POLLUX/LUVOIR requirements for exoplanet science

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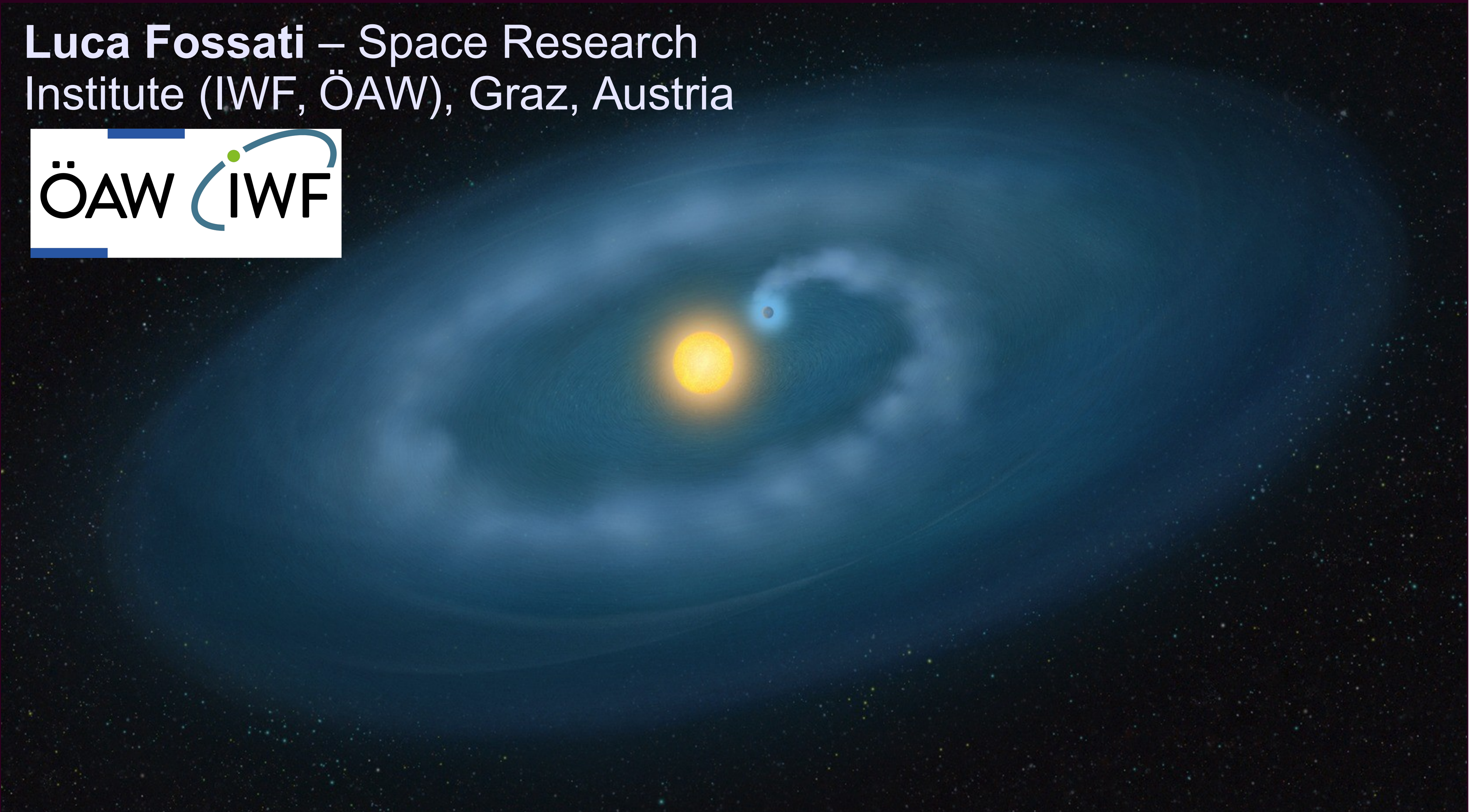


Working Group

Current members (21):

Beth Biller, Anthony Boccaletti, Vincent Bourrier, Jose Caballero, Andrea Chiavassa, Orlagh Creevey, Jean-Michel Desert, David Ehrenreich, Luca Fossati, Ana Ines Gomez de Castro, Carole Haswell, Mats Holmstrom, Kristina Kislyakova, Oleg Kochukhov, Antonino Lanza, Alain Lecavelier des Etangs, Isabella Pagano, Paul Palmer, Chris Pearson, Daphne Stam, Aline Vidotto

Countries covered (9):

Austria, France, Ireland, Italy, Holland, Spain, Sweden, Switzerland, UK
→ There are “missing” countries (e.g. Portugal, Germany, Belgium)

5 exoplanet WG members are also part of the cools stars WG

General science

POLLUX + LUVOIR →

wide range of planetary systems
move towards smaller, rocky planets
young systems

