Fit to observed spectra of the cool dwarfs and ultracool objects

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Ukraine
24° E
28° E
32° E
36° E
40° E
52° N
48° N
44° N
BELARUS
RUSSIA
POLAND
SLOVAKIA
HUNGARY
ROMANIA
MOLDOVA
0
100 Miles
0
100 Kilometers
Kamin'-Kashyrs'kyi
Kovel'
Sarny
Chornobyl'
Chernihiv
Shostka
Konotop
Sumy
Luts'k
Rivne
Korosten'
Kiev (Kyiv)
Pryluky
Novohrad-Volyns'kyi
Zhytomyr
Okhtyrka
Kharkiv
Kupians'k
Sambir
Ternopil'
Bila Tserkva
Lubny
Poltava
Stryi
Khmel'nyts'kyi
Cherkasy
Kremenchuk
Lysychans'k
Luhans'k
Ivano-Frankivs'k
Vinnytsia
Kramators'k
hora Hoverla 6,761 ft. (2,061 m)
Uman'
Kamianets'-Podil's'kyi
Kirovohrad
Pavlohrad
Horlivka
Khust
Chernivtsi
Pervomais'k
Dnipropetrovs'k
Donets'k
Kryvyi Rih
Zaporizhzhia
Kotovs'k
Nikopol'
Mariupol'
Mykolaiv
Melitopol'
Berdians'k
Kherson
Odesa
Sea of Azov
Krasnoperekops'k
Karkinits'ka zatoka
Crimea
Kerch
RUSSIA
Izmail
Yevpatoriia
Feodosiia
Simferopol'
Sevastopol'
Yalta
Black Sea
Vistula
Desna
Don
Donets
Dnieper
Southern Bug
Dniester
Prut

YP's main topics

- Abundances determination
- NLTE
- Model atmosphere
- Lithium
- Peculiar stars
- Ultracool dwarfs
- Telluric spectra.

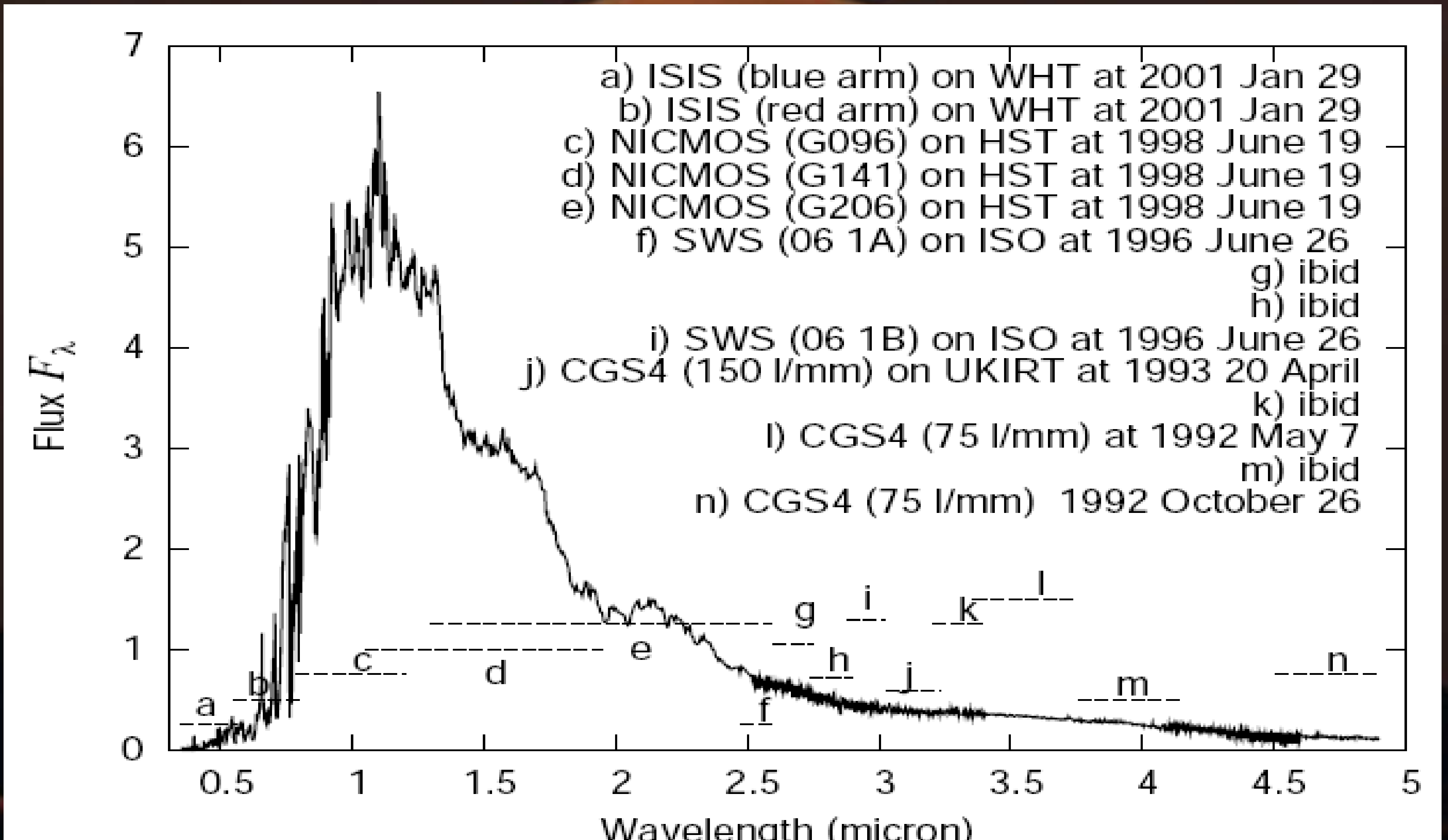
Thanks for collaboratoration and assistance

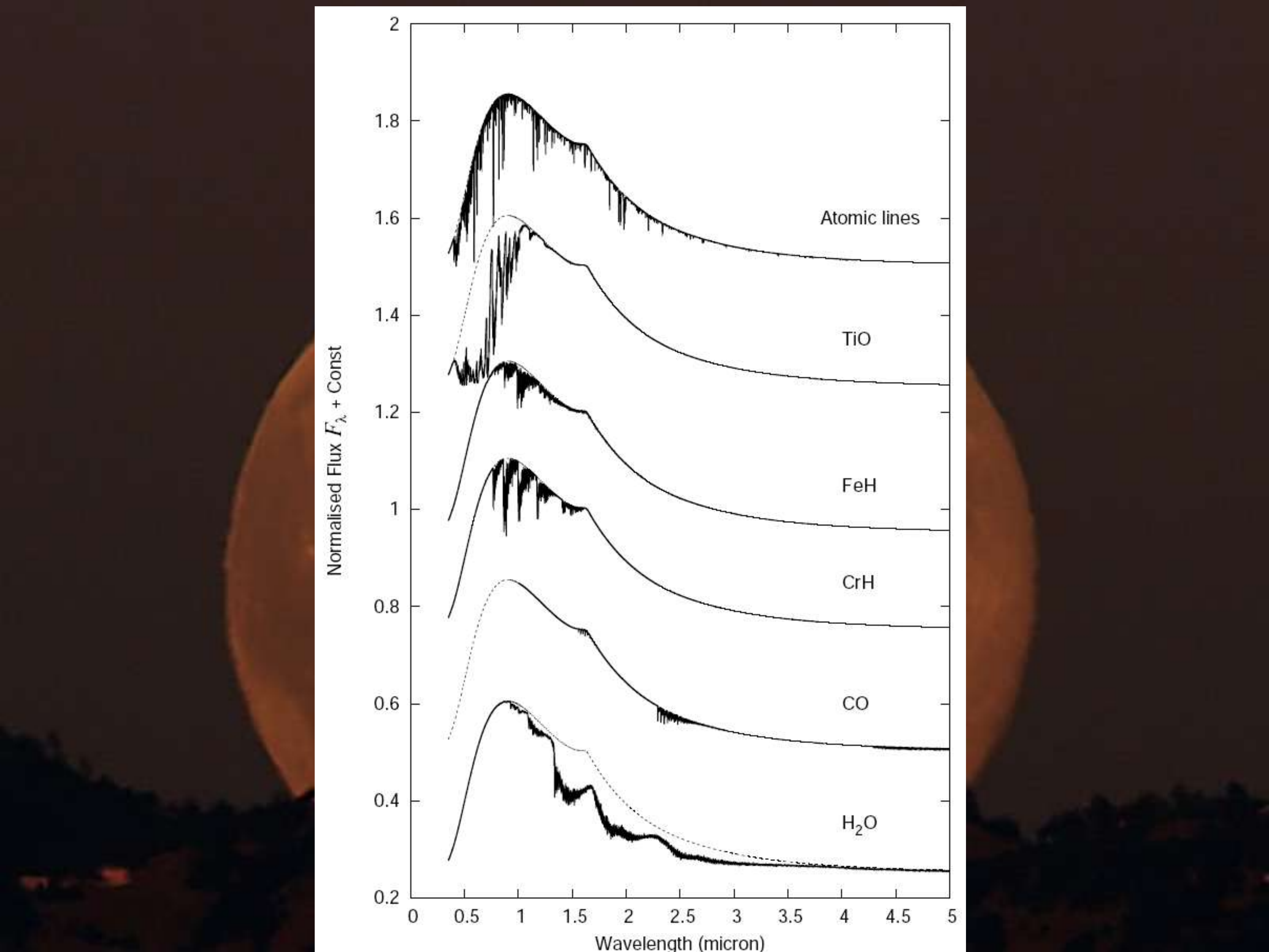
- Victor Bejar
- Yuri Lyubchik
- Larisa Yakovina
- Hugh Jones
- David Pinfield
- Rafael Revolo
- Eduardo Martin
- Maria Rosa Zapatero Osorio
- Enrike Palle

