

## 光コムによる高精度中赤外分子分光

## High-accuracy mid-infrared molecular spectroscopy using optical combs

## Objectives

光コムの登場により可視領域、近赤外領域の分光測定を飛躍的に高めることが可能になった。我々は、近赤外光と差周波法で中赤外光を発生し、これを光源として分子の振動回転遷移のサブドップラー分解能スペクトルを観測して、さらにその遷移周波数を近赤外領域のファイバークムを用いて精密測定することを目指す。さらに広い波長域で多くの分子について光コムによる精密分光を展開していく。

The advent of optical combs has remarkably enhanced the accuracy of frequency measurements in the visible and near-infrared regions. We are developing a sub-Doppler resolution mid-infrared molecular spectrometer using difference frequency generation (DFG) of near-infrared light and a near-infrared fiber comb for precise frequency measurements of the DFG frequency. We are also aiming to extend the wavelength region and to apply these precise measurement techniques to various molecular species.

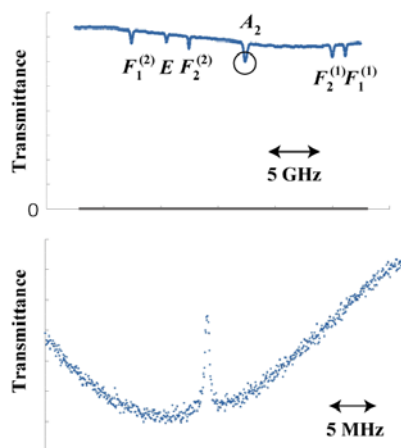


Fig. 1: Doppler-limited resolution spectrum (upper trace) of the P(7) transition of methane and sub-Doppler resolution spectrum (lower trace) of the  $A_2$  component.

## Achievements

- 差周波法で波長  $3.4 \mu\text{m}$  の中赤外光を発生し、これを光源にしてメタンの振動回転遷移で線幅  $400 \text{ kHz}$  の飽和吸収スペクトルを観測した。
- 観測された飽和吸収スペクトルに光源の周波数を安定化し、その周波数をファイバークムで精密測定した。
- 12本のメタンの遷移周波数を不確かさ約  $8 \text{ kHz}$  (相対不確かさ  $9 \times 10^{-11}$ ) で決定した。

- DFG provides  $3.4 \mu\text{m}$  mid-infrared light, which allows us to observe saturated absorption lines of rotation-vibration transitions of methane with a spectral resolution of  $400 \text{ kHz}$ .
- The source frequency is stabilized to the saturated absorption lines and measured using a fiber comb.
- The absolute frequencies of 12 methane lines were determined with an uncertainty of  $8 \text{ kHz}$  (relative uncertainty of  $9 \times 10^{-11}$ ).

Table I. Measured frequencies of the  $\nu_3$  band of  $^{12}\text{CH}_4$

Transition	Frequency / kHz	Standard Deviation / kHz
$F_1^{(2)}$	88 368 863 353.9	9.4
$E$	88 373 149 015.7	40.1
P(7) $F_2^{(2)}$	88 376 181 601.7	8.4
$A_2$	88 382 052 724.0	5.9
$F_2^{(1)}$	88 391 450 564.4	8.7
$F_1^{(1)}$	88 393 030 001.9	11.9
$A_1$	88 679 126 631.3	4.0
$F_1$	88 682 207 769.3	8.6
P(6) $F_2^{(2)}$	88 685 592 321.5	7.1
$A_2$	88 694 688 778.6	8.8
$F_2^{(1)}$	88 698 120 466.4	7.7
$E$	88 699 071 286.0	11.9

## References

- 1) K. Takahata, T. Kobayashi, H. Sasada, Y. Nakajima, H. Inaba, and F-L. Hong, "Absolute frequency measurement of sub-Doppler molecular lines using a  $3.4\text{-}\mu\text{m}$  difference-frequency-generation spectrometer and a fiber-based frequency comb," *Phys. Rev. A* **80**, 032518 (2009).
- 2) M. Abe, K. Takahata, and H. Sasada, *Opt. Lett.* **34**, 1744 (2009).