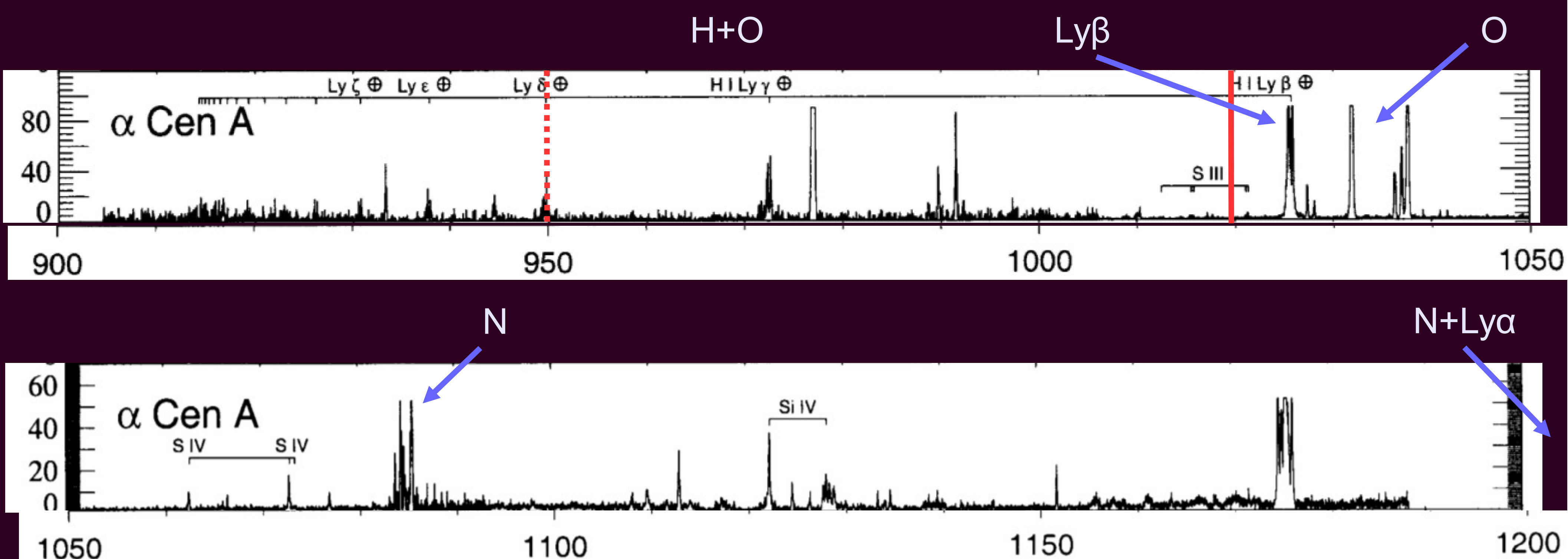
Exoplanet science with POLLUX/LUVOIR has 4 science drivers:
– planet atmospheric characterisation
– planet atmospheric escape
– star-planet interaction
– host star characterisation (share with cool stars WG)

Each instrument requirement is relevant for each of the 4 science drivers

Requirements: shortest wavelength

102 (95) nm

– coverage of the Lyβ line e.g. directly measure the temperature of escaping atmospheric gas (Lyα 121.5nm + Lyβ 102.5nm)
– coverage of O and **N** lines e.g. measure O (102.6 nm) and N (108, 113, 120 nm) during transit of Earth-like planets; NOCH abundances would lead to the detection of extra-terrestrial habitats
– measure lines with wider formation temperatures to explore the details of SPI