Procedure I. UCD spectra modelling

- Wita (Pavlenko 1997) prgram: LTE, 1D etc.
- Model atmospheres from NextGen et al.
- Opacities:
- Na I and K I lines broadening by H and He,
- Dusty opacity as scattering (clouds)
- CIA,
- Molecular line lists by Schwenke (H2O,TiO),Barber et al. (H2O),Gurvitch (CO), Kurucz, VALD, Burrows et al. etc.

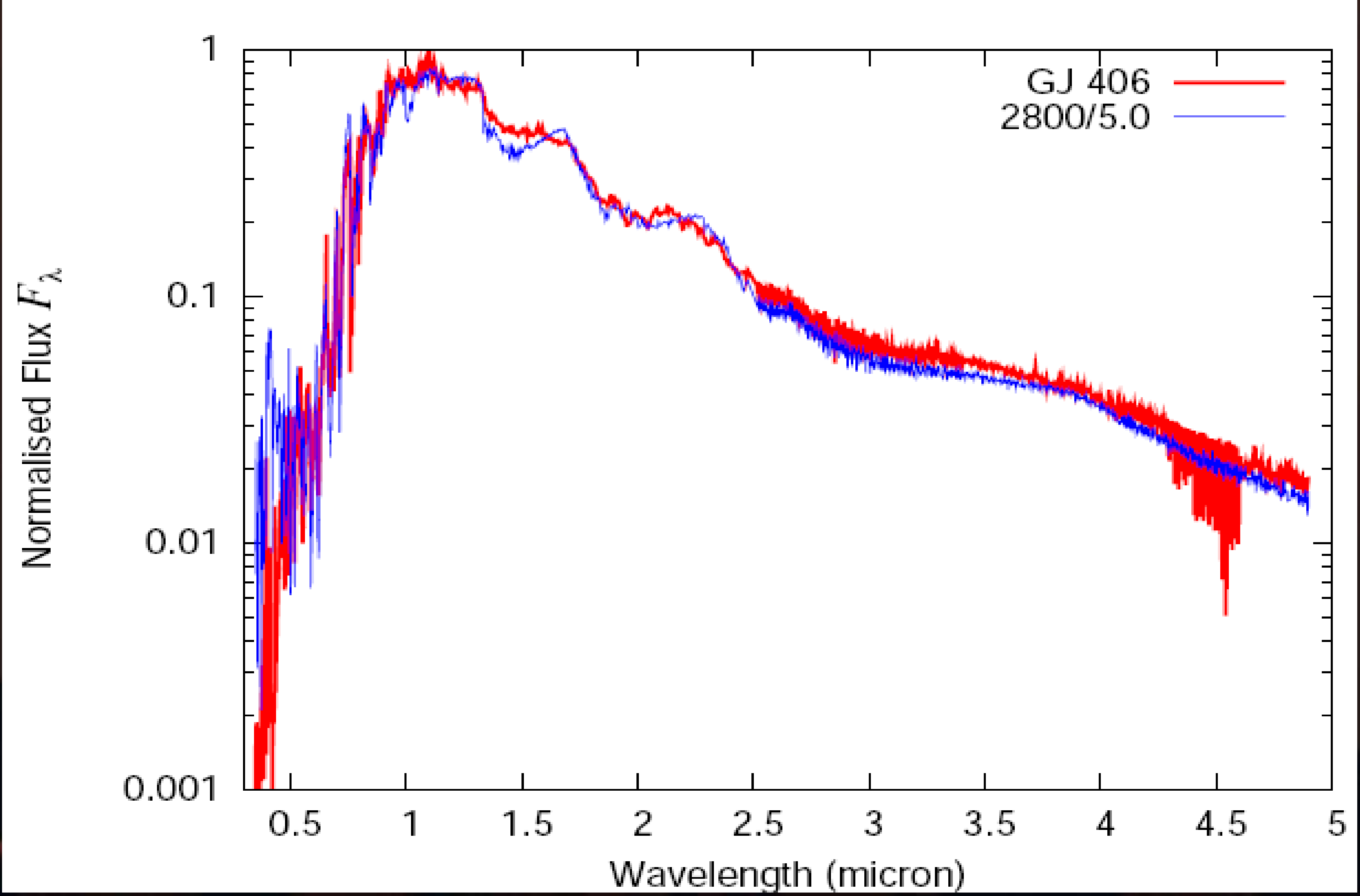
SEDs and modelling: quality of observed data and input physics





Normalised Flux F_λ + Const
Wavelength (micron)
Atomic lines
TiO
FeH
CrH
CO
H_2O
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

