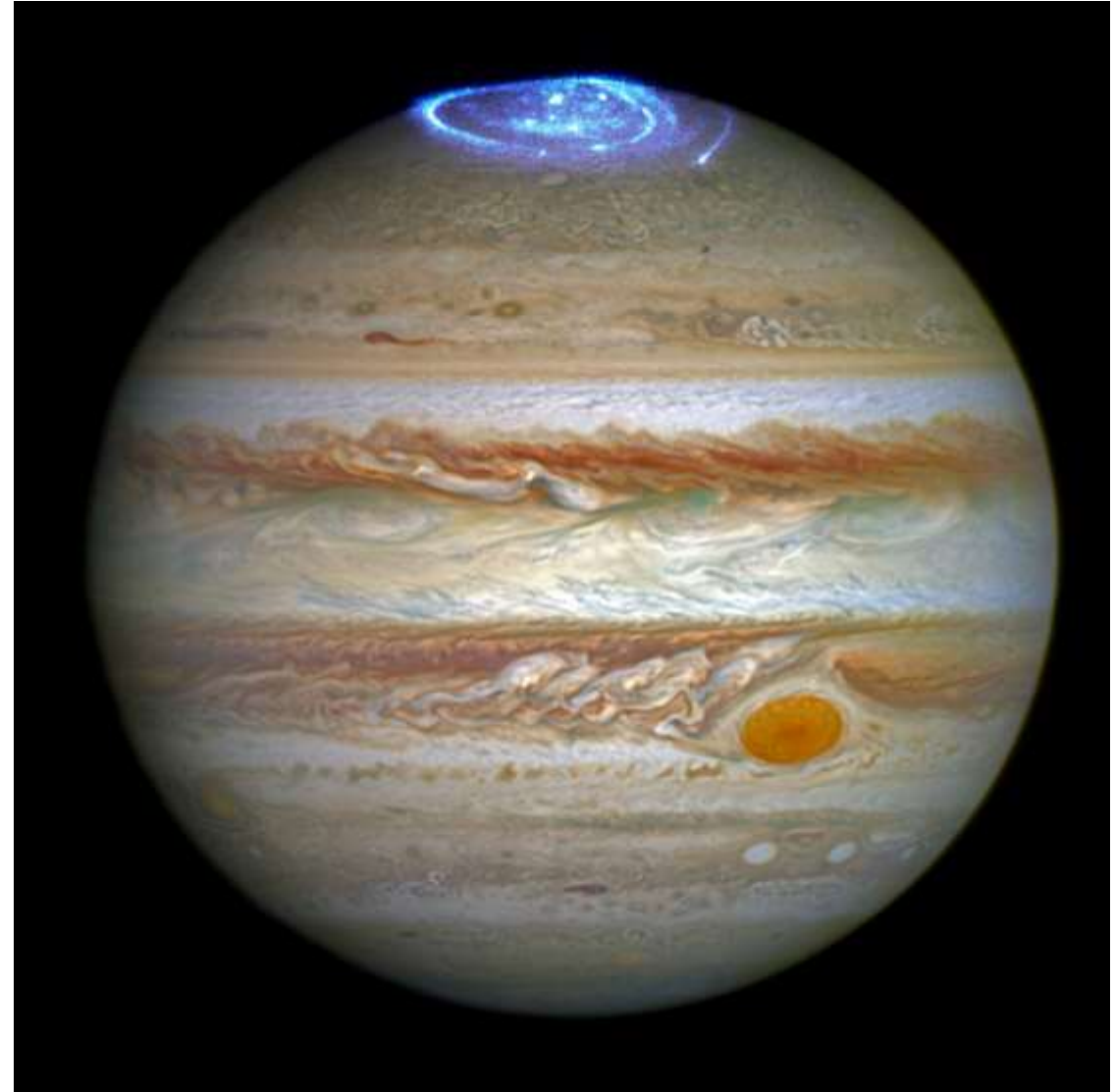


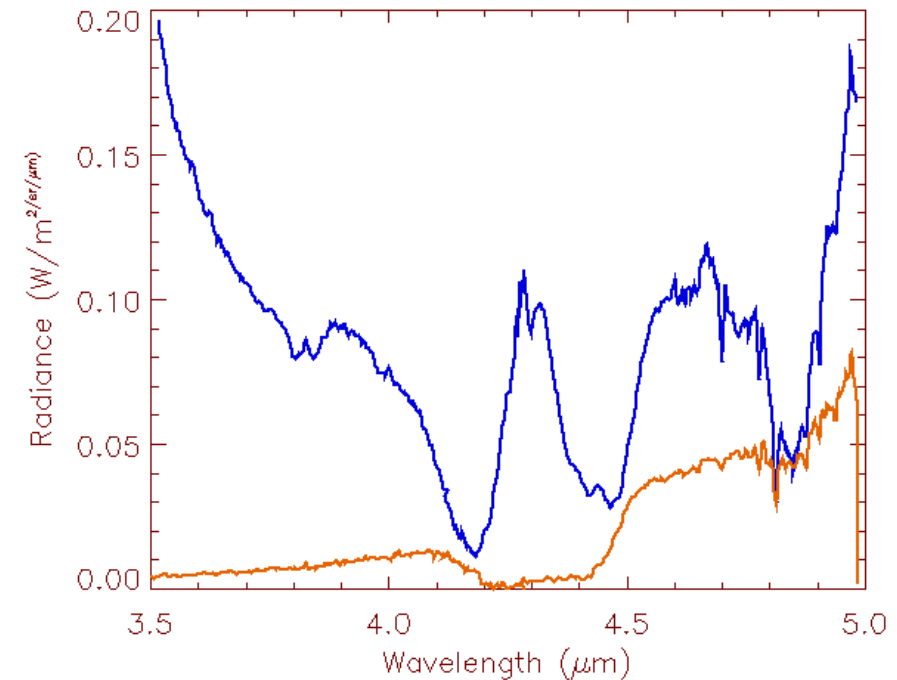
# Auroral emissions

Precipitation of particles from the magnetosphere :

- Primary or secondary emissions : H Ly $\alpha$  & H $_2$  Lyman and Werner bands
- Chemical modifications
- Thermal heating of the upper stratosphere
- Dynamical effects



# Non-LTE mechanisms in planetary atmospheres



Venus, VIRTIS/Venus Express, 2006  
Observation of CO<sub>2</sub> fluorescence at 4.3 μm

# Radiative transfer non-LTE scheme

Non-LTE regime:

$$J_\nu \neq B_\nu$$

Thermal collision time  $>$   
radiative time

Collisional, chemical  
processes to be taken  
into account to  
calculate the source  
function

