Detection of Methane Isotopologues – cw-OPO vs. DFB Diode Laser –

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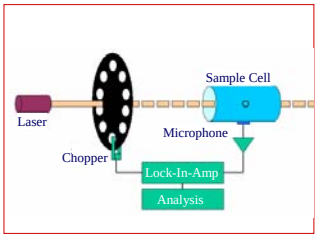
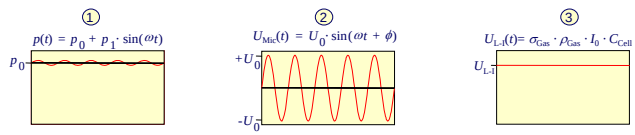
Photoacoustic analyzer

Photoacoustic spectroscopy

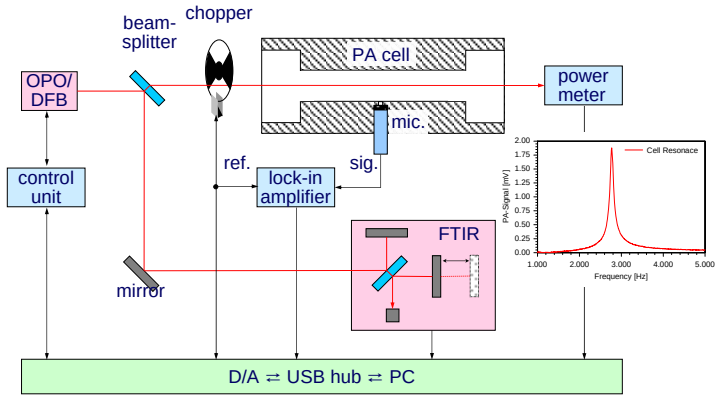


Photoacoustic effect

- **Absorption of electromagnetic radiation**
  - ⇒ $E_{rot/vib} \rightarrow E_{kin}$ (if $\tau_{Lifetime\ exc.\ State} > \tau_{Collision}$)
  - ⇒ Temperature increase
  - ⇒ Gas expansion
  - ⇒ Pressure increase
- **Absorption of modulated radiation**
  - ⇒ Pressure modulation ①
  - ⇒ Detection by microphone ②
  - ⇒ Lock-In-Amplification ③

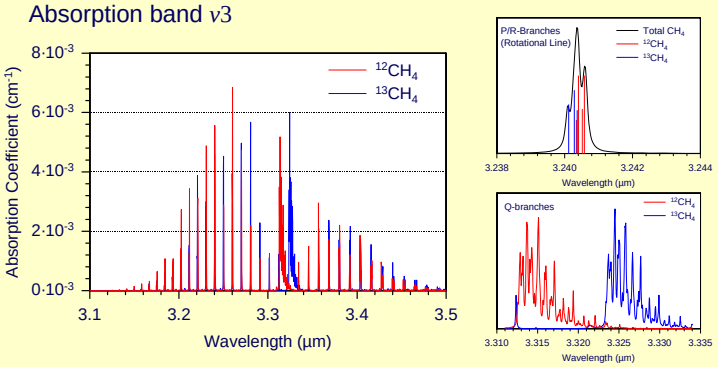


Experimental set-up



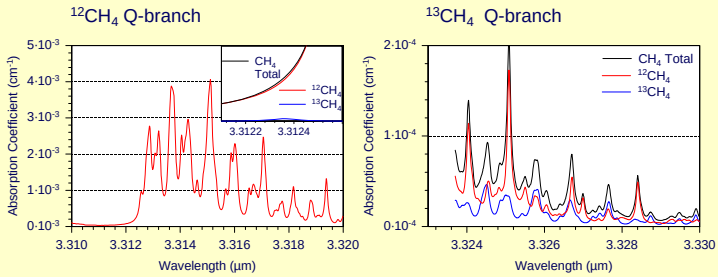
Methane absorption

Absorption band *v*3



- $^{12}CH_4$ and $^{13}CH_4$ each 100 ppm in N_2, 296 K, 1013 hPa
- L.S. Rothman et al., J. Quant. Spectrosc. Radiat. Transfer, 110, 533-572 (2009)