GJ406

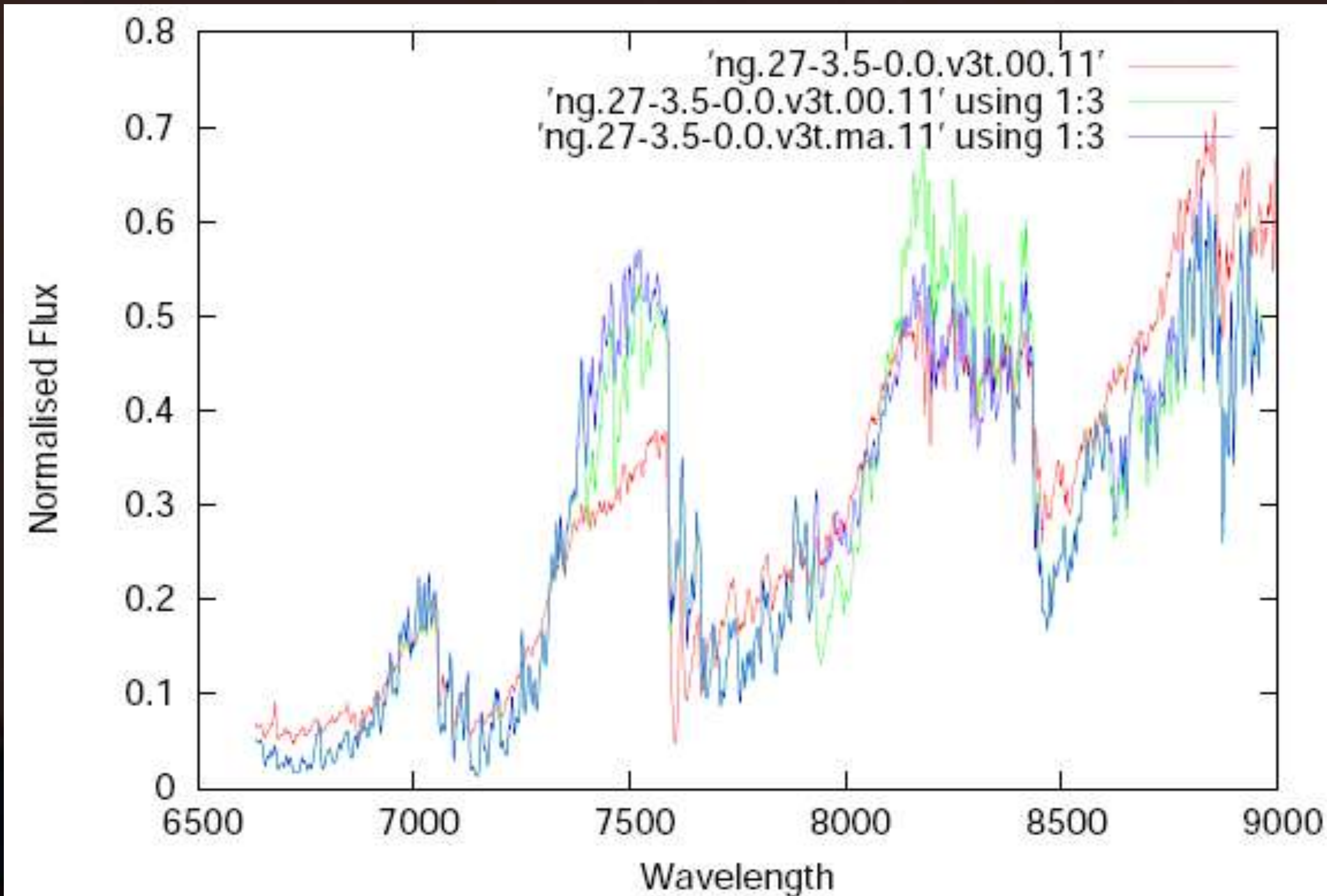


GJ 406
2800/5.0
Normalised Flux F_λ
Wavelength (micron)
1
0.1
0.01
0.001
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

Accuracy of the input data: M-dwarf spectra

VO molecule

	B 4Π_r -	X 4Σ^-
E	12650.0	0.00 0.
ω_e	910.9	1011.3
$\omega_e X_e$	5.0	4.86
Be	0.5246	54825
α	0.004	0.00352



'ng.27-3.5-0.0.v3t.00.11'
'ng.27-3.5-0.0.v3t.00.11' using 1:3
'ng.27-3.5-0.0.v3t.ma.11' using 1:3
Normalised Flux
Wavelength
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
6500
7000
7500
8000
8500
9000

Spectral analysis of mid-resolution K band spectra.

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Received ; accepted

ABSTRACT

Aims. Aims

Methods. Methods. Synthetic spectra method was used to detrmine the physical parameters of stellar atmospheres for the sample of stars from G8 to M9.5 spectral types in the infra-red. Observed spectra of R∼18000 were fitted by the synthetic spectra in four regions of K band...

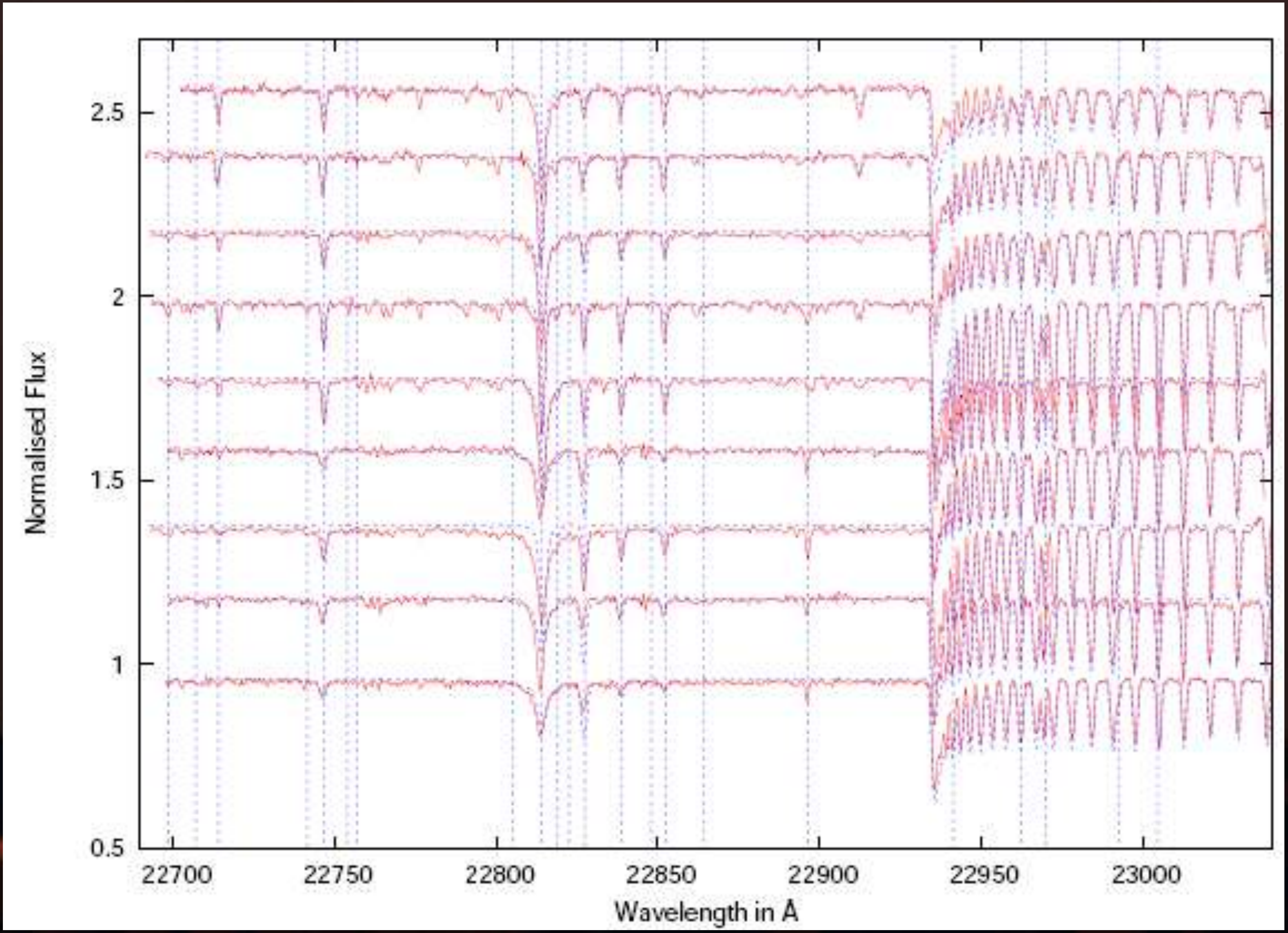
Fits to the near IR spectra:

- MgAl: 20800 -- 21150 A
- Hg: 21400 – 21750 A
- Na: 22050 – 22350 A
- CO: 22700 – 2350 A

Table 1.