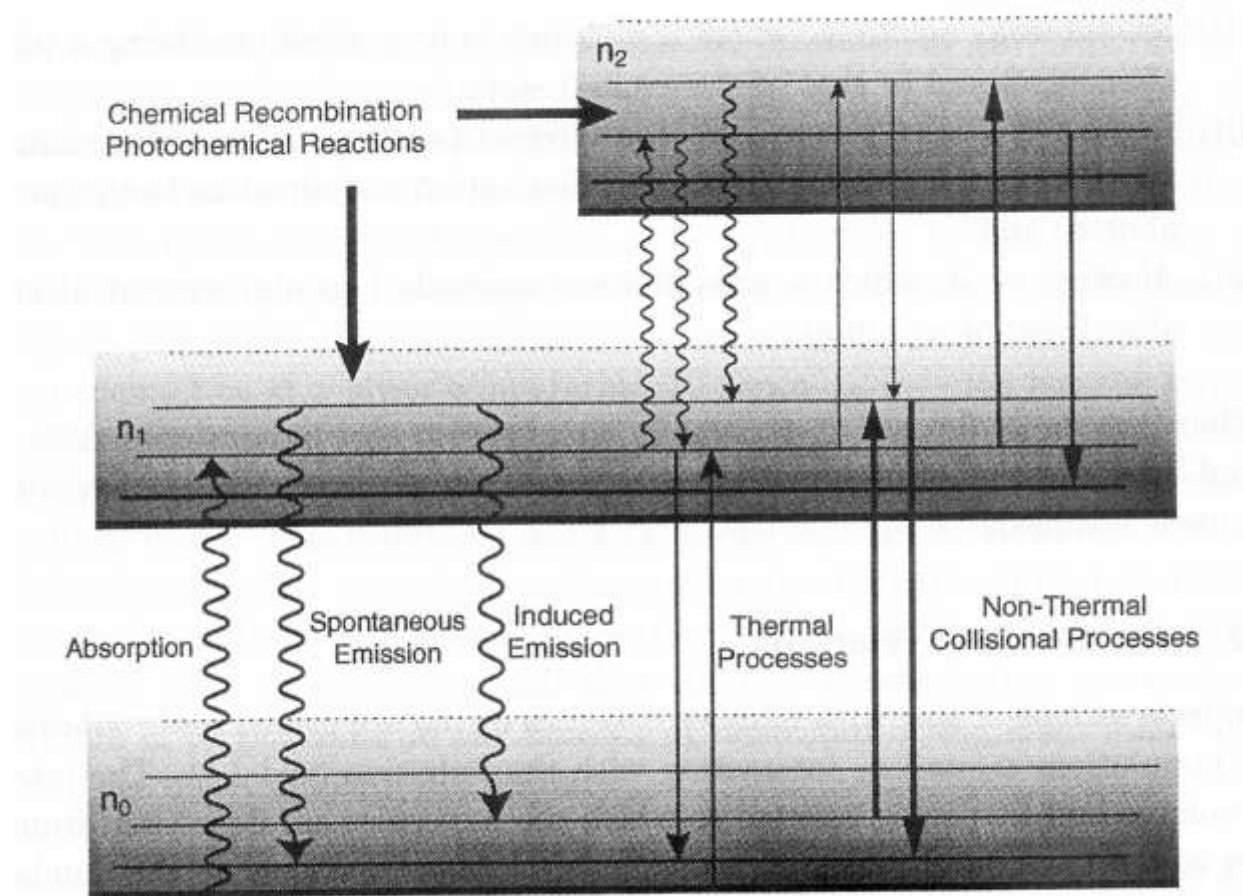


Fig. 3.3 Processes affecting the populations of vibrational levels.

