ВЛИЯНИЕ ТОЧНОСТИ СПЕКТРОСКОПИЧЕСКОЙ ИНФОРМАЦИИ В ЗАДАЧАХ МОНИТОРИНГА МЕТАНА

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INFLUENCE OF THE SPECTROSCOPIC INFORMATION ACCURACY IN TASKS OF THE METHANE MONITORING

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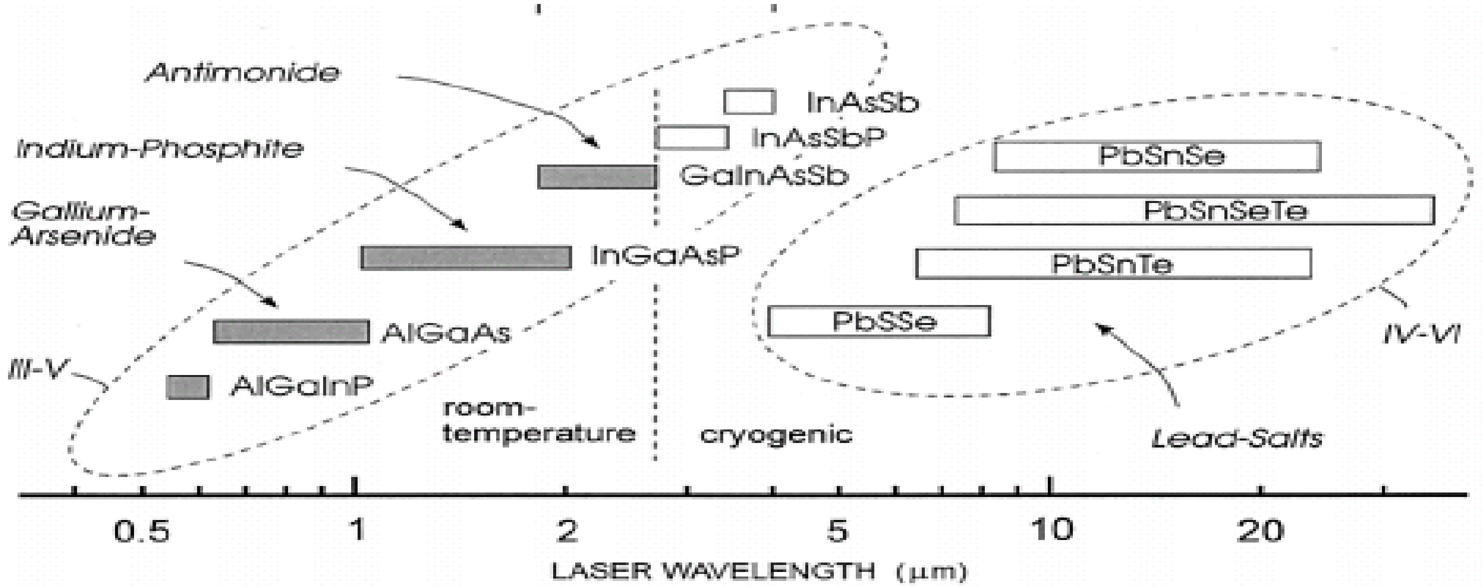
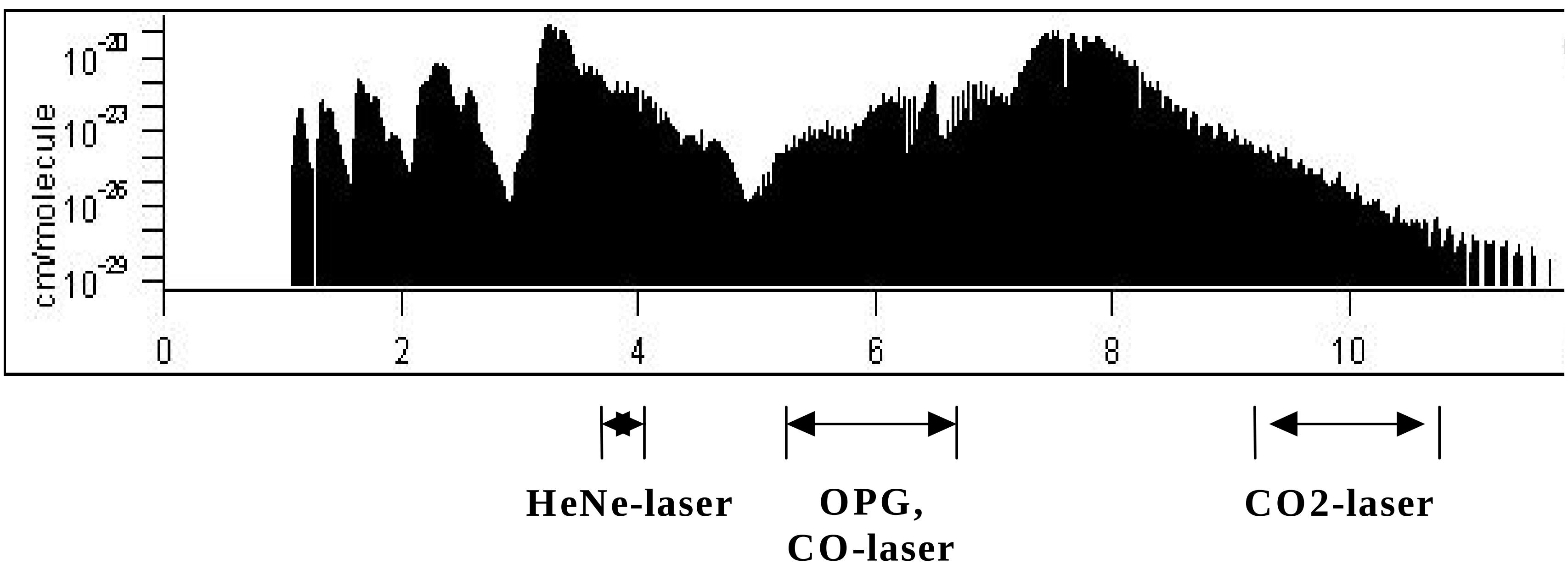
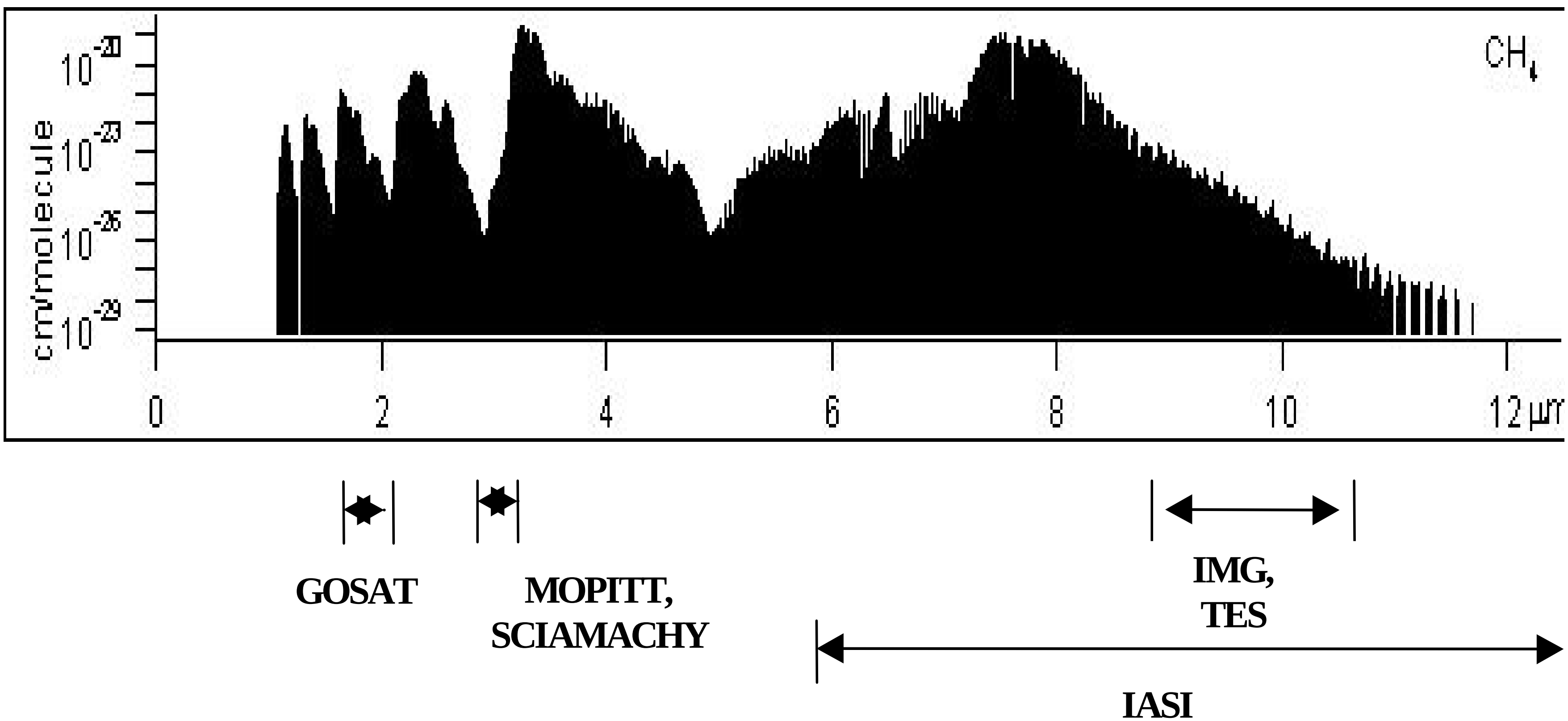
Methane CH_4 is an important trace component in the atmosphere, because of its contribution to global warming as well as its role in complex feedback mechanisms in tropospheric and stratospheric chemistry. Spectroscopic knowledge of the methane spectrum is required for numerous remote sensing applications. Astronomical objects with detectable methane abundances typically include planets, moons and comets in our solar system. The remote control of methane the required absolute high accuracies of the line parameters (0.0001 cm^{-1} for positions, 1-2% for intensities and broadening). But in modern stage of spectroscopy observations can be taken with better signal to noise and high resolution not all spectral bands. Also the theoretical models are dificult to implement and the spectrum is challenging to interpret, the database for methane has envolved as a mixture of theoretical predictions for the longer wavelengths and incomplete empirical results for the currently intractable regions.