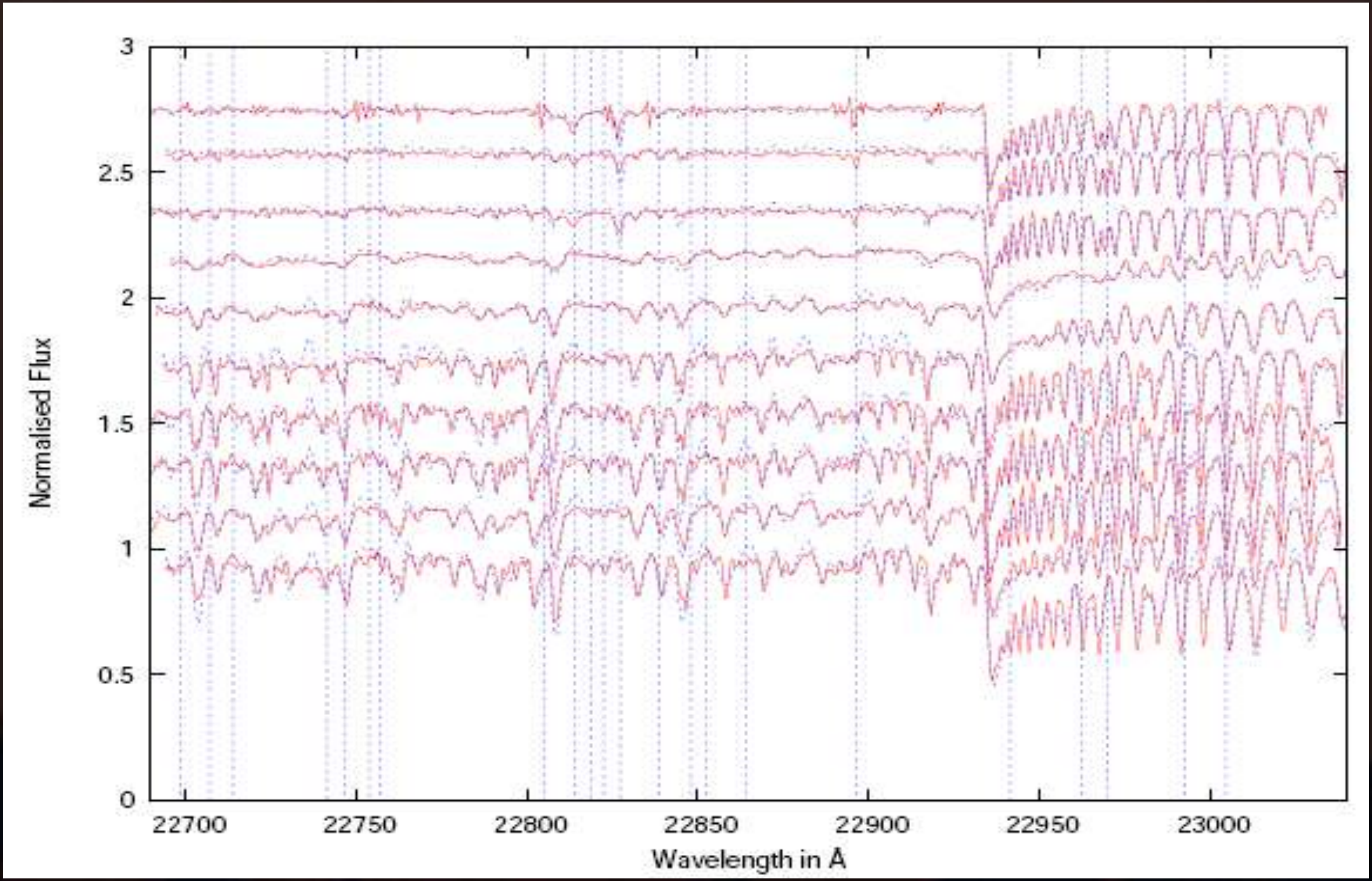
			co	hg	mgal	na	
		Teff	vsini	vsini	vsini	vsini	
LHS2924	M9 V	2400/2500	23/19'	18/16'	22/19'	20/16'	'- best fit by
GJ569B	M8.5 V	2600/2500	25'/29	26'/29	27'/30	26'/28	YP minimization prg
VB10	M8 V	2700/2600	8/13	8/12	8/13	9/13	Schw96 vsin$i$=8km/s
VB8	M6.5 V	2700/2800	13/8'	12/6'	12/6'	14'/11	
GJ4281	M6.5 V	2700/2800	17/12'	17/13'	14/9'	21/17'	
GJ1245A	M5.5[V?]	2900/3000	29/26'	29/27'	31/28'	32/29'	
GJ791.2	M4.5 V	3000/3100	43/40'	60/51'	50/46'	42/40'	
GJ569A	M2.5 V	3400/3500	11/10'	26/22'	25/19'	19/18'	
GJ806	M1.5	3500/3600	12/12'	25'/18	24/17'	14/13'	
HD131976	M1 V	3600/3700	13'/12	26'/10	29/12'	13/12'	DJ03 vsin$i$=10km/s
HD184489	K5 [V?]	4000/4200	11'/13	~15	3/10'	12'/15	
HD201091	K5 V	4000/4200	9'/11	~15	17/13'	9'/11	
HD157881	K5 [IV]	4000/4200	10'/12	12'/12	15'/14	12'/11	
ADS14636	K5 [V]	4000/4200	8'/10.2	42.8'/38	16.4'/18	7'/11	
HD219134	K3 V	4400/4600	11/8'	11'/8	15/11'	12/8'	
HD168387	K2 III	4200/4400	3'/1	2'/2	0.2/0.2	11/9'	
HD166620	K2 V	4600/4800	15/12'	26/16'	15/12'	16/11'	
HD175225	G9 IVa	4600/4800	14/11'	9/9'	11/10'	13/11'	
HD182572	G8 IV	4600/4800	21/17'	8'/7	10'/9	13/11'	

K-dwarfs



Normalised Flux
2.5
2
1.5
1
0.5
22700
22750
22800
22850
22900
22950
23000
Wavelength in Å

M-dwarfs

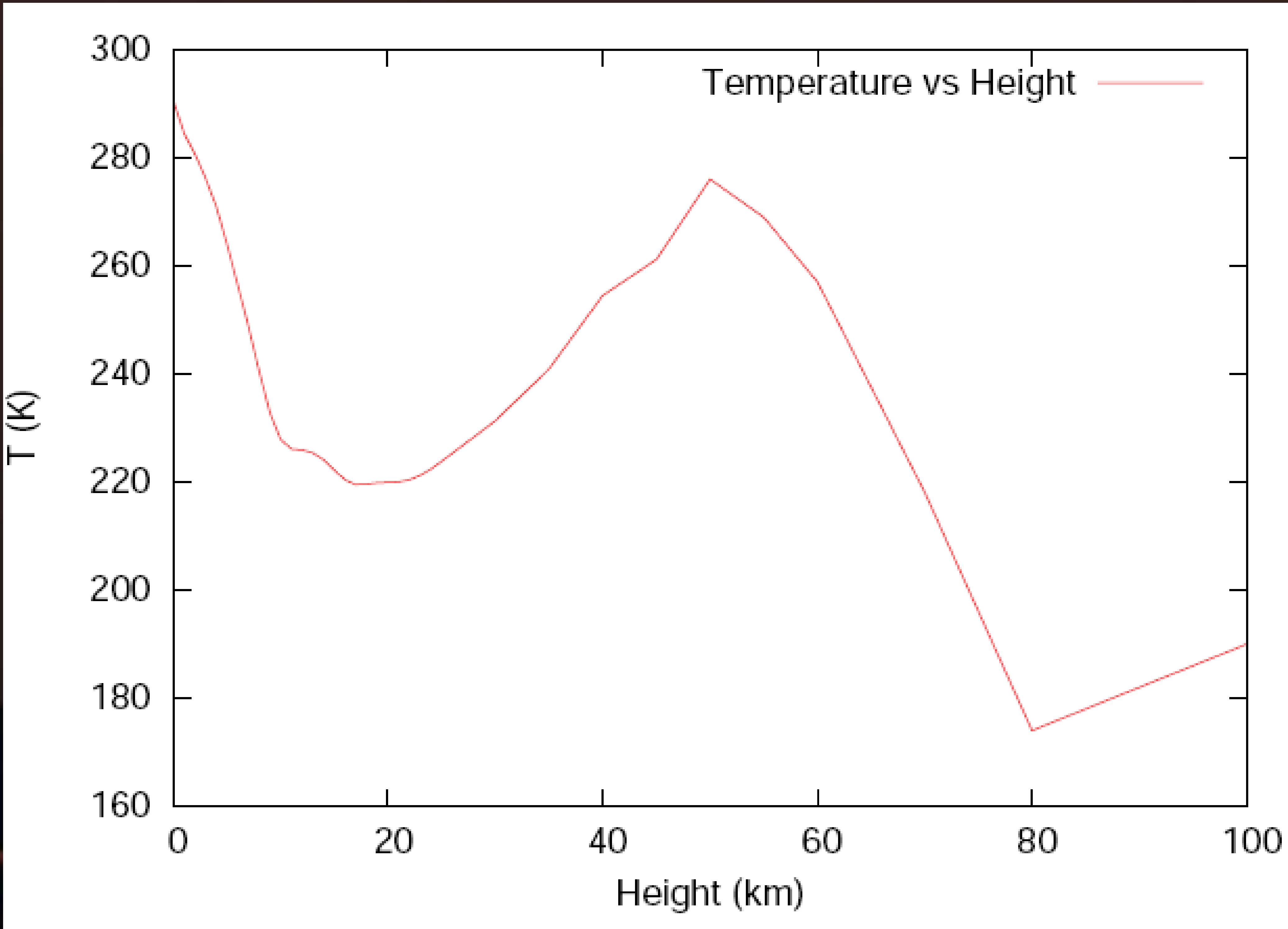


Normalised Flux
3
2.5
2
1.5
1
0.5
0
22700
22750
22800
22850
22900
22950
23000
Wavelength in Å