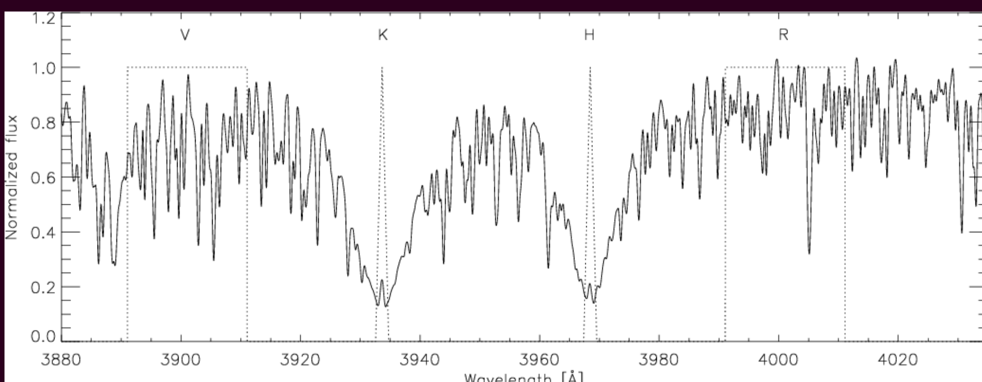


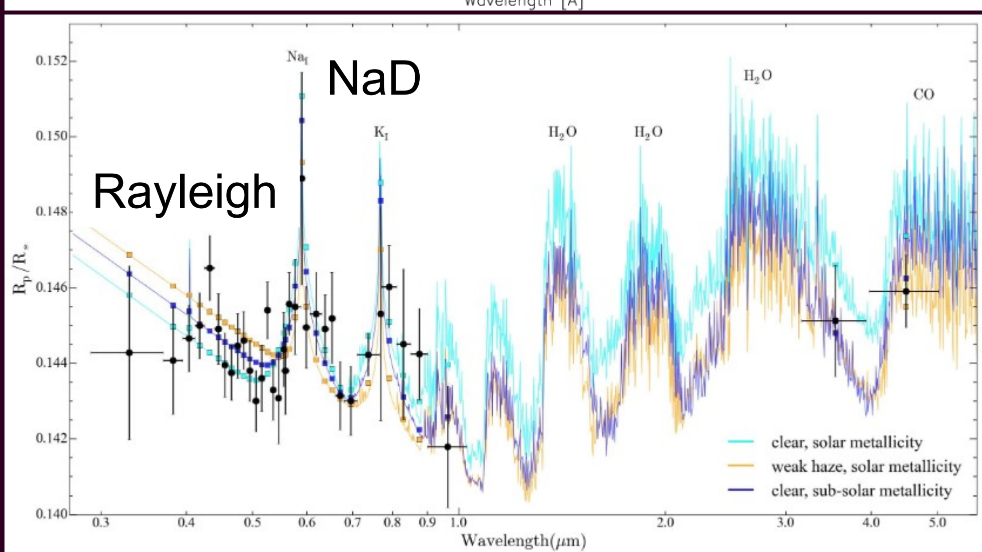
Redfield+2002

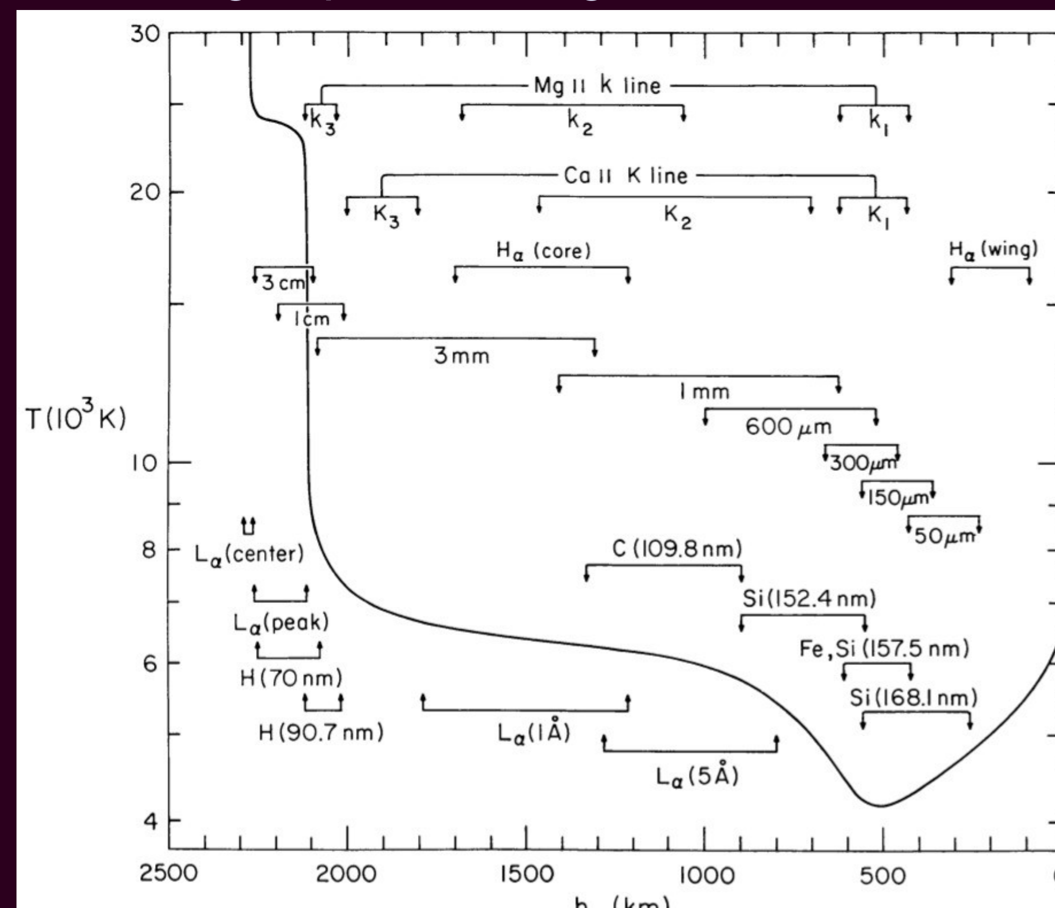
Requirements: longest wavelength

400 (600) nm

– coverage of the Ca2 H&K lines (main optical activity indicator) to study Ca in mineral atmospheres and measure stellar activity (allow meaningful ground-based surveys)
– detect and measure Rayleigh/Mie scattering to infer aerosol physical (altitude, size) chemical (constituents) properties
– polarimetric characterisation of planets: signal increases with decreasing wavelength
– cool stars & ISM WGs
– nice-to-have: NaD lines + Ozone band + scattering in polarised light