ACTIVE SENSORS FOR METHANE DETECTION





PASSIVE SENSORS FOR METHANE DETECTION



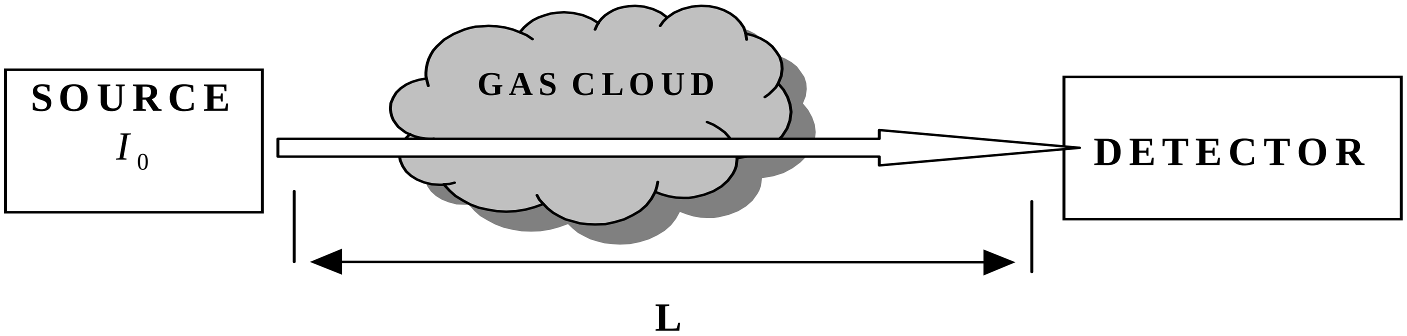
HIGH SPECTRAL RESOLUTION SENSOR: **IMG, TES, SCIAMACHY, GOSAT, IASI**

BROADBAND RESOLUTION SENSOR: **MOPITT**

SPACE-BORNE INSTRUMENTS FOR METHANE DETECTION

Satellite	Device	Method	Profile (P), Total content (TC)	Altitude range, km
SHUTTLE	CIRRIS	Limb	**P**	10-80
UARS	CLAES	Limb	P	10-50
UARS	HALOE	Occultation	P	10-50
EOS-CHEM	HIRDLS	Limb	P	10-50
AQUA	***MOPITT***	Nadir	TC	-
METOP-1,-2, ESA	IASI	Limb	P	1-30
ADEOS	ILAS	Limb	P	10-60
ADEOS-II	ILAS-2	Limb	P	10-60
ADEOS	IMG	Nadir	TC / P	10-50
UARS	ISAMS	Limb	P	10-80
ENVISAT-1, ESA	MIPAS	Limb	P	5-50
ENVISAT-1, ESA	***SCIAMACHY***	Occultation, Limb, Nadir	P / TC	5-70
EOS-AM 2-3	***TES***	Nadir, Limb	P / TC	10-60
Spacelab (ATLAS)	ATMOS	Occultation	P	25-60
EUMETSAT	IASI	Nadir	P / TC	1-15

Uniform optical atmospheric path (pressure P, temperature T ~ const)



$$I(\nu) = I_o(\nu)\exp\left\{- L \cdot \sum_{i=1}^{Ng} K_i(\nu) x_i\right\} \tag{1}$$