Procedure II. Telluric spectra modelling

- High temperatures
- Thick atmosphres
- H- dominates
- TiO, VO, H_2O, methane
- Strong atomic lines
- Dust

- Low temperatures
- Thin atmosphrere
- Line of H_2O, CO_2, methane, O_2, N_2
- Photochemical processes
- Aerosols
- Photochemical processes



Temperature vs Height
T (K)
Height (km)
300
280
260
240
220
200
180
160
0
20
40
60
80
100

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Ozone columns and atmospheric profiles for Kiev by ground based remote sensing (OMI validation)

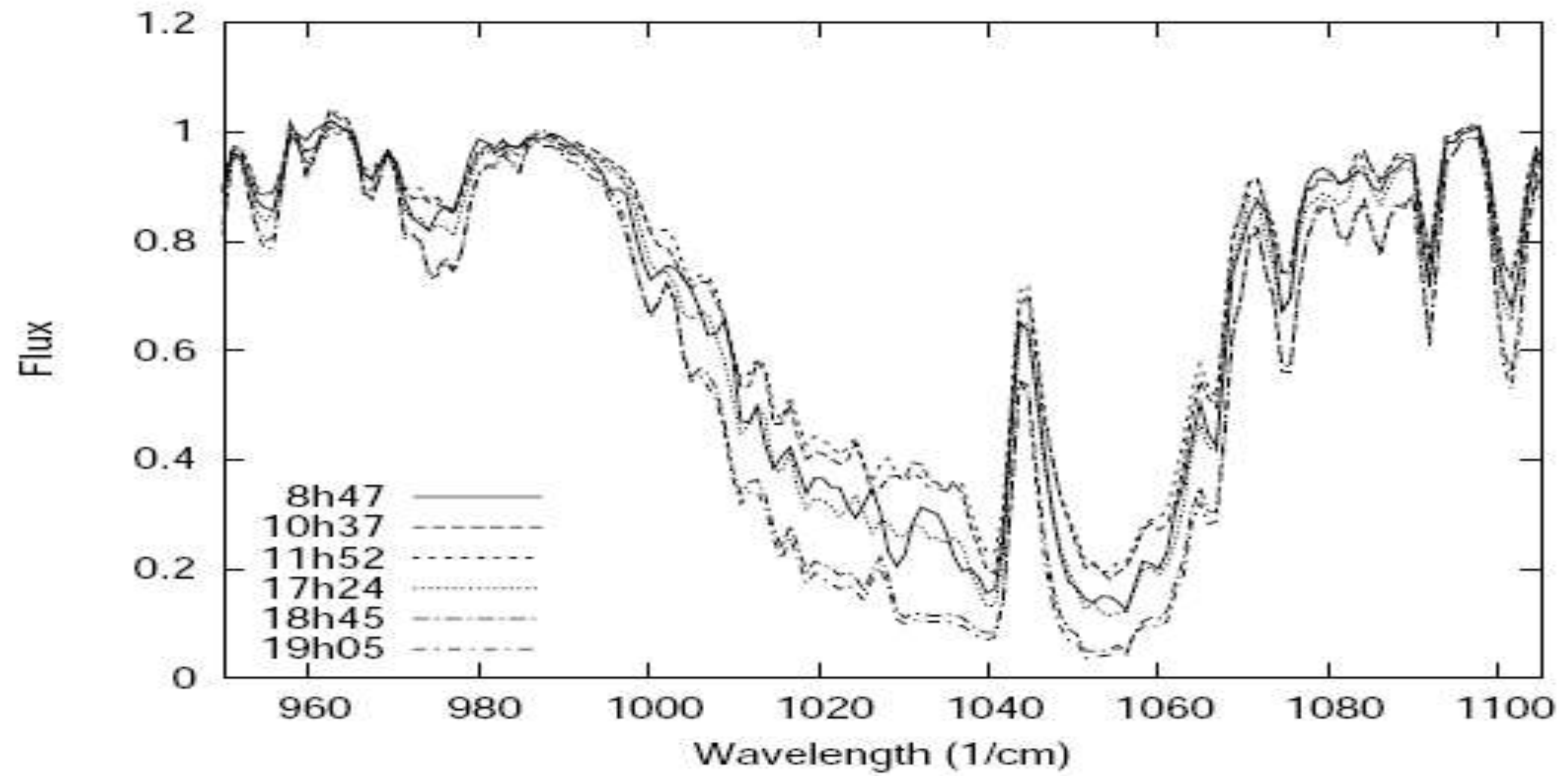
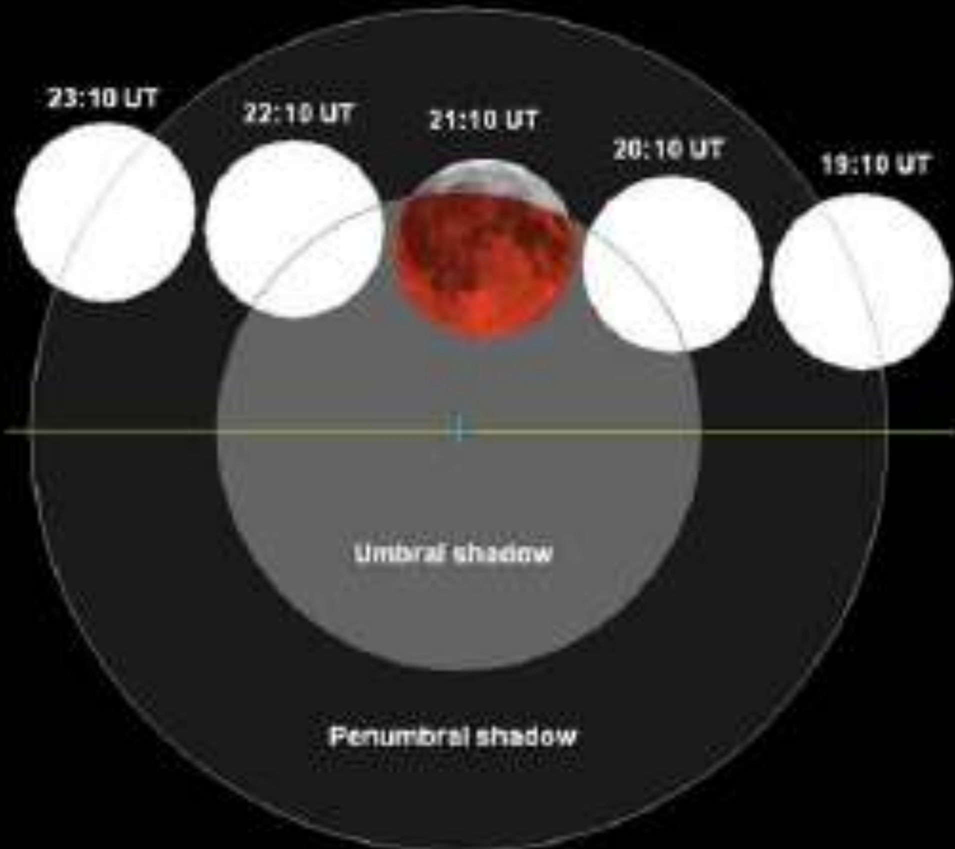


Figure 2. The observed spectra of 27 June 2006 from 8h47 up to 19h05 (z = 30.26 - 72.80 grad, resolution R = 2 cm^{-1})

