Upconversion DIAL for Remote Gas Sensing

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Introduction

❑ Upconversion Technology

The IR detection with high efficiency and low noise.

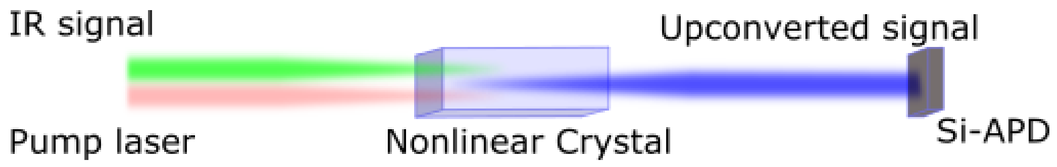

Figure 1. Upconversion module

❑ Differential Absorption Lidar (DIAL)

Laser based measurement of gas concentration at remote distances.

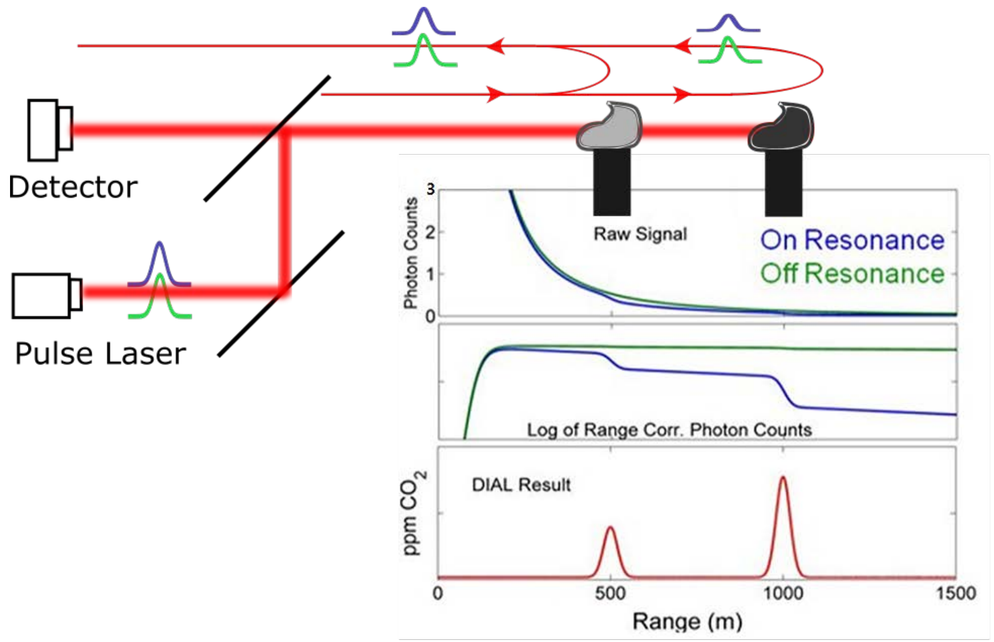

Figure 2. DIAL scheme

❑ Combination of the Two Technologies

Improving the SNR and the sensitivity of the DIAL system by the application of upconversion detection module.

Status

❑ Characterization of Upconversion Noise

Upconverted SPDC (USPDC) noise is the dominant noise source in the upconversion detection (UCD), especially when a periodic poled nonlinear crystal is applied. Before the investigation of the detection limit of the UCD, the physical mechanism of the USPDC noise generation should be studied.

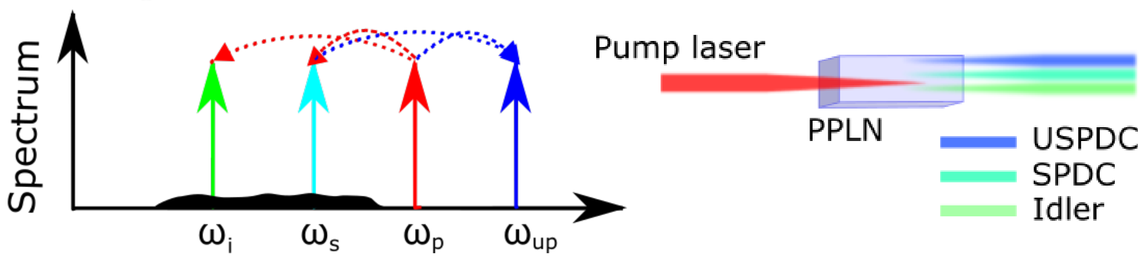

Figure 3 USPDC process

❑ Experiment of SPDC Measurement

Spontaneous Parametric Down-Conversion (SPDC) was investigated experimentally for non-collinear (left) and collinear (right) cases.