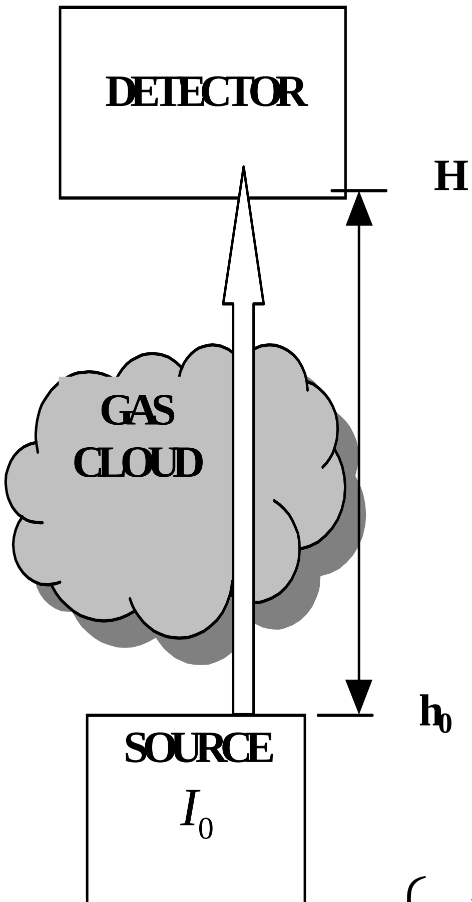
where L is the path length, x is the concentration, Ng is the number of gases in air and K is the absorption coefficient.

Absorption coefficients depends on spectroscopic absorption line parameters (S, α, ν_o):

$$K(\nu) = \frac{1}{\pi}\sum_{j=1}^{N_l} S_j(T)\alpha_j(T,P) / \left[(\nu - \nu_{oj})^2 + \alpha_j^2(T,P)\right]$$

here S is the intensity of absorption line, α is the halfwidth and ν_o is the center of line.

Not uniform optical atmospheric path (P, T $\neq$ const)



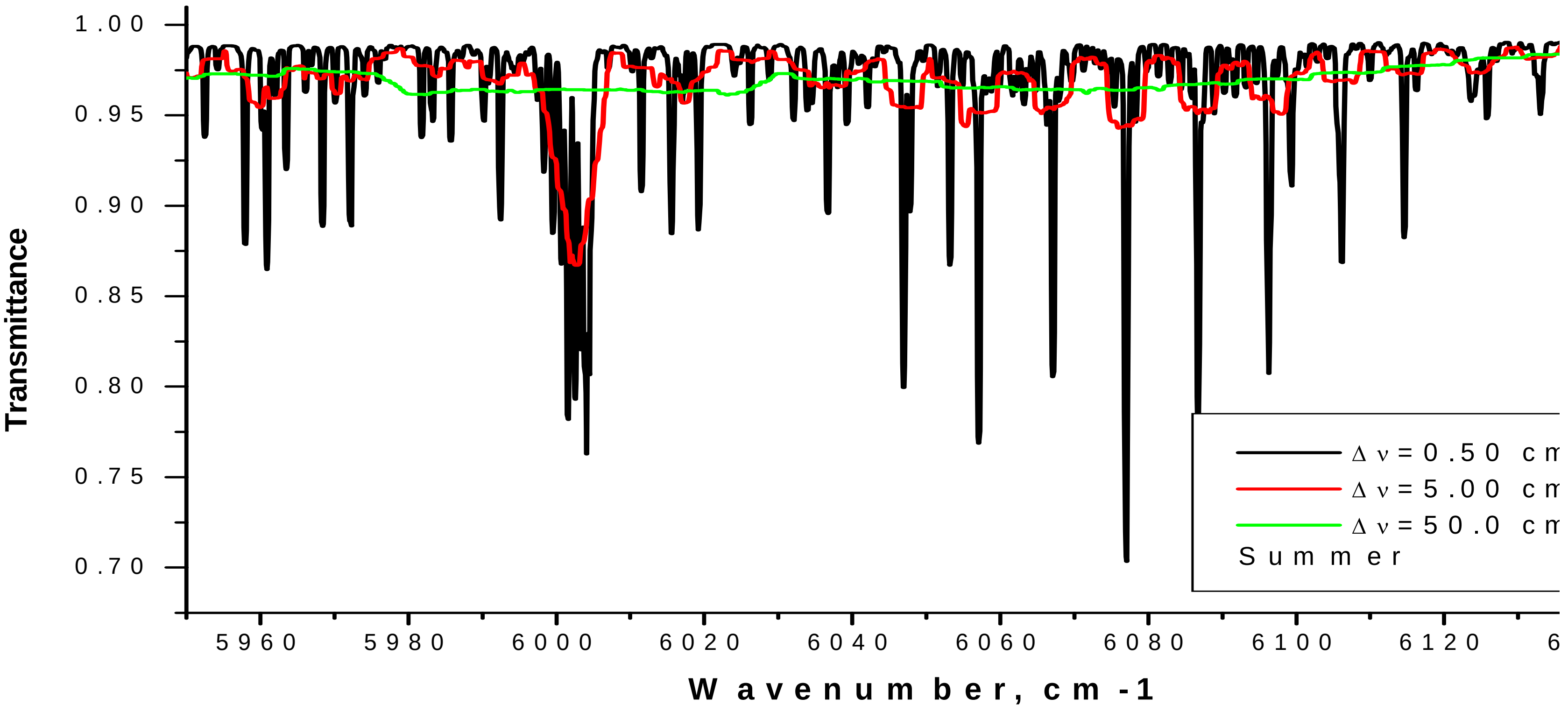
$$I(\nu) = I_o(\nu)\exp\left\{-\int_{h_0}^{H}\left(\sum_{i=1}^{Ng} K_i(\nu, h(P,T))\, x_i\right) dh\right\} = I_o(\nu)\, t(P,T)$$