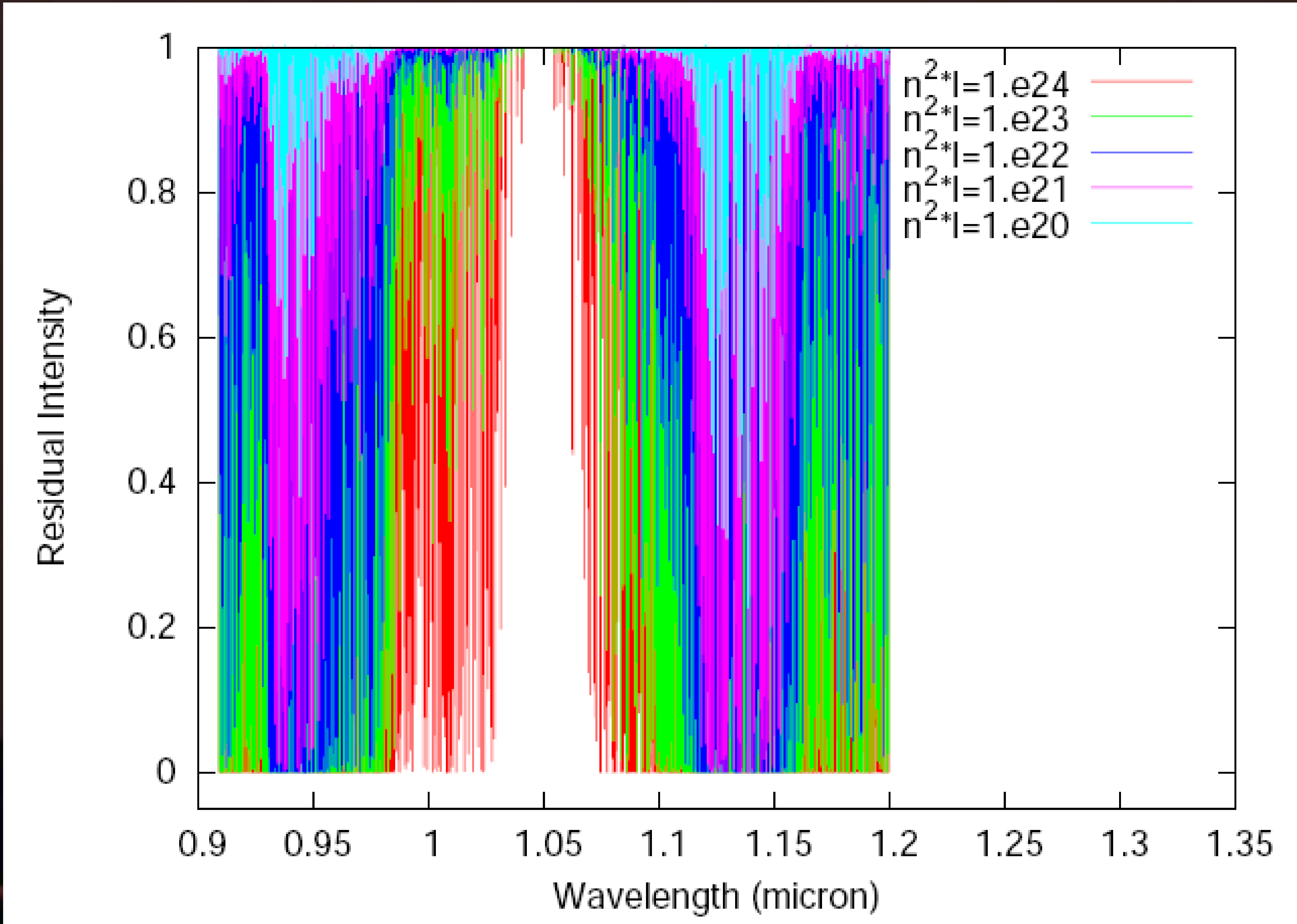
Transmitted **and** ***reflected*** **spectrum of the Earth**


23:10 UT
22:10 UT
21:10 UT
20:10 UT
19:10 UT
Umbral shadow
Penumbral shadow

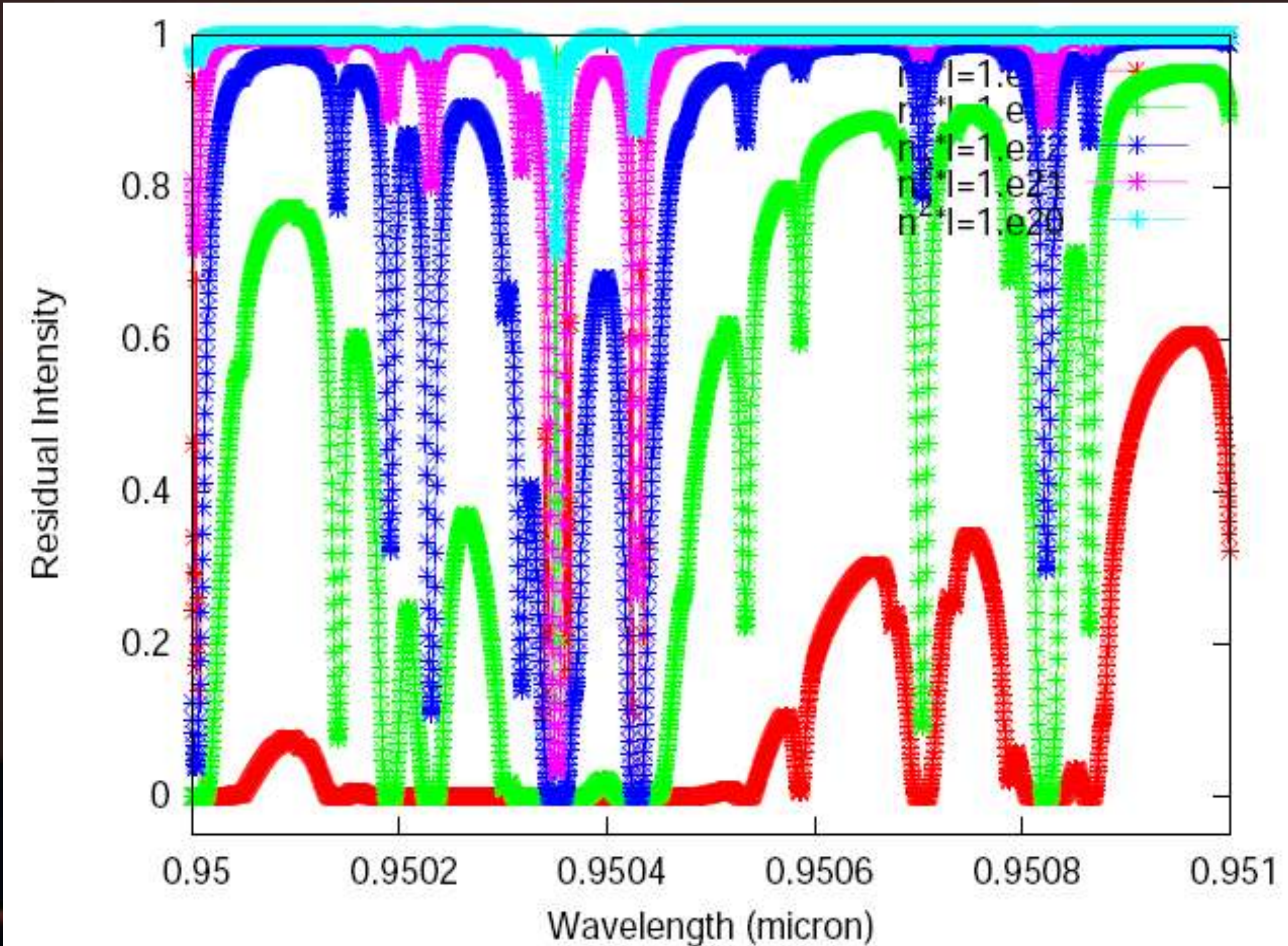
Modelling of spectra

- Model atmosphere
- Model of molecular bands (MODTRAN):: smoothed opacities
- Low resolution spectra