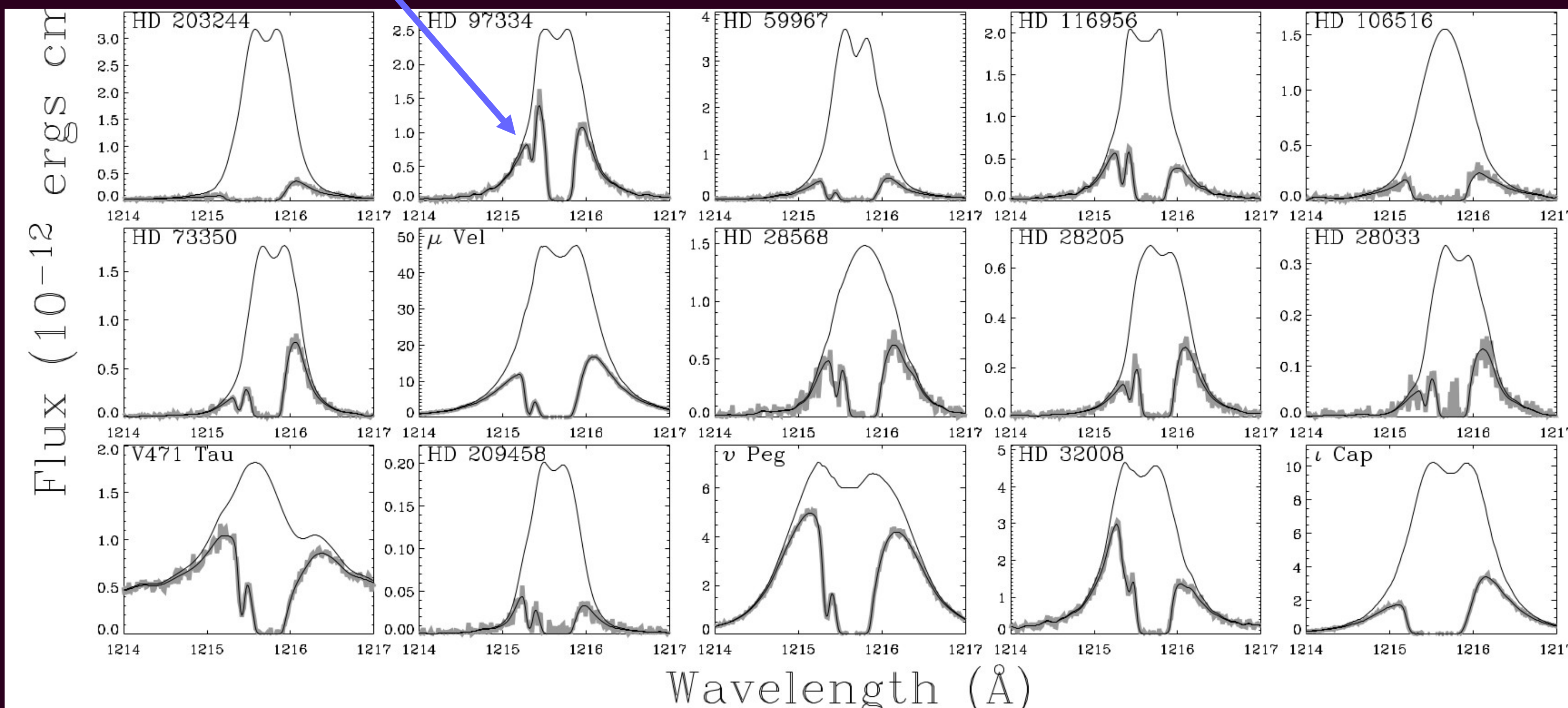


Requirements: spectral resolution

120,000 / 200,000

– high resolution (120,000) to resolve sharp stellar emission lines, to reconstruct Lyα line (Deuterium line!), and to detect sharp planetary absorption lines
– ultra-high resolution (200,000) to study dynamics of outflows from atmospheres and detect the very sharp geocoronal emission