where H, h_0 are the low and high altitude and t is the transmittance.

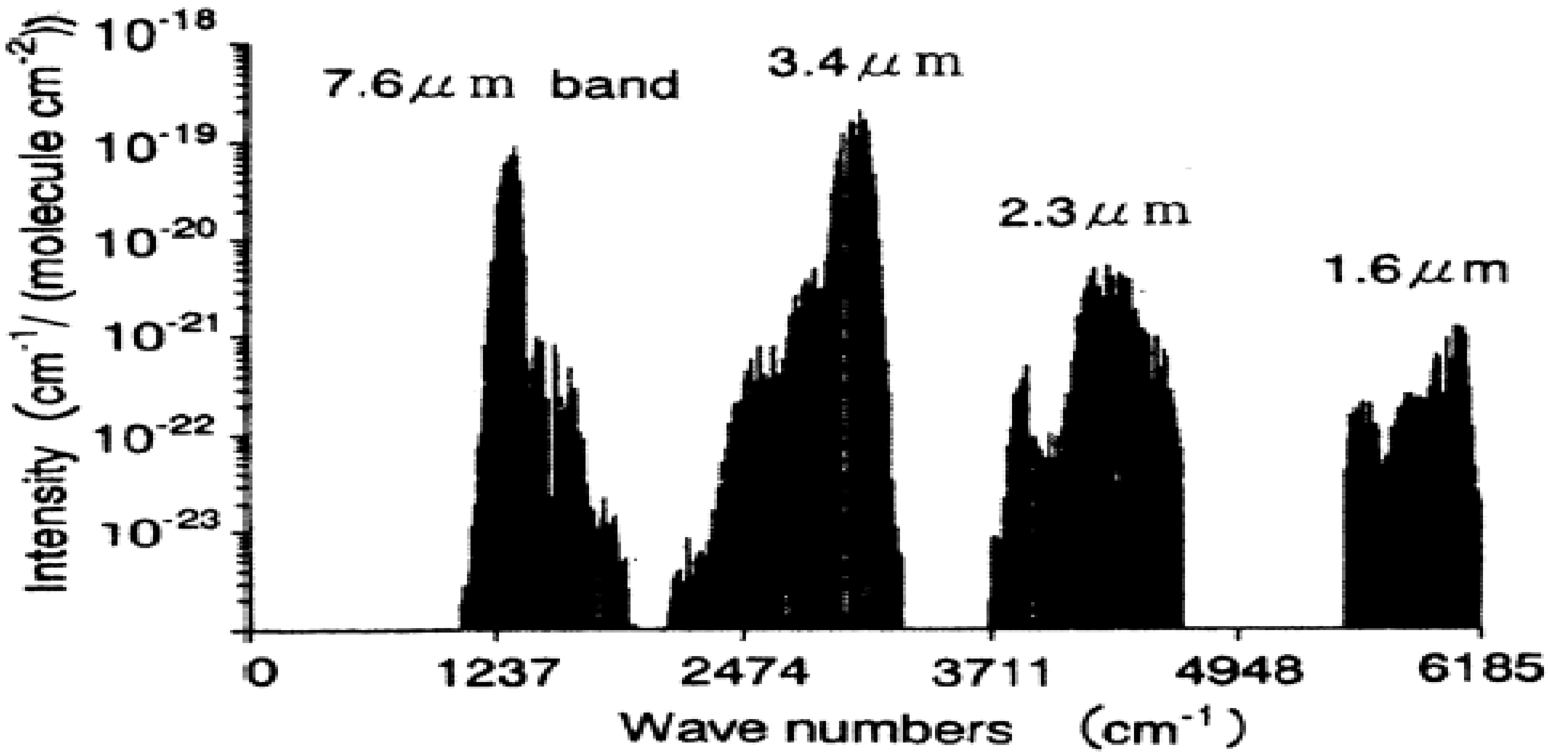
Measured spectral radiance (transmittance) it is connected with true radiance and slit function ***A()*** of the device by a ratio:

$$\widehat{I}(\nu) = \int_{\Delta\nu} A(\nu - \nu')I(\nu')d\nu' \qquad (3)$$

Equations (1-2) represent a monochromatic kind of radiation, and (3) represent the convolution of the true radiation with the slit function of device.



INFORMATION ABOUT METHANE SPECTROSCOPIC DATA S DATA BASE *HITRAN 2004*



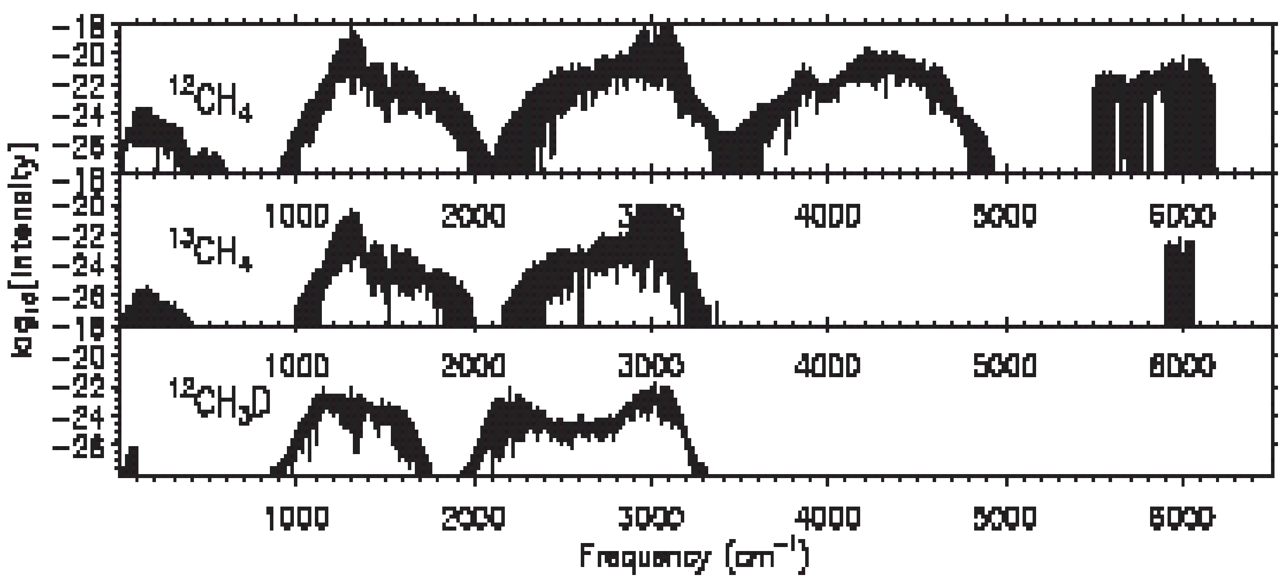
Isotopic abundance used for HITRAN

Molecule	Isotope	Abundance
CH4	12CH4	0.98827
	13CH4	0.01110
	12CH3D	0.00061

Comparison of 2001 and prior HITRAN methane parameters[a]

Polyad	# of Isotopes	# of Bands	Range $(cm)^{-1}$	2001 Update		1992–2000 HITRAN	
				Σ Intensity	# Lines	Σ Intensity	# Lines
Rotational	3	8	0–578	5.11×10^{-23}	8681	5.11×10^{-23}	8681
Dyad	3	27	855–2078	5.25×10^{-18}	65,478	5.30×10^{-18}	21,906
Pentad	3	34	1929–3476	1.14×10^{-17}	77,345	1.14×10^{-17}	10,184
Octad	1	9	3370–4810	9.09×10^{-19}	57,332	8.59×10^{-19}	4632
Tetradecad	2	4	4800–6185	1.22×10^{-19}	2632	1.22×10^{-19}	2632

[a] Σ Intensity values are in units of $cm^{-1}/(molecule\ cm^{-2})$ at 296 K.