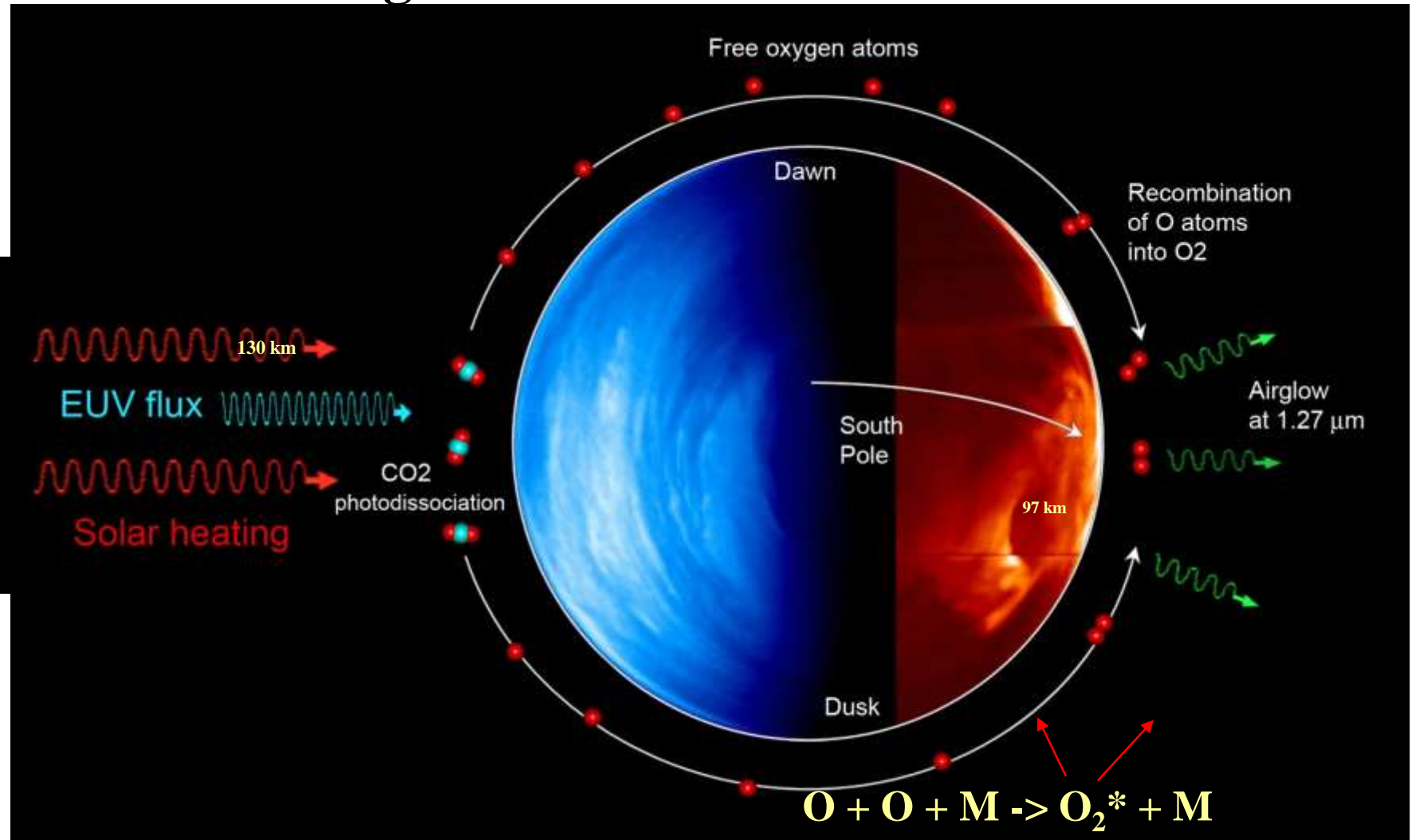
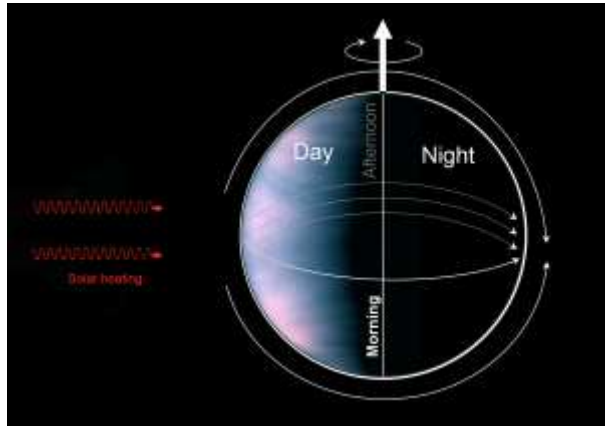
# Some non-thermal processes

1. **Vibrational-vibrational energy transfer.**  
Example : CO<sub>2</sub> molecule ; exchange with N<sub>2</sub>
2. **Electronic to vibrational energy transfer.**  
Example: O(<sup>1</sup>D) state exciting the N<sub>2</sub> vibrational modes
3. **Chemical recombination or chemiluminescence** Example:  
ozone bands at 10 μm
4. **Photochemical reactions**  
Example : O<sub>2</sub> emissions at 1.27 μm
5. **Dissociative recombination (O<sub>2</sub><sup>+</sup> + e<sup>-</sup> → O\* + O)**
6. **Collisions with charged particles (auroral processes)**

Moreels et al, Experimental Astronomy, 2008  
Observations from Observatoire de Haute Provence (1998)