Wood+2005a



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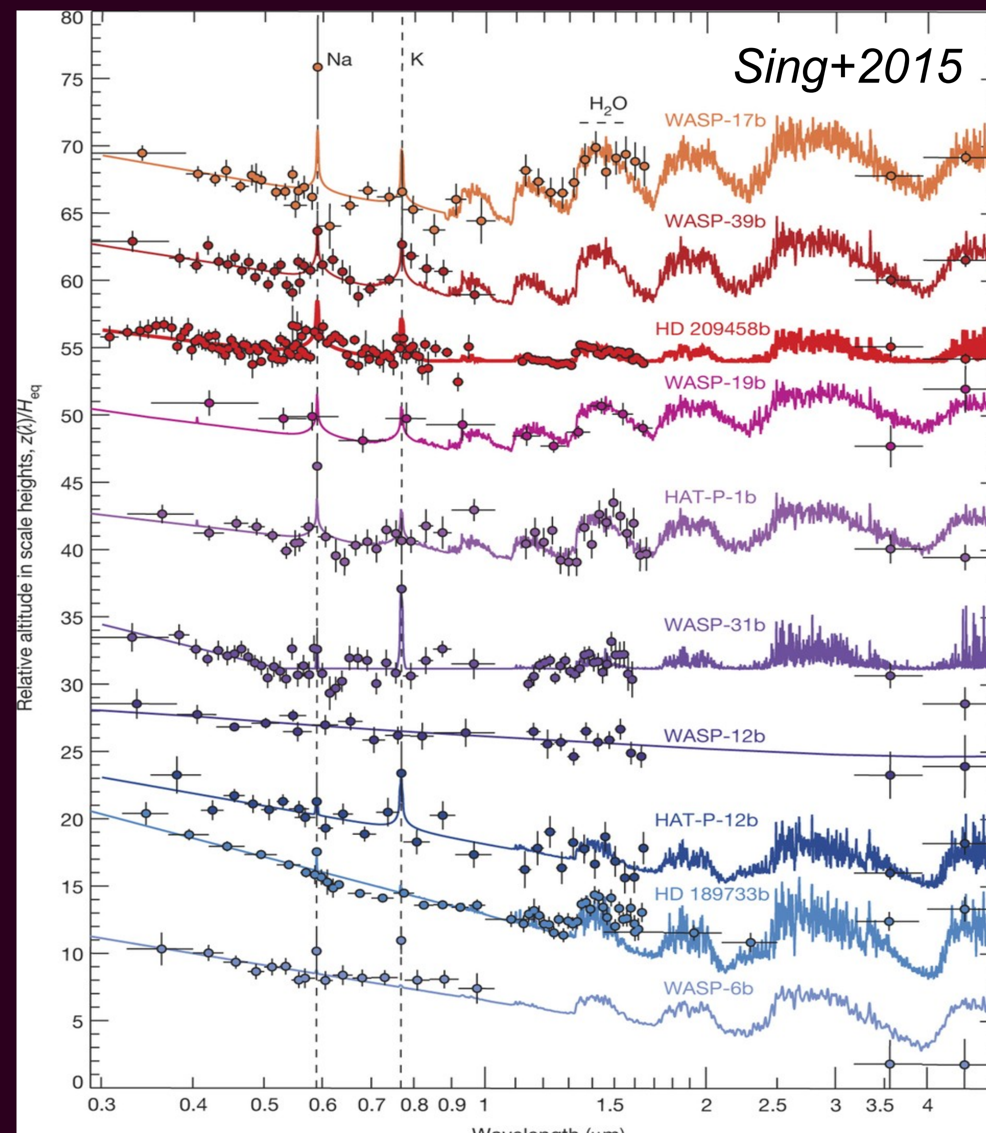
Simultaneous wide wavelength coverage, particularly for polarimetric studies!



Requirements: S/N

!!! 10^5 integrating for 15 hours over 1 Å a total flux of 5×10^{-17} erg cm^{-2} s^{-1} !!!

– Most difficult and important observation: detecting features in the transmission spectrum of an Earth-like planet, namely a transiting Earth mass/size planet in the habitable zone of a G-type star

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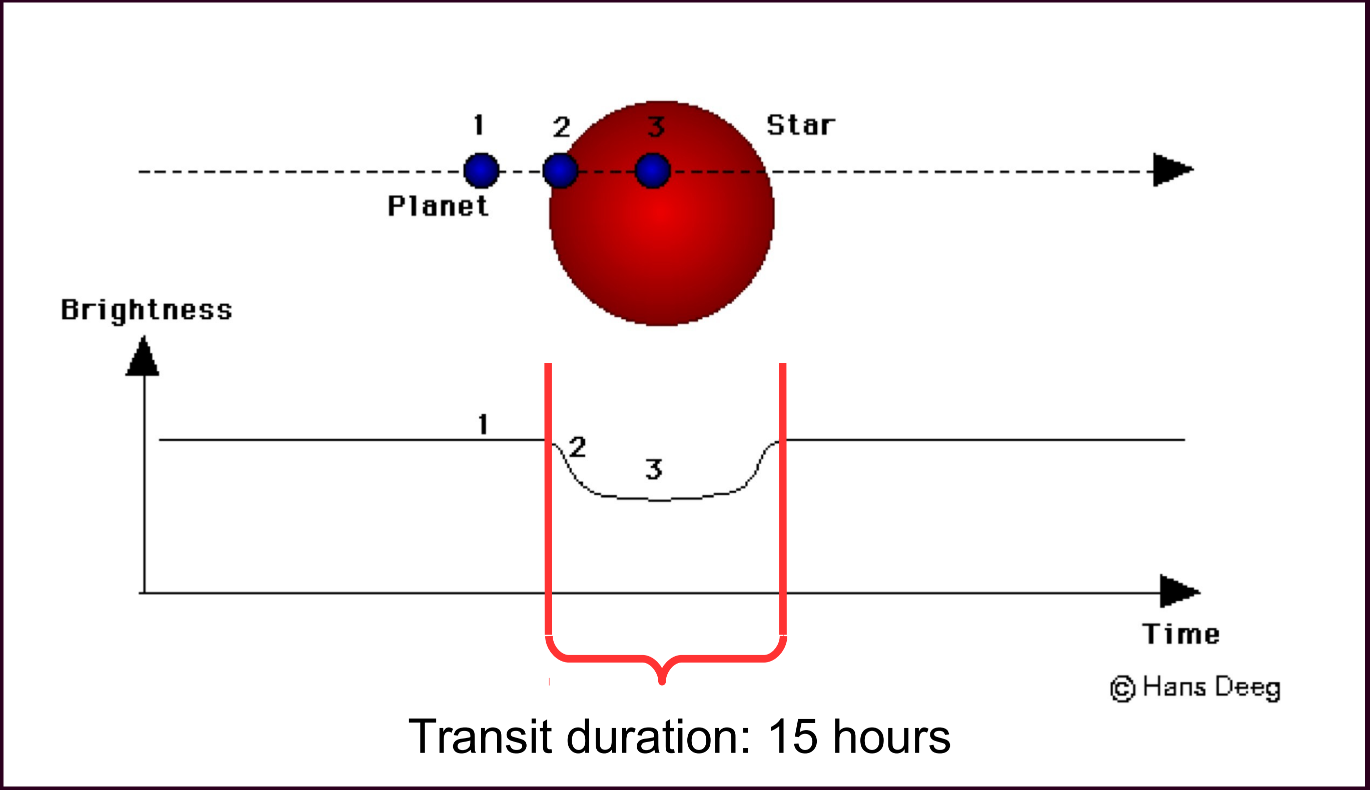