SPECTROSCOPIC ANALYSIS OF THE MAIN ISOTOPE 12CH4 ABSORPTION BAND

DYAD	PENTAD	OKTAD	TETRADECAD
1200-1600 см-1	2200-3250 см-1	3500-4800 см-1	5200-6700см-1
10-4	2*10-3 (4*10-4)	4*10-2 (5*10-3)	-
3%	3% (2%)	15% (5%)	-
			8*10+3 / 200

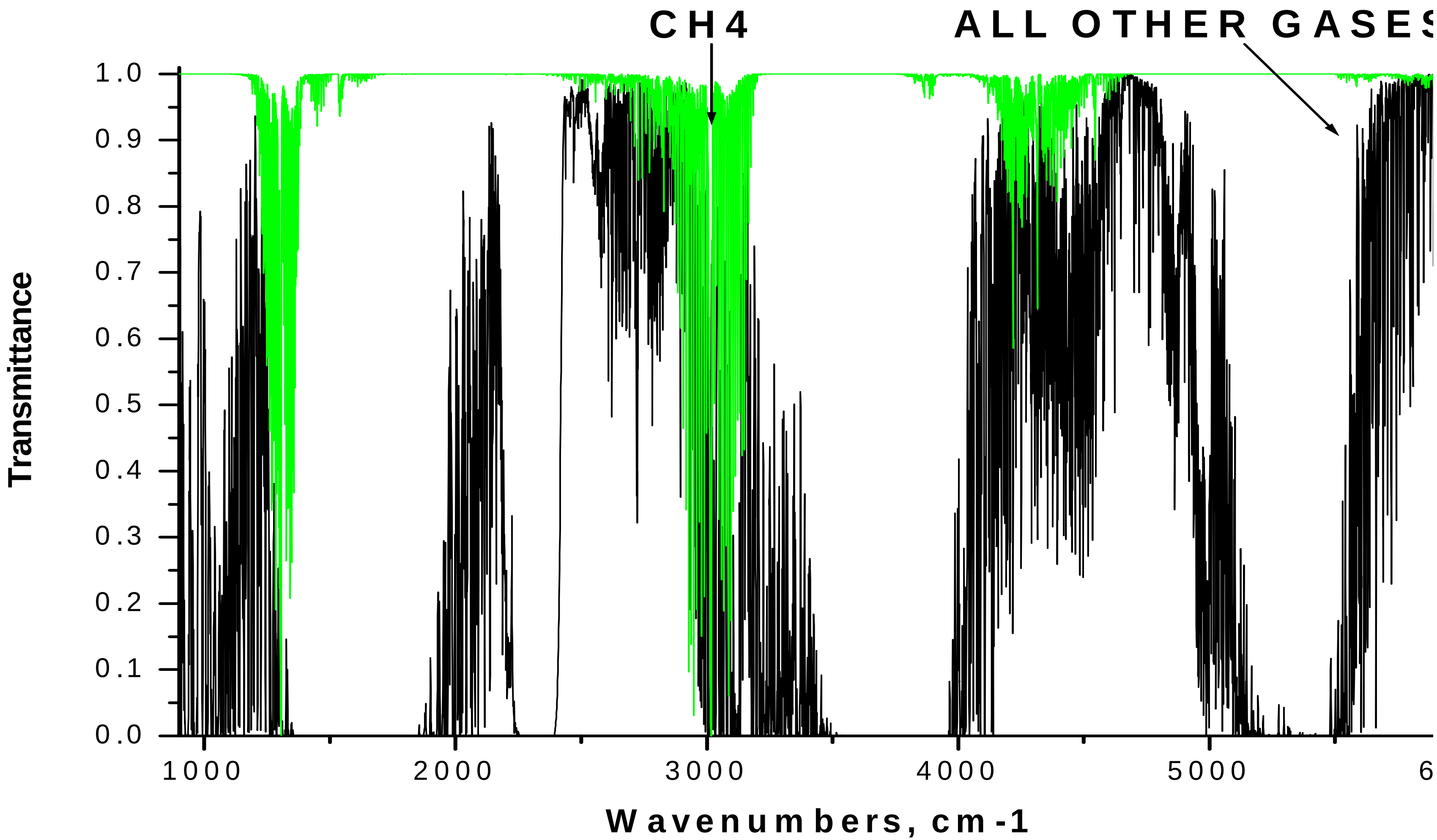
For isotope methane 13CH4 on this day present experiment data up to 5000 cm-1 and processing only up to PENTAD.

