Circumplanetary material could obscure molecular absorption signals from the forming planet PDS70b

Gabriele Cugno[1], **Polychronis Patapis**[1], **Tomas Stolker**[2], **Sascha P. Quanz**[1], **et al.**

[1] Institute for Particle and Astrophysics, Wolfgang-Pauli-Strasse 27,8093 Zürich, Switzerland

[2] Leiden Observatory, Leiden University, Niels Bohrweg 2, 2333 CA Leiden, The Netherlands

INTRODUCTION

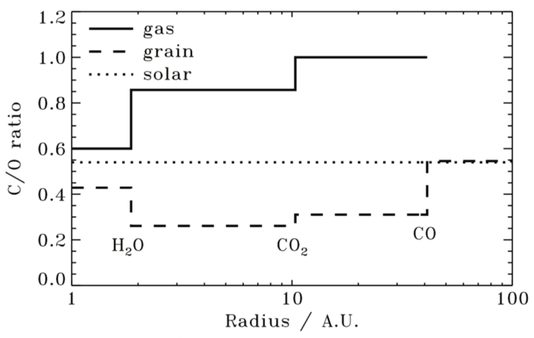


Figure from Öberg+2011.

- Elemental abundance ratios, e.g. C/O, deliver crucial information to reconstruct where planets have formed with respect to icelines in circumstellar disks.
- To validate the models, we need to measure C/O ratios in planets still forming in their natal environment.

- PDS70 is the only confirmed system that is hosting two forming planets that are carving the disk gap.
- Initial atmospheric characterization of PDS70b indicates T_{eff}~1200-1400 K, with R_p>2 R_J
- Enforcing dynamical stability, Wang+2021 constrained the mass of PDS70b to be <10M_J
- The protoplanets are still forming, as they are accreting material from their surrounding (Haffert+2019, Wagner+2018)

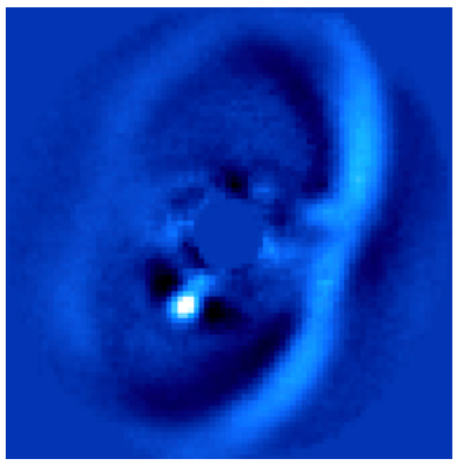


Figure from G. Cugno,
Data presented in Müller+2018, see also Keppler+2018, Haffert+2019, Stolker+2020, Wang+2021

PDS70b is the best available laboratory to test our current modelling of atmospheric enrichment.

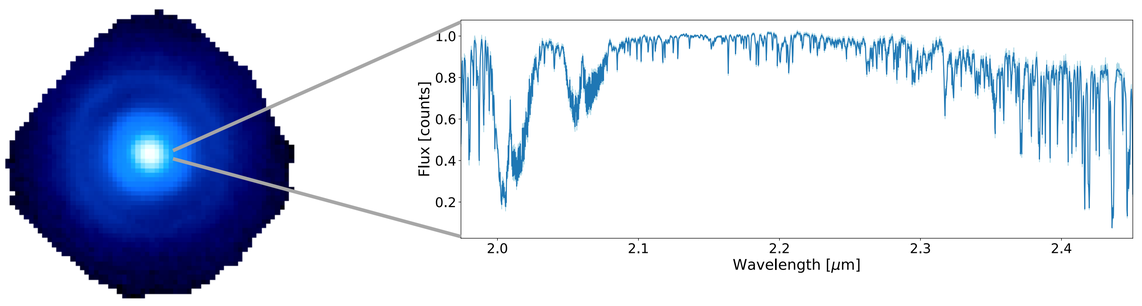
AIMS

Aims:

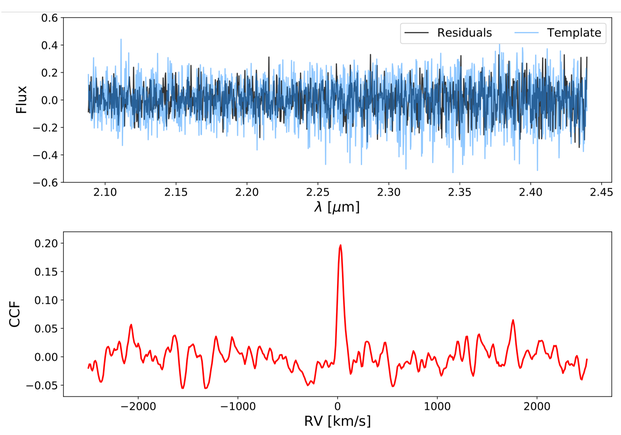
- To investigate the presence of molecules in the atmosphere of the companion PDS70b
- To confirm the presence of atmospheric absorption features detected in the SED
- To quantify the amount of material and dust obscuring the planet signal

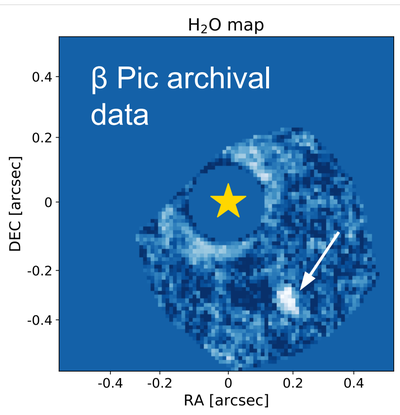
STRATEGY

We obtained medium resolution data with the VLT/SINFONI spectrograph



We applied spectral cross correlation to perform molecular mapping



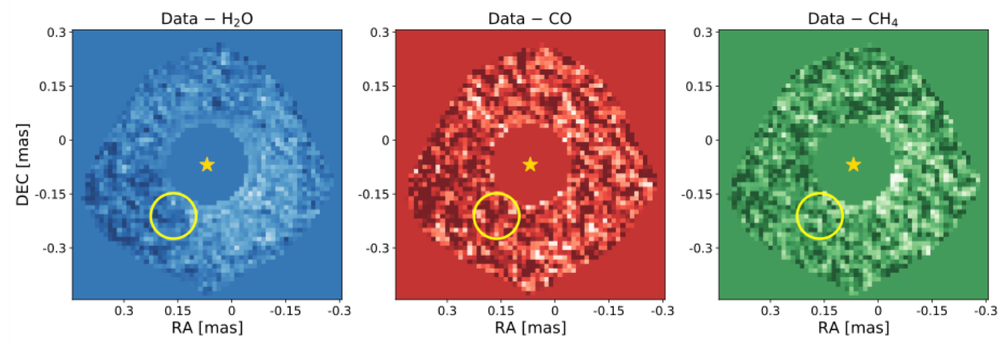


Cugno+ subm.
See also Hoeijmakers+ 2018

Molecular mapping can identify individual molecules in the emission spectrum of directly imaged exoplanets, allowing the study of their chemical composition.

RESULTS

No molecule was detected at the location of PDS70b



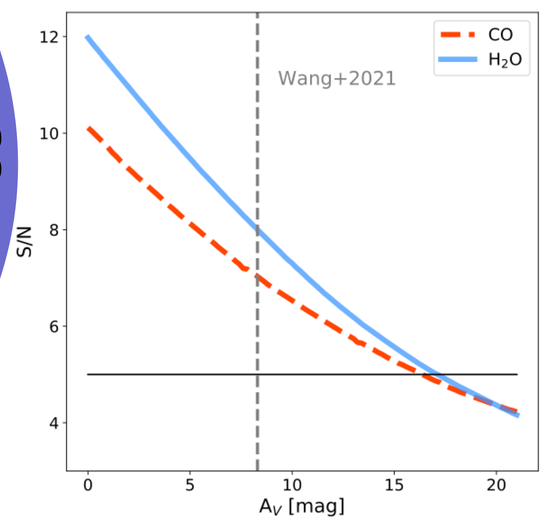
H_2O, CO and CH_4 molecular maps of the PDS70 system at RV~15 km/s. The central star represents the position of PDS70A, while the yellow circle indicates where a signal from PDS70b should be found.

What physics can we derive?