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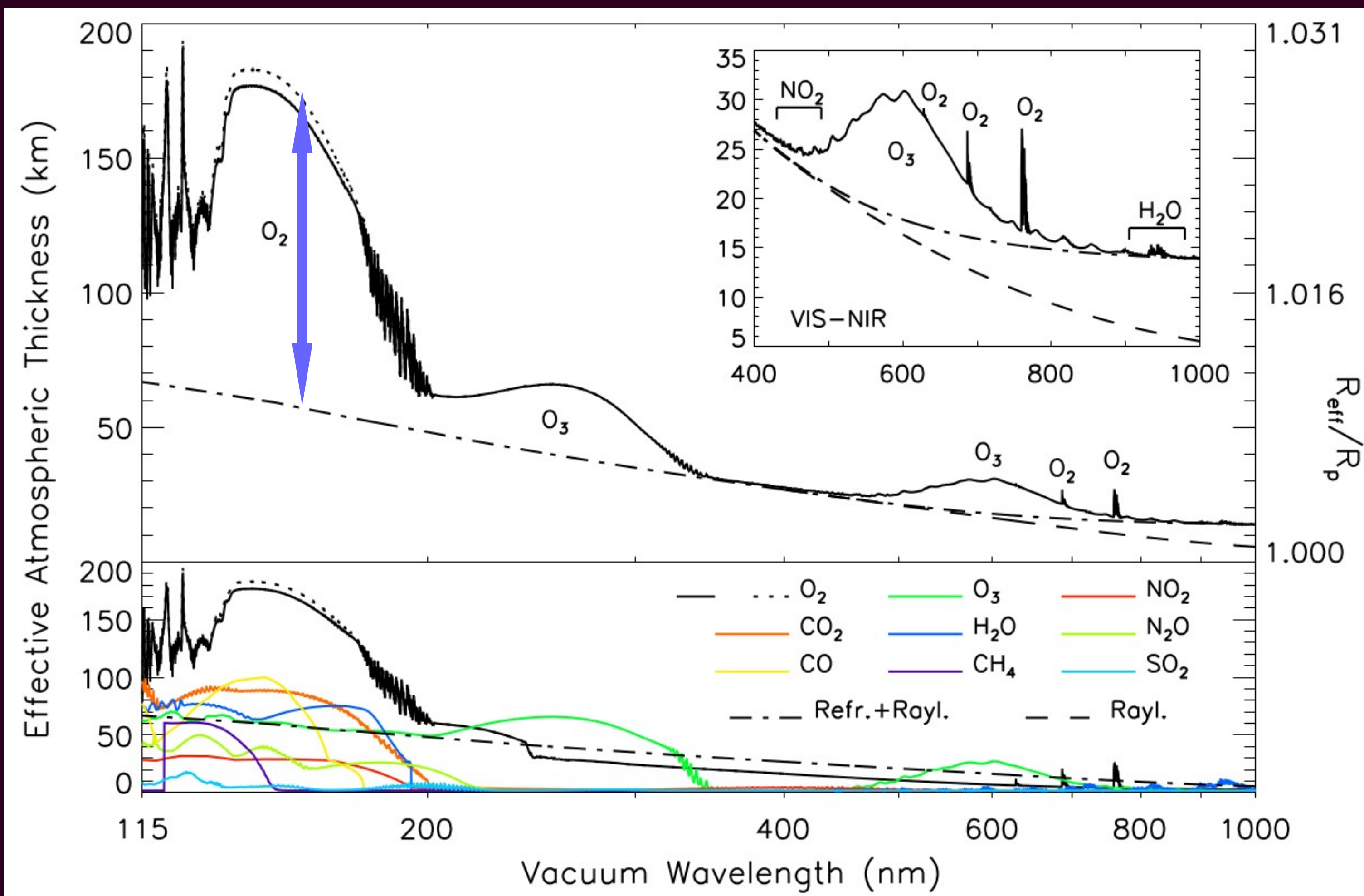

