Molecular Spectroscopy with kHz Accuracy in the Mid-Infrared

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Introduction

Precision spectroscopy of molecules in the mid-infrared region where the fundamental bands are located is of great interest in fundamental physics. Mid-infrared lasers with narrow linewidth and long-term stability are needed. In this presentation we report a new method to reduce the linewidth of a continuous-wave optical parametric oscillator (OPO) by locking the near-infrared pump and signal lights to an optical frequency comb, which also results in a long-term stability of the mid-infrared idler laser. Combined with high sensitive multi-pass cell or cavity-enhanced absorption technique, it allows to measure weak transitions of molecules with an accuracy of a few kHz.

Experimental Setup

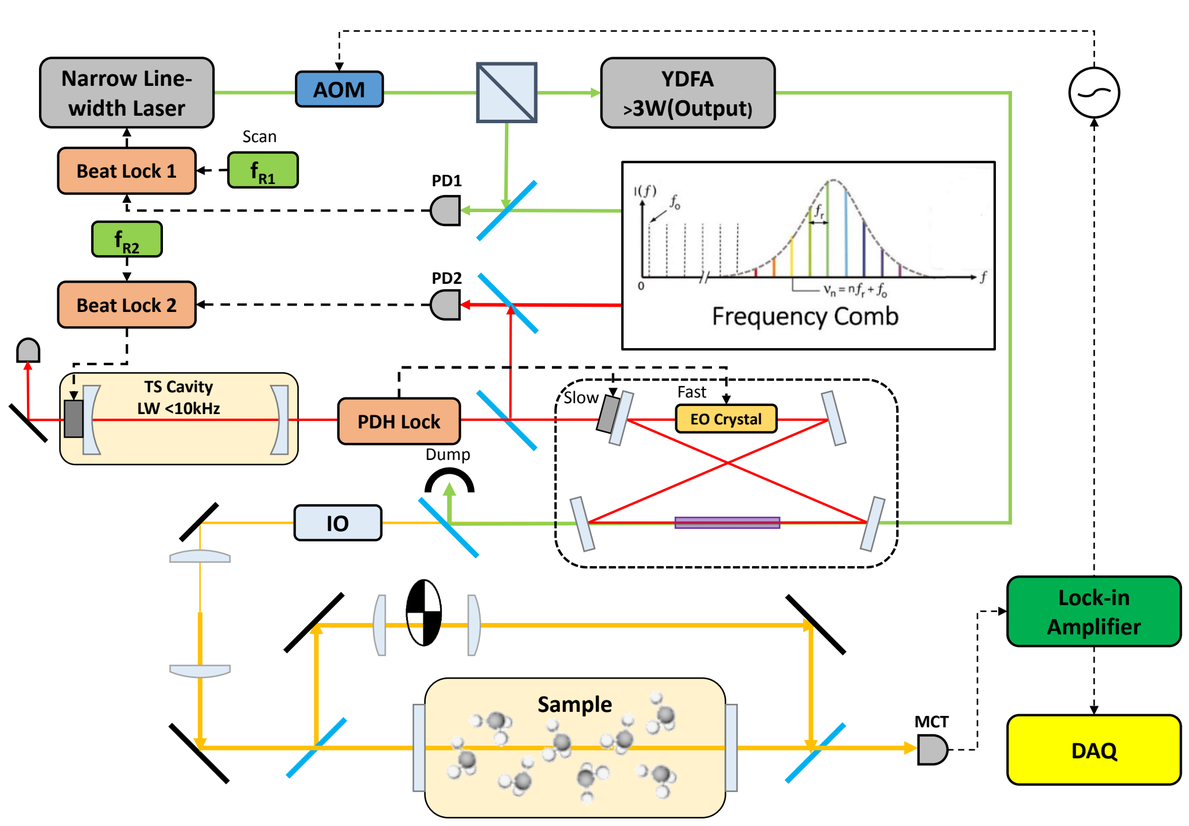

Fig 1. Narrow linewidth OPO and FMS optical Layout

