### Entangled Two Photon Absorption (ETPA)

#### MOTIVATION
- Light to measure and stimulate biological systems.
- Two-Photon induced phenomena.
- Significantly increased cross section and S/N.
- Lower photon flux: reduction photobleaching effects.
- Effects of quantum correlated photons in spectroscopy.
- Rate of Two Photon Absorption (TPA).

\[
\sigma_{TPA} = \sigma_E \varphi + \delta \varphi^2
\]

where 
- \(\sigma_E\) is the entangled two photon cross section
- \(\varphi\) is the ordinary TPA cross section
- \(\delta\) is the TPA nonlinear coefficient

\[
\sigma_E = \sigma_E(T_E, A_E, \mu_g, \mu_f, \Delta E_{gf}, \Delta)
\]

#### Experimental Setup
- **Pump Light Source**
  - Commercial laser diode
  - (Sanyo DL-5146-101S)
  - 40 mW CW @ 411 nm
  - Tunable over >10nm
  - Multimode

- **Photon pair generation**
  - Entangled photons through SPDC
  - BBO Crystal Type I
  - Colinear

- **Fluorescence Imaging**
  - Wavelength: 411.1164 nm
  - 852.1 nm
  - 539.5 nm
  - 411.1164 nm
  - 455.5 nm
  - 459.3 nm
  - 852.1 nm
  - 894.3 nm

#### Conclusion and Perspectives Towards ETPA in Cs Atoms
- Set up and characterized a test bench for ETPA measurement through:
  - Total coincidence rate (SPCM)
  - Spectral correlations
  - And fluorescence detection (PMT)
- Fully characterized commercial laser diode in view of single mode emission at 411nm
- Obtained a high flux of entangled photons over >230 nm with a BBO type I Xtal
- Next steps:
  - Validate the detections systems with alternative molecules or crystals:
    - RH in Methanol
    - ZnTPP in Toluene
    - BBO type II
    - PPKTP

Towards an experimental demonstration of Entanglement-Induced Two-Photon Transparency

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**References**


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**Entangled Two Photon Absorption (ETPA)**

**Setup overview**

**ETPA Cs**

- TPA: 6S_{1/2} → 8S_{3/2} 411,11 nm
- Absorption linewidth < 5 MHz
- 14% of TPA fluorescence through 455 nm & 459 nm decay channels

Fluorescence imaging at 852 nm

**Photon pair generation**

- Entangled photons through SPDC
  - BBO Crystal Type I
  - Colinear

- Joint spectrum width >230 nm
  - extend over both 6P channels
  - ~200 coincidences/s/nm²

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**Conclusions and Perspectives Towards ETPA in Cs Atoms**

We have:

- Set up and characterized a test bench for ETPA measurement through:
  - Total coincidence rate (SPCM)
  - Spectral correlations
  - And fluorescence detection (PMT)
- Fully characterized commercial laser diode in view of single mode emission at 411nm
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Next steps:

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Towards an experimental demonstration of Entanglement-Induced Two-Photon Transparency