Betremieux & Kaltenegger 2013

Not planet detection: $(R_p/R_s)^2$ ~ 0.01% or 100 ppm

BUT

Planet atmospheric detection, hence detecting differences in transit depth as small as 10^{-5} / 5x10^{-6}

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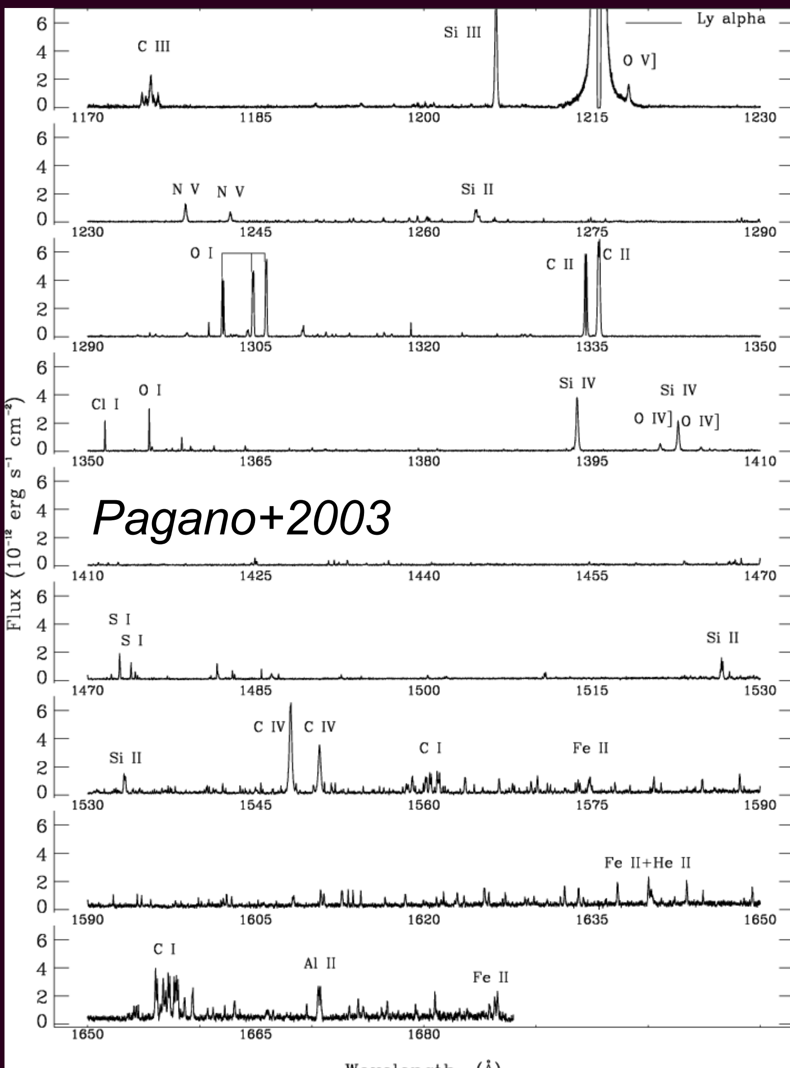
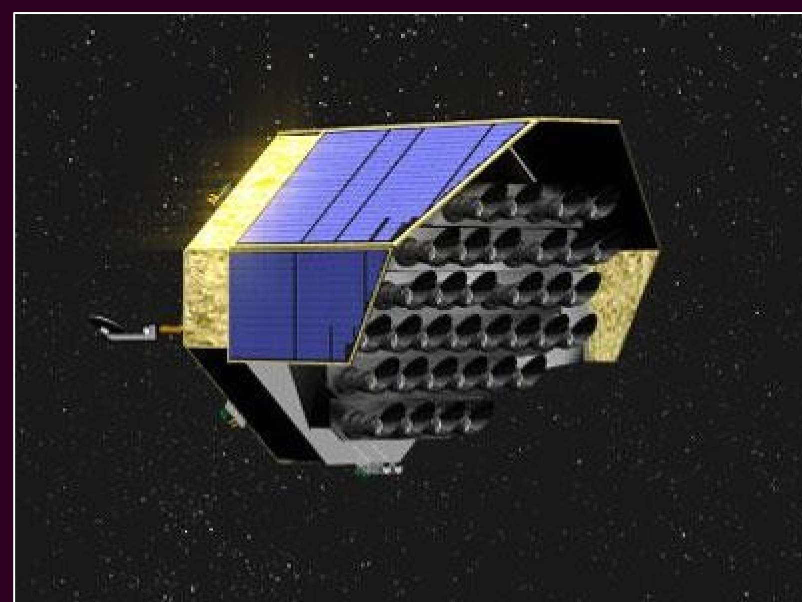


Narrow (~1 Å) stellar emission lines, but for molecular bands (O_2, O_3) one can integrate over tens of Å.