Main Isotopologues

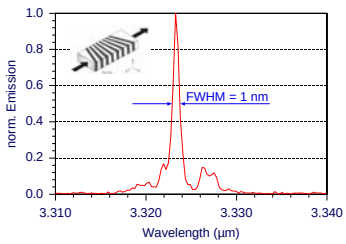


- CH_4 100 ppm in N_2, 296 K, 1013 hPa
- Natural abundance*: $^{12}CH_4$: 98.8 % ; $^{13}CH_4$: 1.1 %

* Considerably depending on origin and evolution of specific sample.

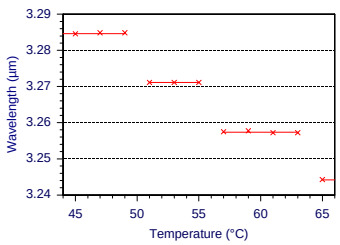
Optical-parametric oscillator

Spectral Emission: Idler wave



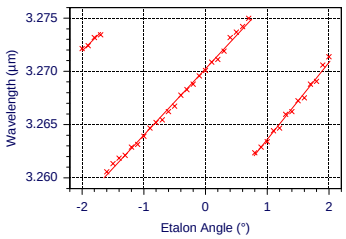
- Tuning range: 700 nm (3.2 - 3.9 µm)
- Spectral linewidth: 1 nm
- Max. output power: 1.0 W @ 3.2 µm
  0.4 W @ 3.9 µm

Wavelength vs. crystal temp.



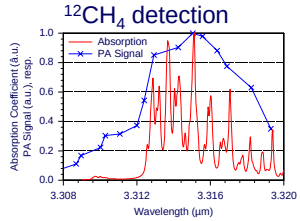
- Tuning range: 40 nm
- 2 nm / °C ; 45°C – 65°C
- With etalon: Δλ: 13 nm

Wavelength vs. etalon angle

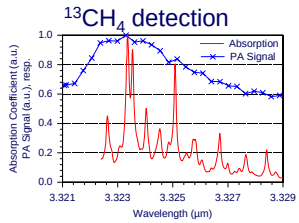


- Tuning range: 16 nm
- 4 nm / ° ; [-2°] – 2°
- Resolution: 0.5 nm

$^{12}CH_4$ detection

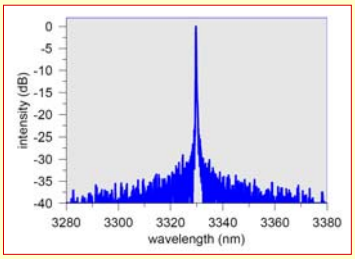


$^{13}CH_4$ detection



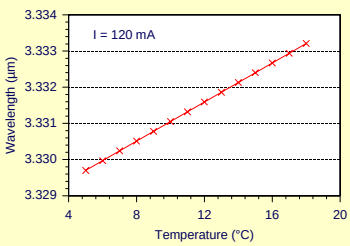
DFB diode laser

Spectral emission



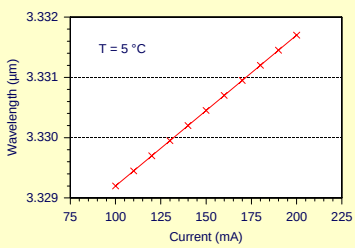
- Tuning range: 6 nm (3.329 – 3.335 µm)
- Spectral linewidth: ca. 3 MHz (0.1 pm)
- Max. output power: 2.5 mW
- Single frequency: SMSR > 35 dB

Wavelength vs. temperature



- Tuning range: 3.5 nm
- 0.27 nm / °C
- 5 – 18 °C

Wavelength vs. current



- Tuning range: 2.5 nm
- 0.025 nm / mA
- 77 – 200 mA (above threshold)

$^{12}CH_4$ / $^{13}CH_4$ detection