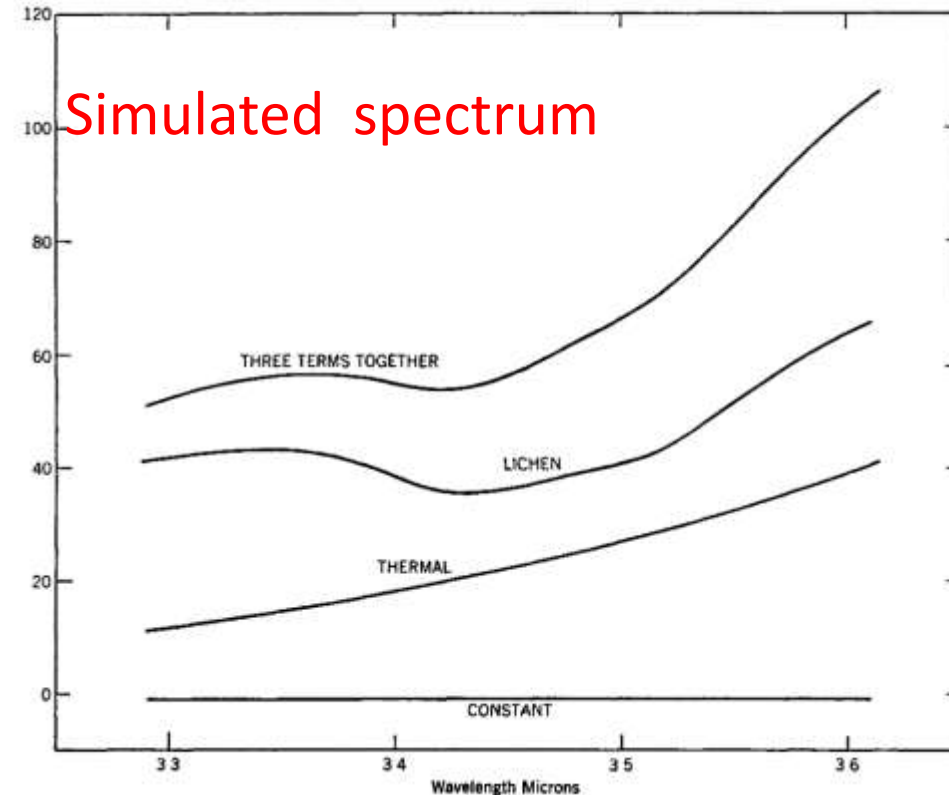
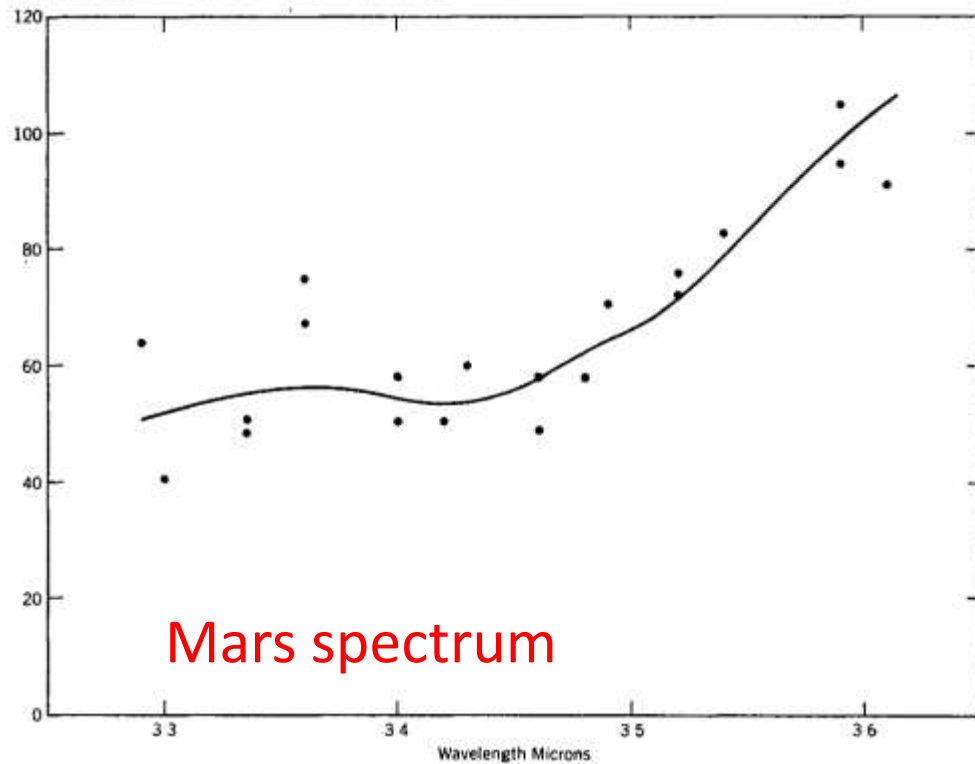
# A conceptual picture of O<sub>2</sub> (Δ) production and airglow on Venus