SPECTROSCOPIC ANALYSIS OF THE MAIN IZOTOPE 12CH3D ABSORPTION BAND

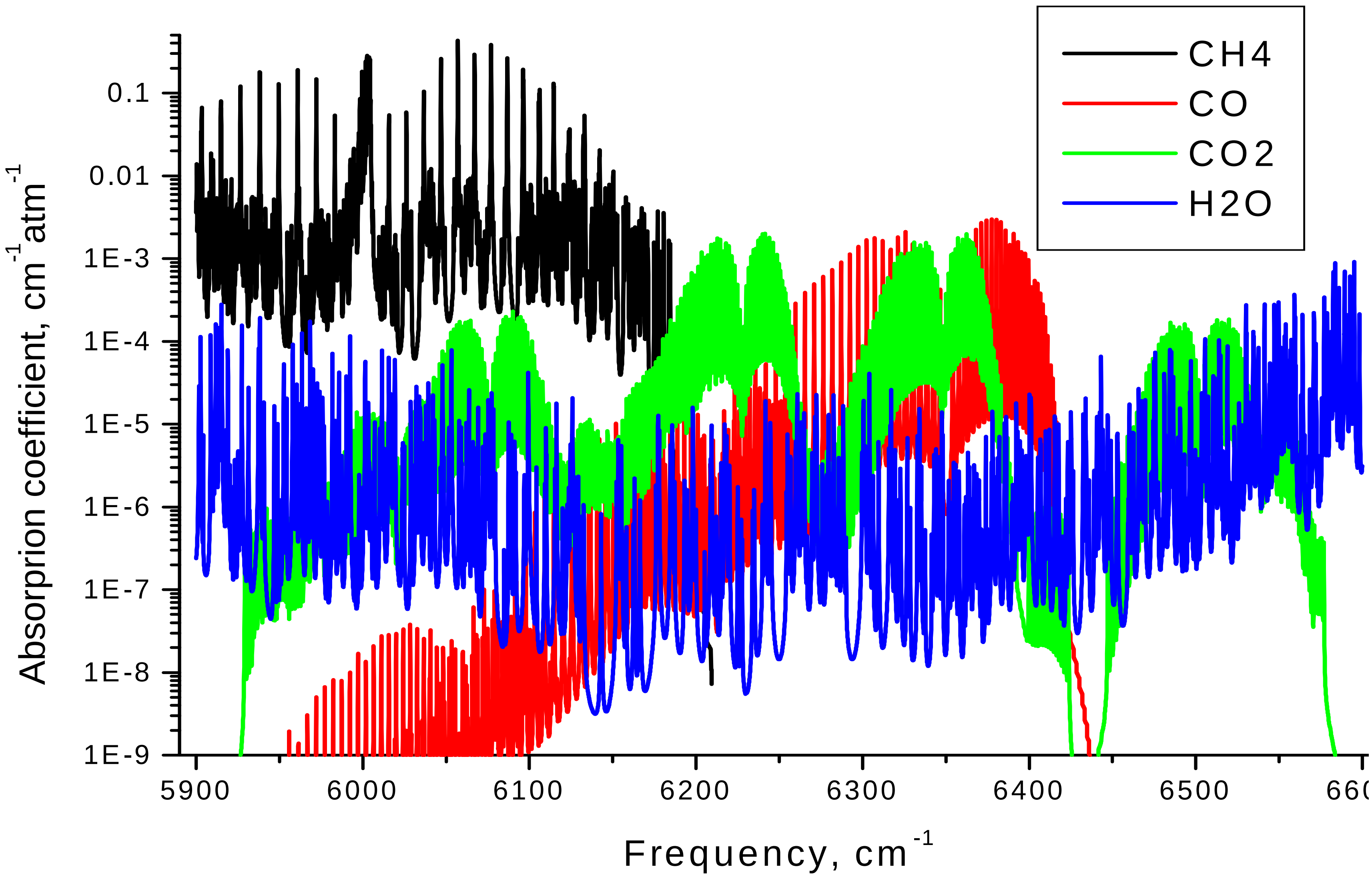
TRIAD	NONAD	HIGH STATES
900-1700 см-1	1900-3250 см-1	3250-3700 см-1
10-3	10-3	- (10-3)
3%	3%	- (4%)

The yellow color is the prospective progress in methane analysis.

CALCULATION TRANSMITTANCE OF THE ATMOSPHERE AND METHANE ON THE OPTICAL PATH 0-100 km



ABSORPTION COEFFICIENTS OF THE GASES ABSORBING SOLAR RADIATION IN 1.6 mkm SPECTRAL BAND



ABSORPTION COEFFICIENTS OF THE GASES ABSORBING SOLAR RADIATION IN 10 mkm SPECTRAL BAND