Assumption 1: PDS70b has a chemical composition similar to those of other giant planets

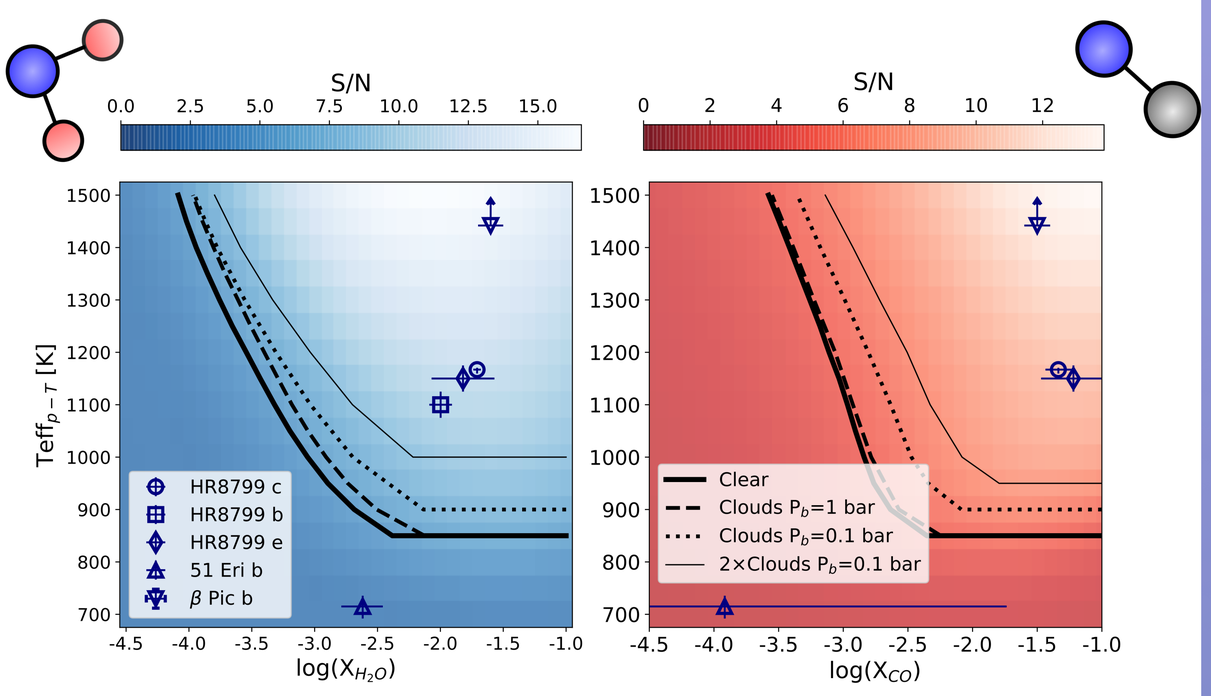
Assumption 2: with our observation we are directly probing the planet atmosphere.

Assumption 1: the minimal extinction necessary to hide the molecular signal of PDS70b is A_V~16 mag.



Signal to noise ratio of the detection of H_2O and CO as a function of extinction affecting the emission spectrum of the planet. Assuming PDS70b has the same chemical composition as HR8799c, an additional extinction with A_V≈16-17 mag (A_K≈1.2 mag) is required in order not to detect molecules with S/N>5. The vertical dashed line shows the maximum value obtained by SED fitting from Wang+2021. Such extinction would have revealed molecules in the planet atmosphere with S/N~7-9.

Assumption 2: PDS70b presents chemical properties different than other directly imaged companions.



H_2O and CO detection maps as a function of mass fraction X_{mol} and effective temperature $T_{eff,p-T}$ of the planet. Markers represent measurements for other directly imaged companions. Thick solid lines separate the region with S/N>5 from regions with S/N<5, i.e., represent the molecular detection limit as a function of planet temperature for clear atmospheres. Dashed, dotted and thin solid lines represent the molecular detection limits for different cloud configurations based on HR8799e (Mollière+2020).

CONCLUSION

- Non-detection of molecules suggests that a dusty environment likely enshrouds PDS70b
- Higher resolution observations could provide molecular detections and new information on the dust properties

gabriele.cugno@phys.ethz.ch
https://people.phys.ethz.ch/~gcugno/