# 3. A summary of historical errors or difficulties in the navigation through planetary data

# A summary of historical errors or difficulties

- Spectroscopic evidence for vegetation on Mars (Sinton, ApJ, 1957)

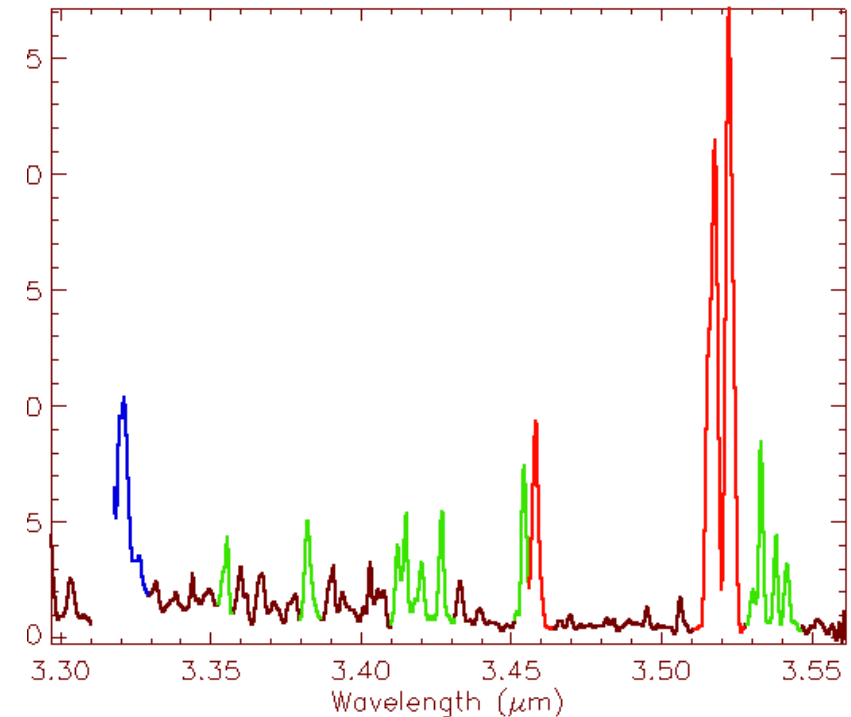


# A summary of historical errors or difficulties

- Detection of chlorophyll on Mars (Sinton, 1957)
- Spectral confusion absorption/emission – « doublet » 3.52 micron

Ballester et al. 1994 claiming for unknown emission features

Re interpretation Drossart et al. 1995 as CH<sub>4</sub> features and cloud deck reflection between absorption



# A summary of historical errors or difficulties

- Detection of chlorophyll on Mars (Sinton, 1957)
- Spectral confusion absorption/emission – doublet 3.52 micron (Ballester et al. 1994 / interpretation Drossart et al. 1995)
- Methane on Mars : where is the CH<sub>4</sub> ?

