RICE

QC Laser-Based Sensor for $^{13}CO_2/^{12}CO_2$ Isotopic Ratio Measurements

Preliminary studies

D.Weidmann, C.Roller, K.Uehara and F.K. Tittel

Rice University
Houston, TX

PSI/RICE Workshop June 6, 2003 Boston, MA

- Research motivation
- Previous DFG sensor experiment
- Laser characteristics
- Line strategy
- Calculated spectra

Motivation for high precision δ value measurements

$$\delta^{13}C=\{[^{13}C/^{12}C]_{sample}/\,[^{13}C/^{12}C]_{std}-1\}\cdot 1000\ (^{0}/_{00})$$

Required precision $\leq 0.1\ ^{0}/_{00}$

- Atmospheric Chemistry
- Volcanic gas emission studies
- Combustion diagnostics
- Non invasive medical diagnostics
- Plant Biology

Criteria for CO_2 absorption line selection

- Line Strength
- Temperature stability $\Delta T = \frac{\Delta\delta\, kT^2}{1000\Delta E}$
- Interference effects by other atmospheric gases
- $^{12}CO_2$ and $^{13}CO_2$ absorption lines in same wavelength scan range

$^{12}CO_2$ & $^{13}CO_2$ absorption line selection

Erdelyi et al. and NCAR biocomplexity line selection

	Frequency (cm-1)	Intensity $cm^{-1}/molec.cm^{-2}$	Lower State Energy (cm^{-1})	
$^{12}CO2$	2299.642	2.093E-20	1339	$\Delta T = 6mK$
$^{13}CO2$	2299.795	3.10E-20	197	

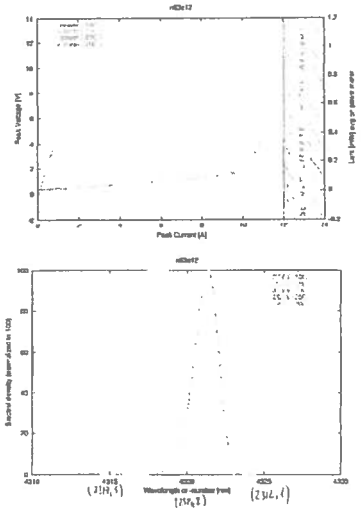
Alpes Laser line selection

$^{12}CO2$	2314.304	9.15E-20	942	$\Delta T = 250mK$
$^{13}CO2$	2314.408	1.99E-21	917	
$^{12}CO2$	2315.281	9.73E-20	921	$\Delta T = 90mK$
$^{13}CO2$	2315.360	1.43E-21	994	

Interesting absorption line selection

$^{12}CO2$	2311.1	1E-19	704	$\Delta T \rightarrow \infty$
$^{13}CO2$	2311.4	5E-21	704	

Alpes 4.3 μm QCL characteristics – April 2003



High threshold current

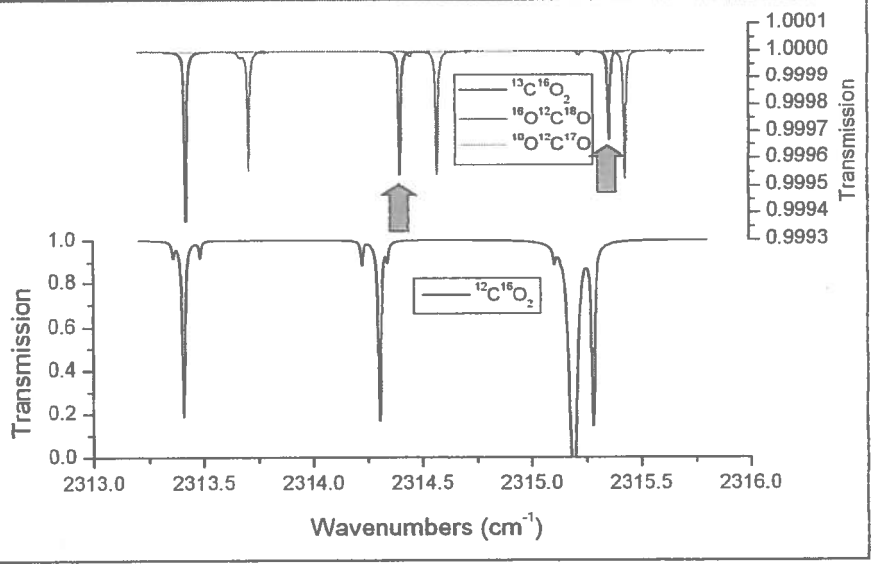
⇩

High thermal dissipation

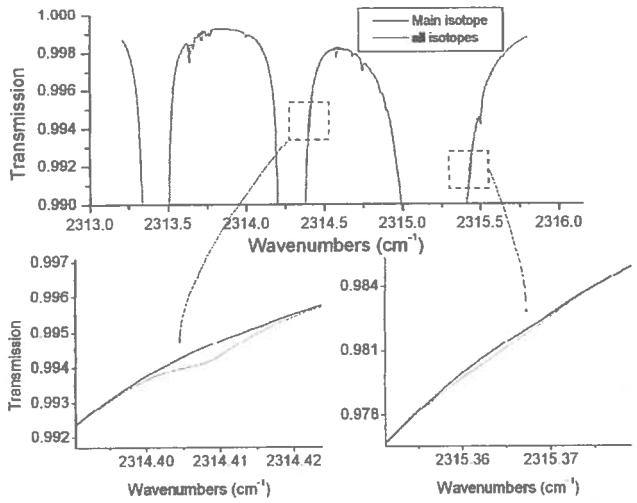
Frequency tuning range at
–20 and –10 °C:
2313.5 - 2316.15 cm^{-1}

Issue:
Unknown spectral characteristics

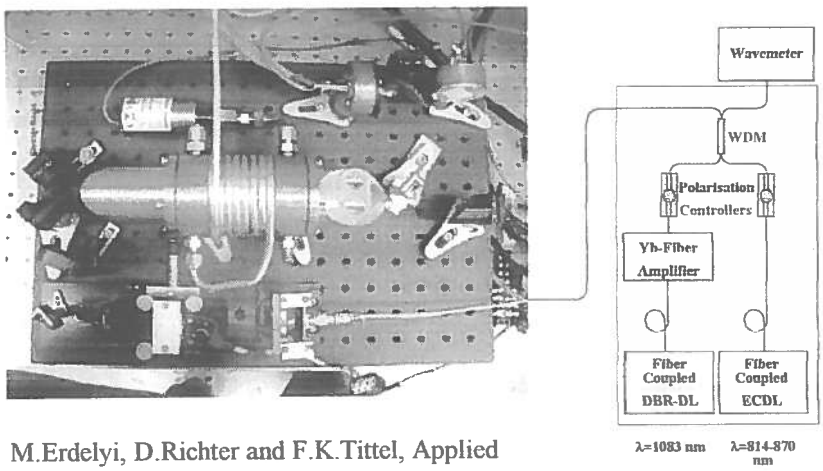
Simulated HITRAN spectra



Simulated HITRAN spectra



DFG based CO_2 Isotopic Ratio Sensor Platform-2000-2001



M.Erdelyi, D.Richter and F.K.Tittel, Applied Physics B, 75, 289-295, October 2002

Proposed QCL based CO_2 Isotopic Ratio Sensor Platform