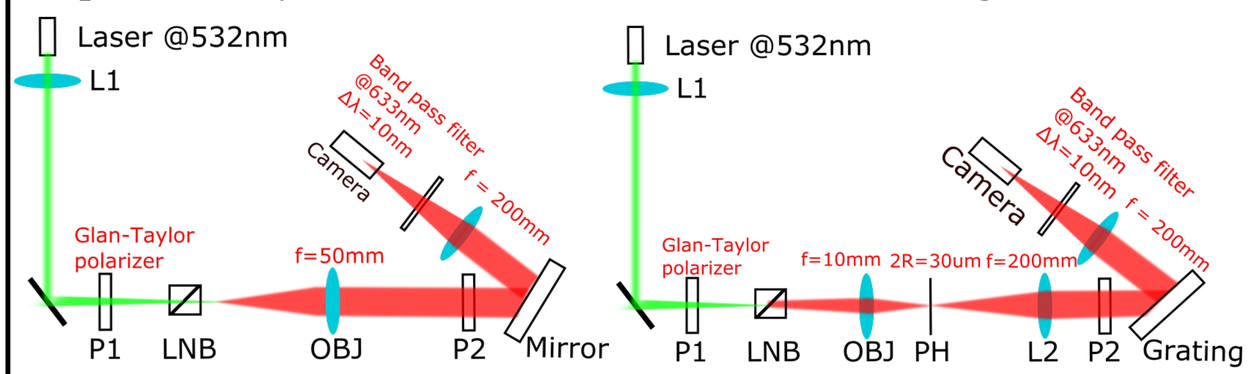

Figure 4 Experiment Schemes for the down conversion & SPDC measurement

A ring pattern was obtained for the non-collinear phase matching down conversion. The noise intensity of collinear SPDC was proportional to $sinc^2\left(\frac{\Delta kL}{2}\right)$ as shown in Fig. 5.

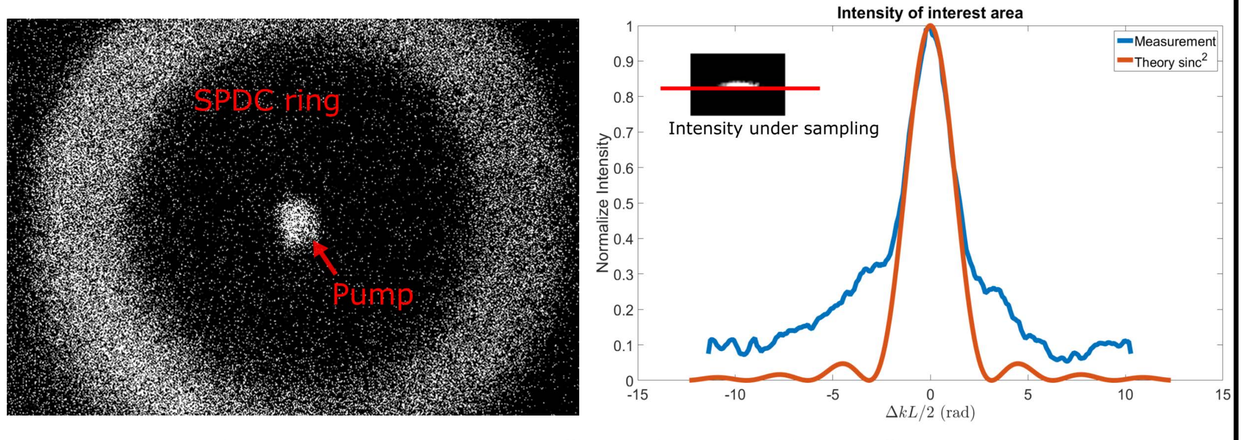

Figure 5 Ring pattern of non-collinear phase matching & collinear SPDC spectrum

❑ USPDC in Periodic Poled crystal

A physical model for the USPDC intensity calculation was developed.

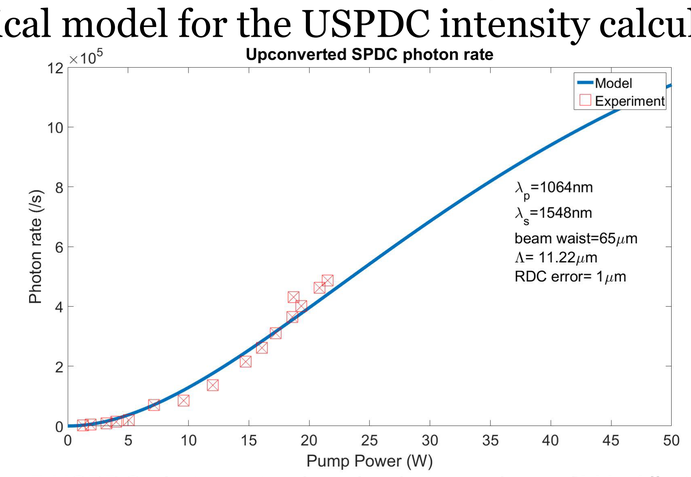

Figure 5 USPDC photon rate given by the experiment [*MA. Albota and NC. Wang, Opt. Lett. 29, 1449-1451 (2004)*] and the physical model

❑ Upconversion Module

An upconversion module for CH_4 measurement was built.