# A story of CH<sub>4</sub> detections on Mars

- Mars Express/PFS Formisano et al, ground based observations – intermittent detection from orbit 0-30 ppbv

*Formisano, Vittorio; Atreya, Sushil; Encrenaz, Thérèse; Ignatiev, Nikolai; Giuranna, Marco Detection of Methane in the Atmosphere of Mars 2004Sci...306.1758F*

- Curiosity Chemcam : sporadic detection 5 to 21 ppbv local on Gale crater
- Exomars TGO and ACS : CH<sub>4</sub> less than 0.06 ppbv

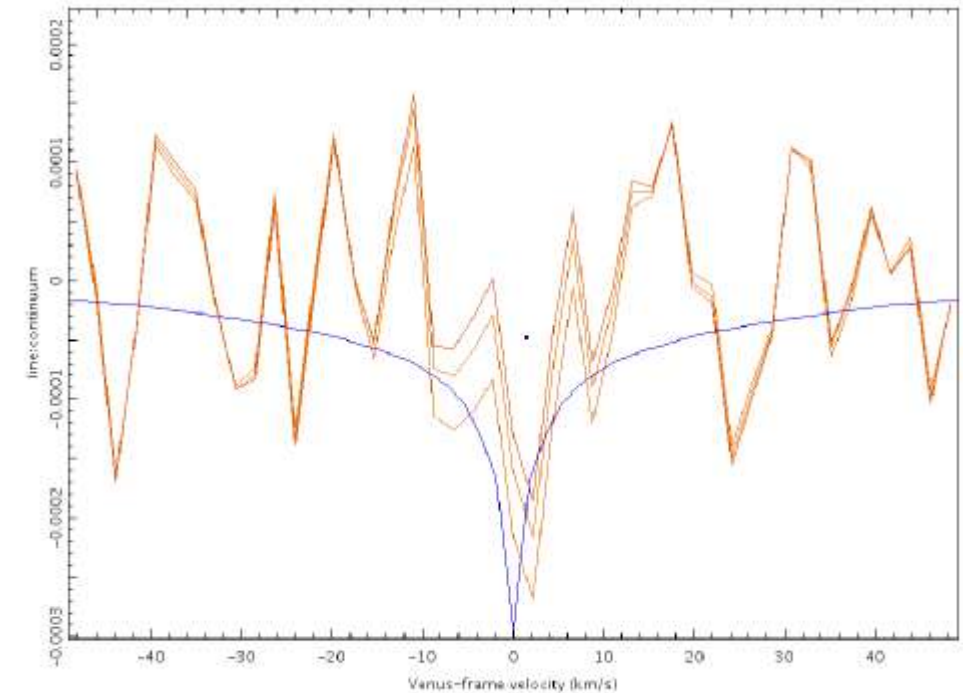
*Knutsen, Elise W.; Villanueva, Geronimo L.; Liuzzi, Giuliano et al. Comprehensive investigation of Mars methane and organics with ExoMars/NOMAD 2021Icar..35714266*

# A summary of historical errors or difficulties

- Detection of chlorophyll on Mars (Sinton, 1957)
- Spectral confusion absorption/emission – doublet 3.52 micron (Ballester et al. 1994 / interpretation Drossart et al. 1995)
- Methane on Mars : where is the  $\text{CH}_4$  ?
- Phosphine on Venus : where is the  $\text{PH}_3$  ?

# A story of PH<sub>3</sub> detections on Venus

- Greaves, Jane S.; Richards, Anita M. S.; Bains, William et al. Phosphine gas in the cloud decks of Venus 2021NatAs...5..655G
- Trompet, L.; Robert, S.; Mahieux, A. et al. Phosphine in Venus' atmosphere: Detection attempts and upper limits above the cloud top assessed from the SOIR/VE spectra 2021A&A...645L...4T
- Snellen, I. A. G.; Guzman-Ramirez, L.; Hogerheijde, M. R. et al. Re-analysis of the 267 GHz ALMA observation of Venus. No statistically significant detection of phosphine
- Encrenaz, T.; Greathouse, T. K.; Marcq, E. et al. A stringent upper limit of the PH<sub>3</sub> abundance at the cloud top of Venus 2020A&A...643L...5E



# A summary of historical errors or difficulties

- Detection of chlorophyll on Mars (Sinton, 1957)
- Spectral confusion absorption/emission – doublet 3.52 micron (Ballester et al. 1994 / interpretation Drossart et al. 1995)
- Methane on Mars : where is the  $\text{CH}_4$  ?
- Phosphine on Venus : where is the  $\text{PH}_3$  ?
- Sodium in HD209458 : where is Na ?