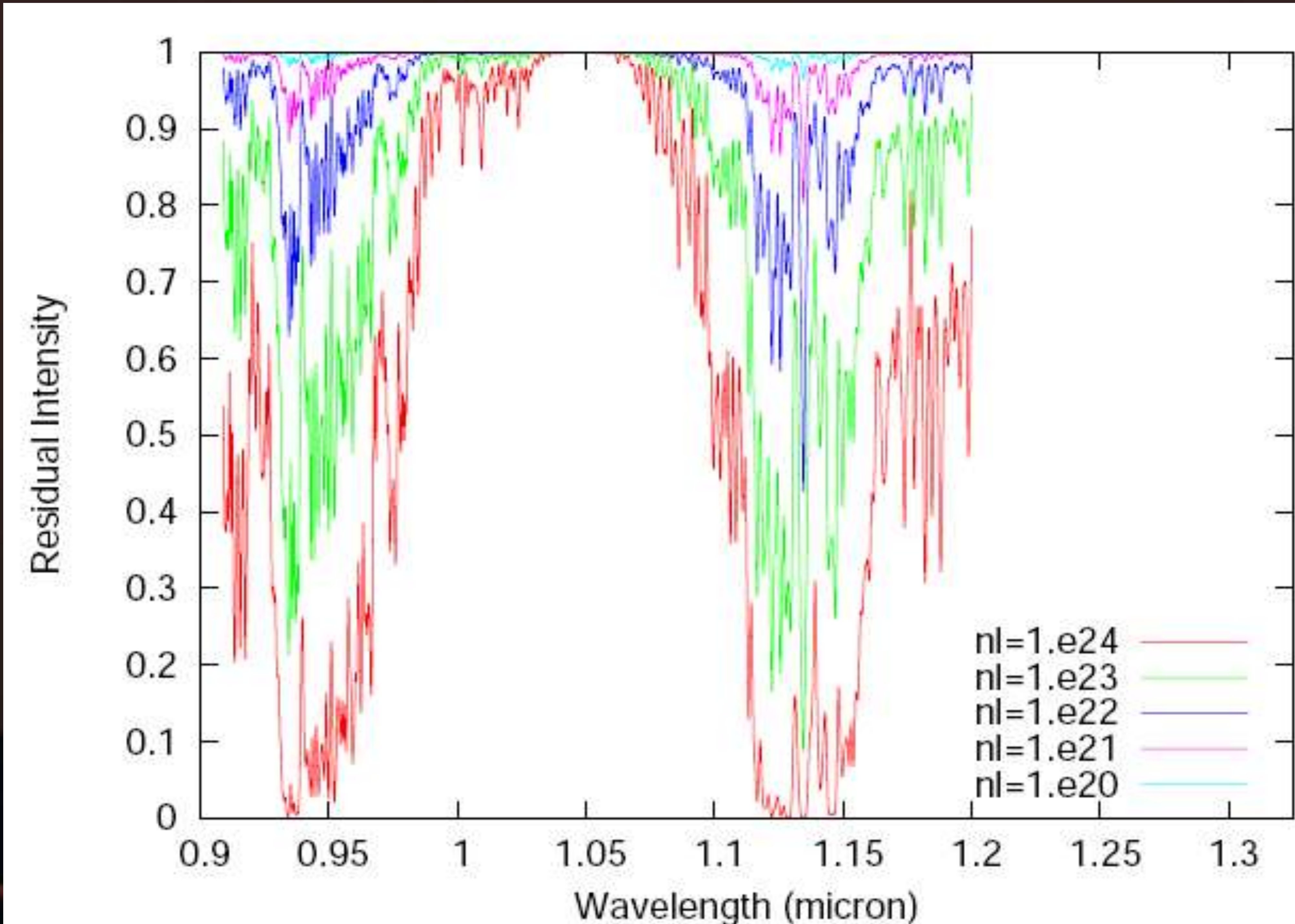
- One slab model atmosphere
- Line by line computations (TASS)
- Absorption by lines is treated explicitly (Voigt profiles, damping constants... etc.)



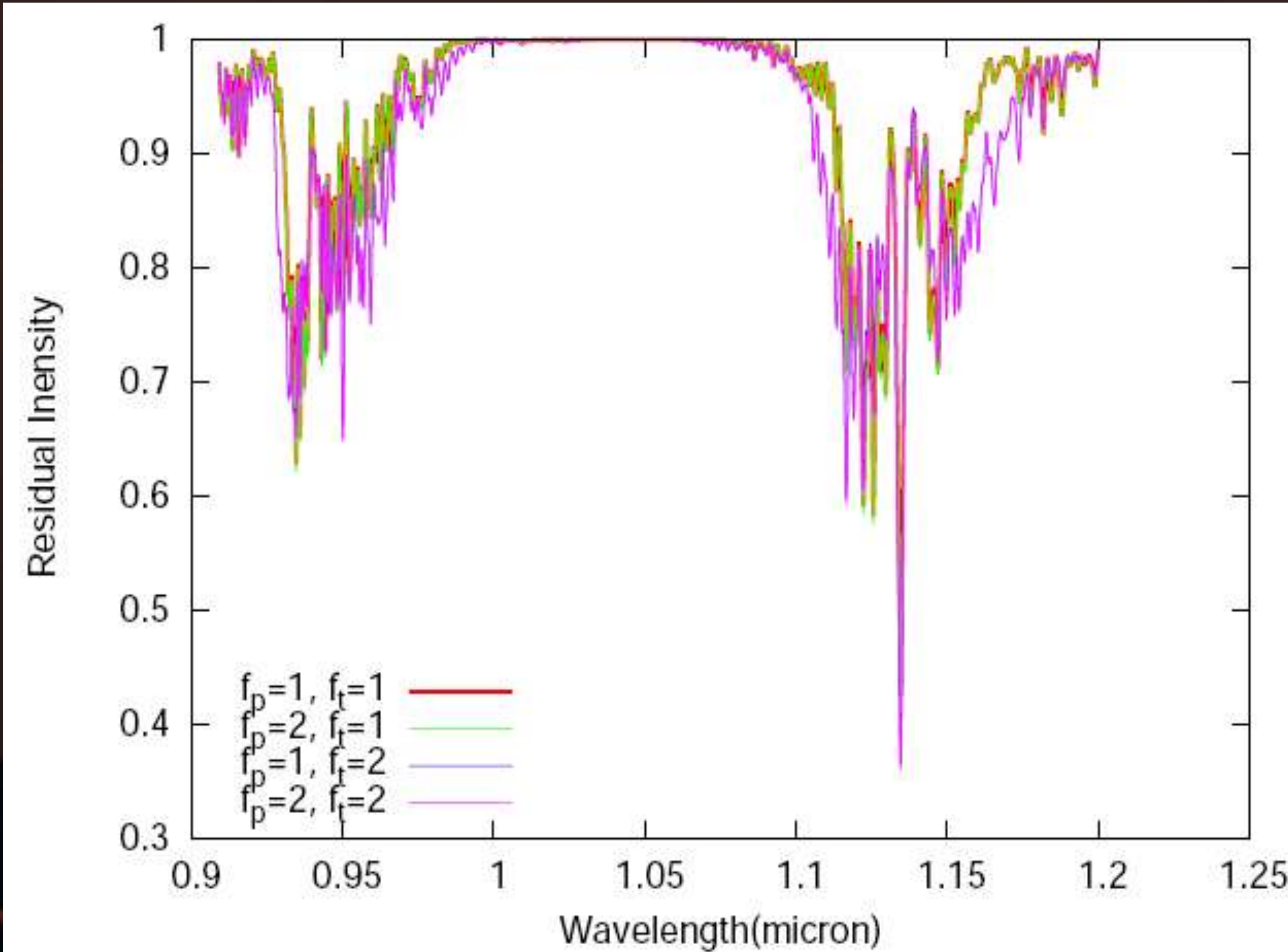
Residual Intensity
0
0.2
0.4
0.6
0.8
1
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
1.3
1.35
Wavelength (micron)
n^2*l=1.e24
n^2*l=1.e23
n^2*l=1.e22
n^2*l=1.e21
n^2*l=1.e20