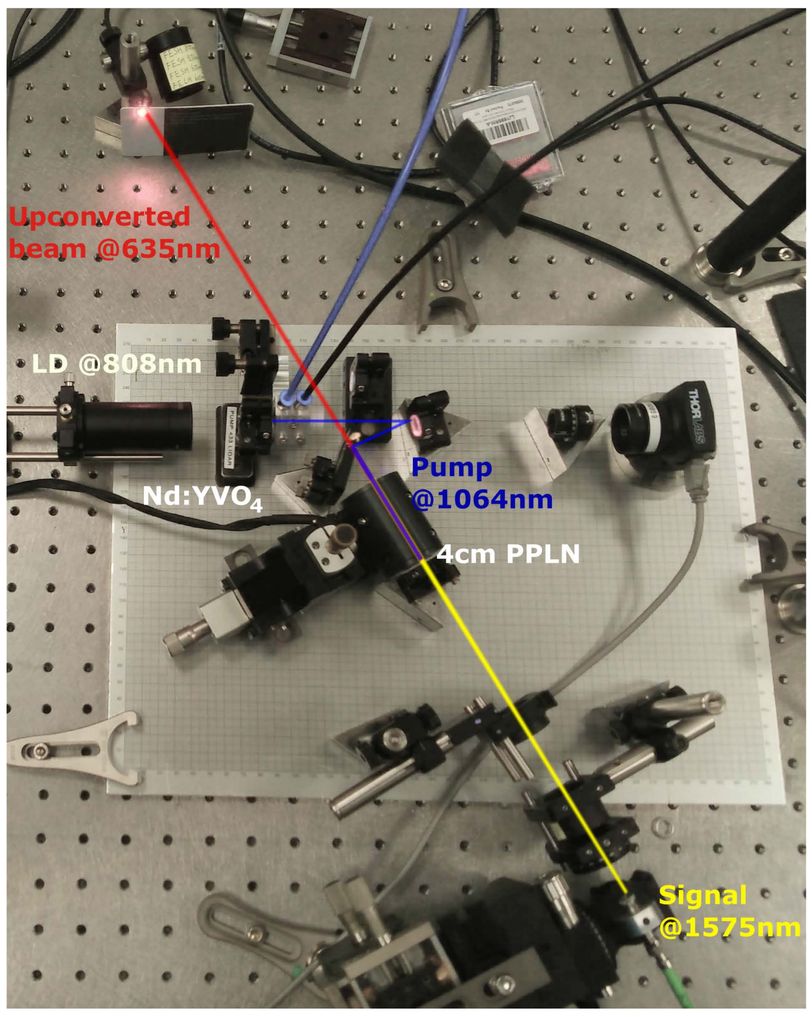

Figure 6 Upconversion module

The upconversion efficiency is 20~30%, the intracavity power can go up to 60 W. The setup needs further optimization. A portable module will be developed.

Secondments

❑ DLR

- First visit (April 2017, 1 week)
  Learning both the working principle and structure details about the DIAL system in DLR.
  Preparation for the experiment in the second visit.
- Second visit (May 2017, 1 month)
  Installing the upconversion module to the DIAL system.
  Characterization of the whole system/CH4 measurements.

❑ ICFO/RADI(Feb 2018, 1 month)

Learning the working principle of OPO system as DIAL sources for other gas species measurement.

Publications

❑ Accepted poster presentation

"Theoretical investigation of the upconverted SPDC noise in the upconversion detection", poster presentation at DOPS Annual Conference 2016, Nov 24th, Denmark.

❑ Planned publications

"USPDC noise in the upconversion process".
"Upconversion DIAL system for CH4 measurement".

ECTS credits obtained (25/30)

Mid-IR science and technology, 5 ECTS, Feb, 2016
Entrepreneurship in mid-IR technologies, 5 ECTS, Aug, 2016
Noise in electromagnetic and optical systems, 5 ECTS, 2016
Numerical method in photonics. 5 ECTS, 2016.
Progress: Advanced photonic devices journal club, 5 ECTS.
Planned: Leadership development for tomorrow's mid-IR technologies and applications, 2017