# A story of Na detection on HD209458b

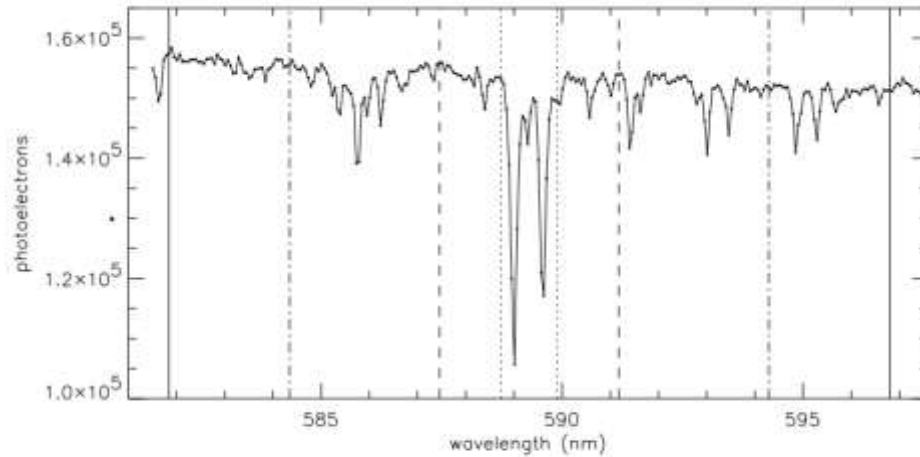


FIG. 1.—Portion of an STIS spectrum of HD 209458, centered on the Na D lines. The vertical axis is the number of detected photoelectrons per

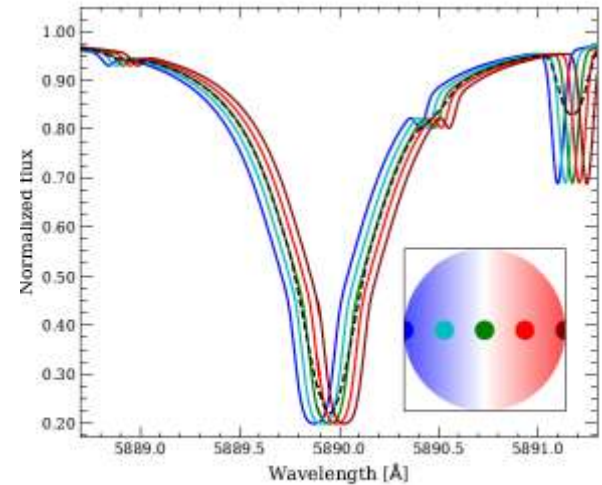


Fig. 3. Modelled stellar spectra around the Na I D2 line of HD 209458 system, containing only the RM effect. The black dashed line shows

- Charbonneau, David; Brown, Timothy M.; Noyes, Robert W.; Gilliland, Ronald L. *Detection of an Extrasolar Planet Atmosphere* 2002ApJ...568..377C
- Casasayas-Barris, N.; Pallé, E.; Yan, F. et al. *Is there Na I in the atmosphere of HD 209458b?. Effect of the centre-to-limb variation and Rossiter-McLaughlin effect in transmission spectroscopy studies* 2020A&A...635A.206C
- Morello, G.; Casasayas-Barris, N.; Orell-Miquel, J.; Pallé, E.; Cracchiolo, G.; Micela, G. *The strange case of Na I in the atmosphere of HD 209458 b. Reconciling low- and high-resolution spectroscopic observations.* 2022A&A...657A..97M

# Concluding remark



**Thou shouldst be careful before announcing any molecular detection on a planet. Especially if the molecule is of biological interest.**

# An unusual journey in the Solar System

Polar view is difficult to access from Earth telescopes for Solar System planets – not even talking about exoplanets

Polar views were obtained by various missions of exploration and have revealed key parameters in the atmospheric structure and dynamics, of importance not only locally, but even for the global redistribution of energy

# And exoplanets ?

... knowing the polar processes in the Solar System may help to better address the exoplanets simulations