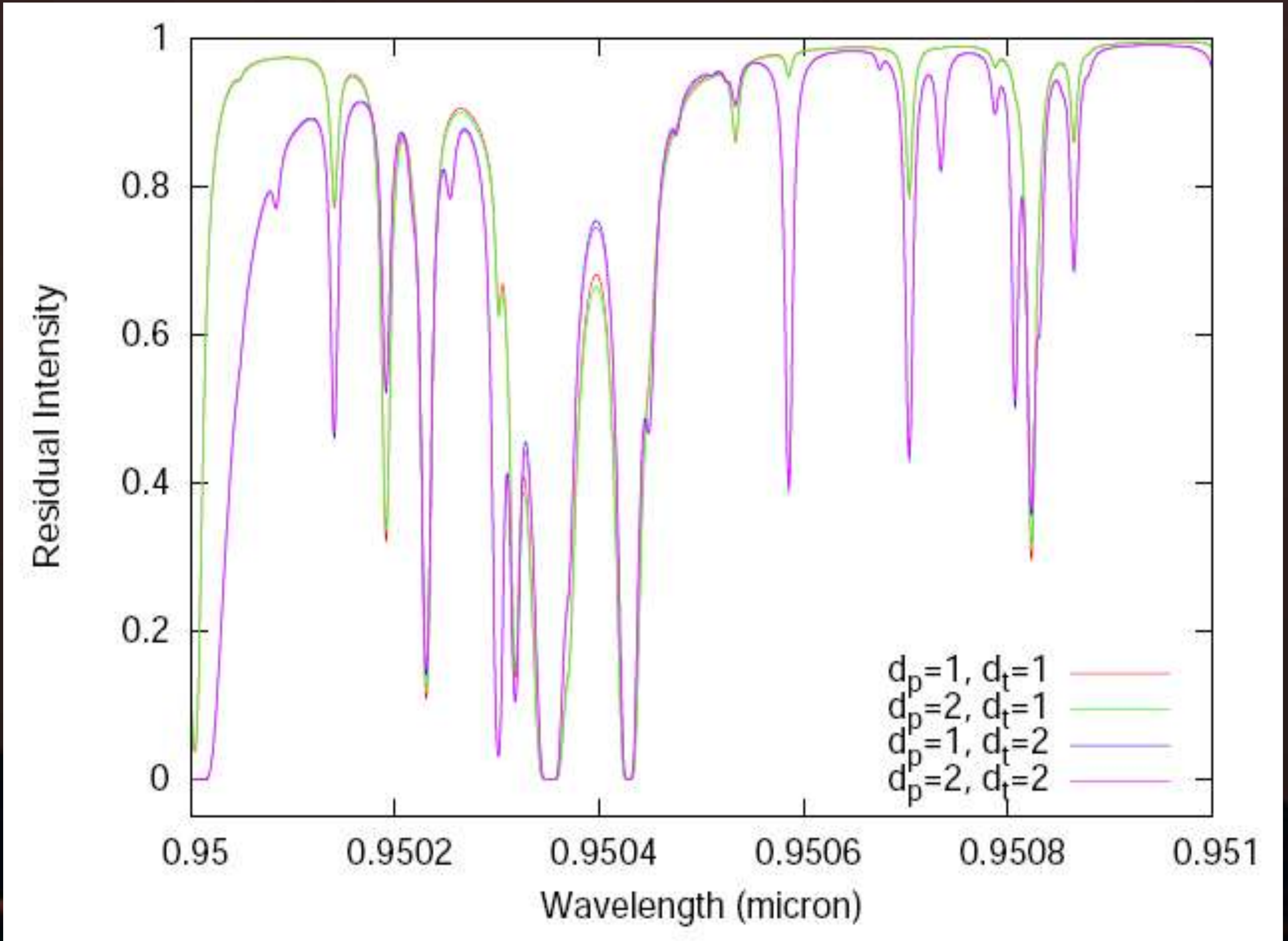
Residual Intensity
1
0.8
0.6
0.4
0.2
0
0.95
0.9502
0.9504
0.9506
0.9508
0.951
Wavelength (micron)
n^2*l=1.e21
n^2*l=1.e20



Residual Intensity
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
1.3
Wavelength (micron)
nl=1.e24
nl=1.e23
nl=1.e22
nl=1.e21
nl=1.e20

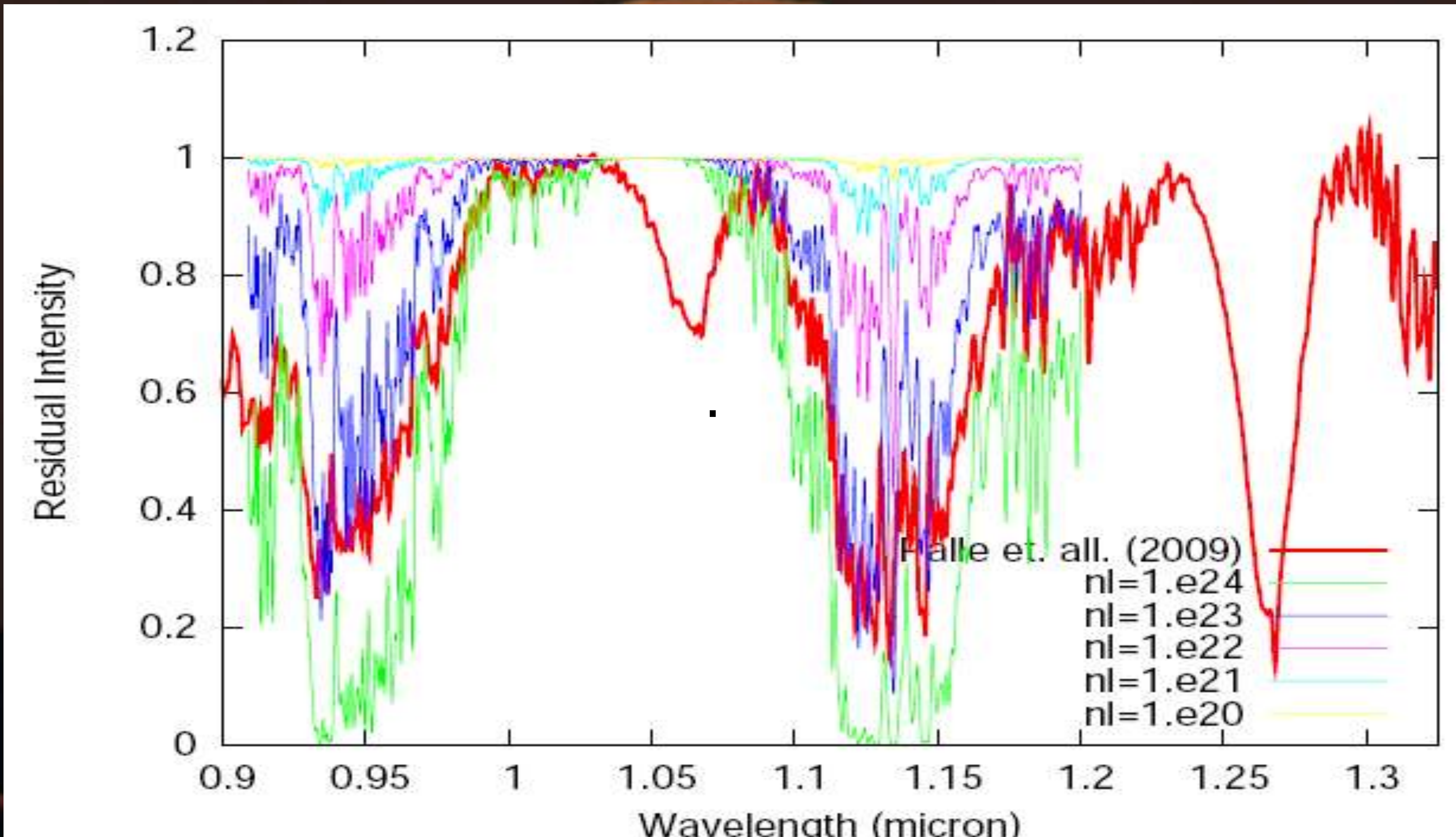


Residual Inensity
Wavelength(micron)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
f_p=1, f_t=1
f_p=2, f_t=1
f_p=1, f_t=2
f_p=2, f_t=2



Residual Intensity
Wavelength (micron)
0
0.2
0.4
0.6
0.8
1
0.95
0.9502
0.9504
0.9506
0.9508
0.951
d_p=1, d_t=1
d_p=2, d_t=1
d_p=1, d_t=2
d_p=2, d_t=2

Comparison with observations



Conclusions I.

- Palle et al. (2009) observed really transmitted and reflected light of the telluric atmosphere.
- Earth is the first rocky planet discovered spectroscopicvally.
- If something is possible at once, it can be repeated many times...

Conclusions II.

- We can provide a good fits to the observed spectra of UCD in the selected spectral regions.
- To provide any confident fits the existed input data (molecular line lists, model atmospheres, etc) have to be refined substancially.
- Situation with modelling spectra of extra-solar planets looks as very promising, if we use all knowledge accumulated for planets of SolSys.
- Any collaboration is very appreciated.

Some plans

- Fundamental parameters of UCD determined by EB's. Verification of the input data and theory.
- Lithium and deuterium test applications.
- Telluric and planetary spectra.