Realistically PLATO will detect Earth-like planets as bright as V=8 mag, that is as close as 60 pc

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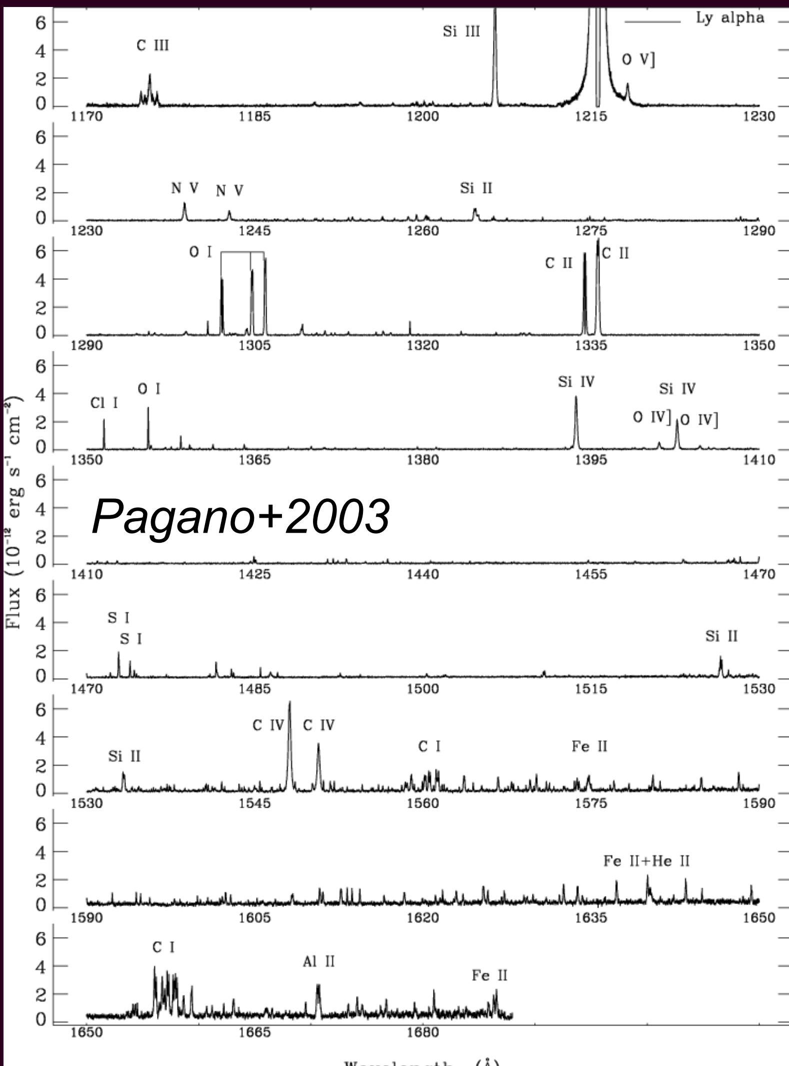

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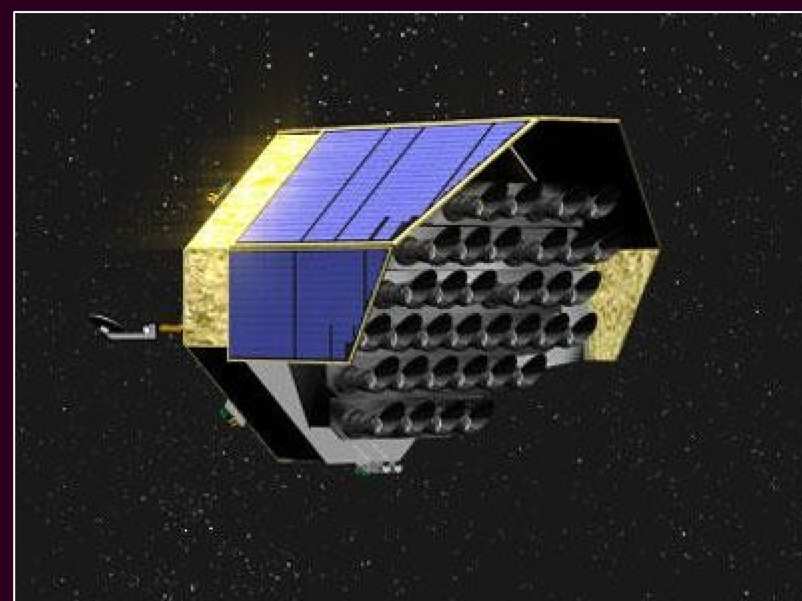

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Earths orbiting K- and M-type stars!!!

Requirements: detection level

Background 50 times lower than COS

– We need to be able to very clearly detect the stellar spectral features on which to try to detect the signal from the atmosphere of the Earth-like planet.
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– In-transit time plus out-of-transit time in comparable amount

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Requirements: flux stability

!!! 0.001% over 30 hours !!!

– We need to make sure that flux variations across the transit are not caused by instrumental instabilities

Requirements: polarisation

Circular: 10^{-6} / Linear 10^{-11} !!!

...1 polarised photon every 10^{6} in V and 1 polarised photon every 10^{11} in Q,U
– detection and measurement of average longitudinal magnetic fields of 1 G in single spectral emission lines (e.g. SPI)
– detection of the polarised light reflected from Earth-like planets

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Requirements: time resolution

0.5 / 1 minute

– detect and resolve stellar flares (~5-20 minutes)
– detect and resolve planet transit asymmetries (5 minutes)