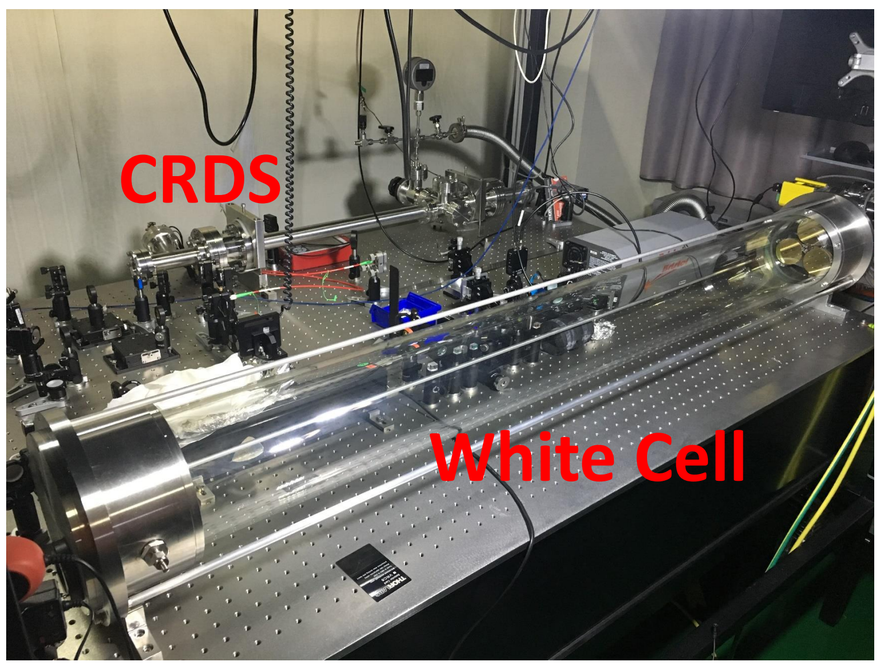

Fig 2. CRDS and White Cell

Laser Performance

Signal Laser @ 1566nm

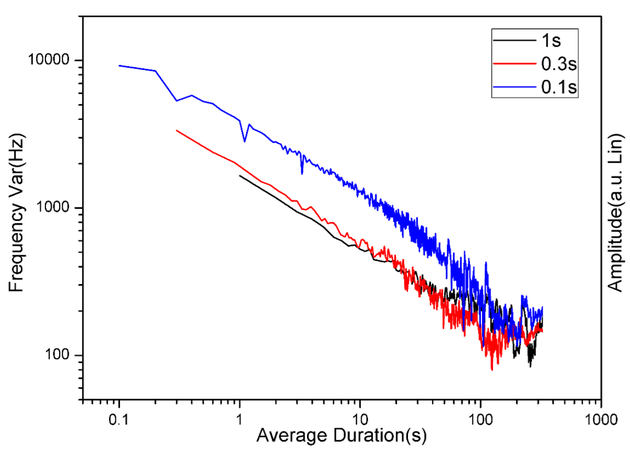

Fig 3. Laser Long-term Stability

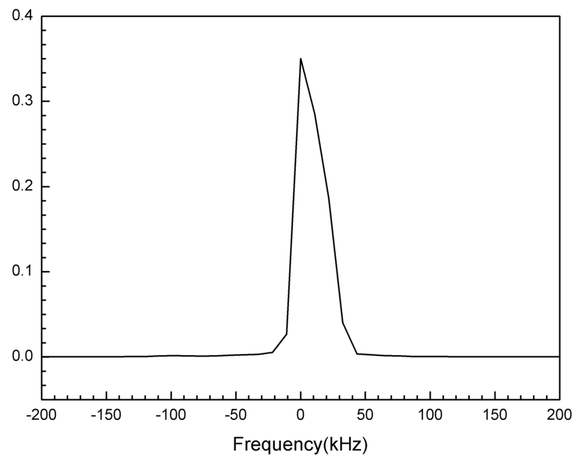

Fig 4. Laser Linewidth (10ms)

Current results & Expectancy

CH_4 Demonstration (Before Laser Lock)

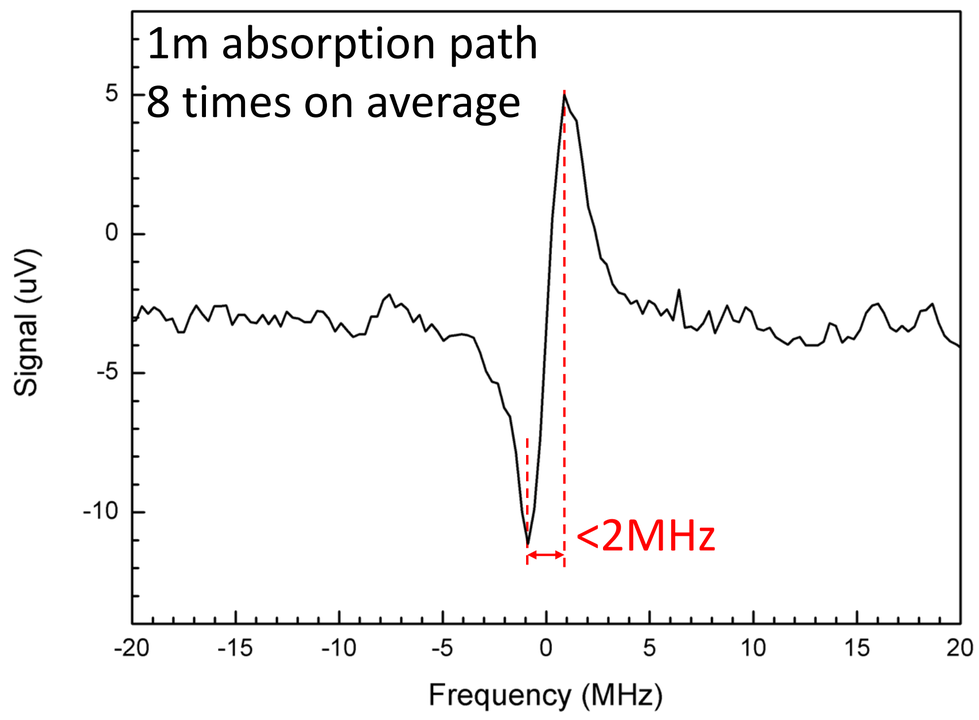

Fig 5. CH_4 @3017.71 cm^{-1}

CH_4 Demonstration (After Laser Lock)

With a narrower linewidth mid-infrared laser, we can improve the spectral resolution to a few tens of kHz.

Table 1. Spectral Linewidth of CH_4@3017.71cm^{-1}

Linewidth	Before Laser Lock	After Laser Lock
Pressure Broadening	148kHz(3.2Pa)	9.2kHz(0.2Pa)
Transit-time Broadening	69kHz(6mm)	41kHz(10mm)
Saturation Broadening	~(1.5)	~(0.27)
Total Linewidth	345kHz	57kHz

References

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