- Cavity enhancing and filtering
- Cluster effect
- Double resonance cavity
- $P = 6000$
- Signal frequency
- (1) Frequency scans over Cs D1 F=3 to F′=4 transition under OPO lasing mode.
- (2) Frequency scans over Cs D1 F=5 to F′=4 transition under SPDC biphoton mode.

**Setup**

- Second order coincidence
  $g^{(2)}(0) = \frac{<a_+^†(t)a_+(t+	au)a_+(t+	au)a_+(t)>}{<a_+(t)a_+(t+	au)a_+(t+	au)a_+(t)>}$
  - Determine the linewidth [3][4]
  - $g^{(2)}(0) = \frac{e^{|\Delta f|^2}}{1+e^{|\Delta f|^2}}$
  - $\Delta f = 0.05$ MHz

**Coincidence measurement**

- Cauchy-Schwarz inequality
  $g^{(2)}(0) \leq 1$
  - Figure (a) and (b) show the coincidence measurements at 0.4 mW and 0.05 mW, respectively. The resonant filtering lines (red solid) indicate the linewidth of the SPDC photon source is 2.5 MHz. In Figure (c), by assuming the signal/idler anti-correlation is thermal behavior, i.e. $g^{(2)}(0)=2$, the violation of Cauchy-Schwarz inequality shows the quantumness of the SPDC biphoton source.

**Future works**

- Although the violation of C.-S. inequality has shown the quantumness of our photon source, the value of $g^{(2)}(0)$ still has space for improvement, by reducing the non-correlated noise generated from the SPDC source or optimizing the biphoton generation rate at the low pump power operation, since, according to Figure (c), the non-correlated noise appears to increase with pump power.
- The insulation measure against the environmental light is under constructing.
- Test and study the interaction between SPDC photons and high-optical-density Cs cloud.

**Reference**