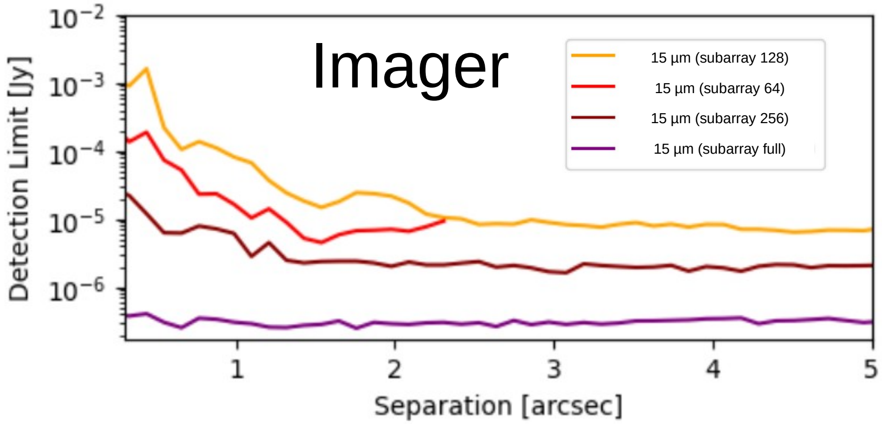
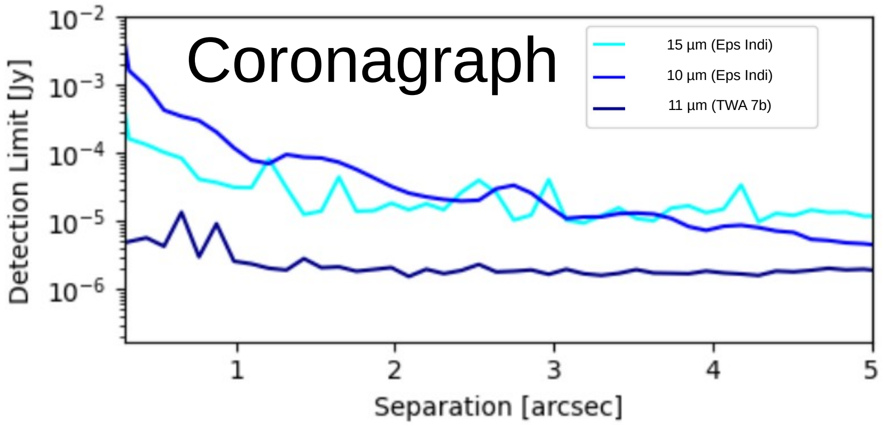
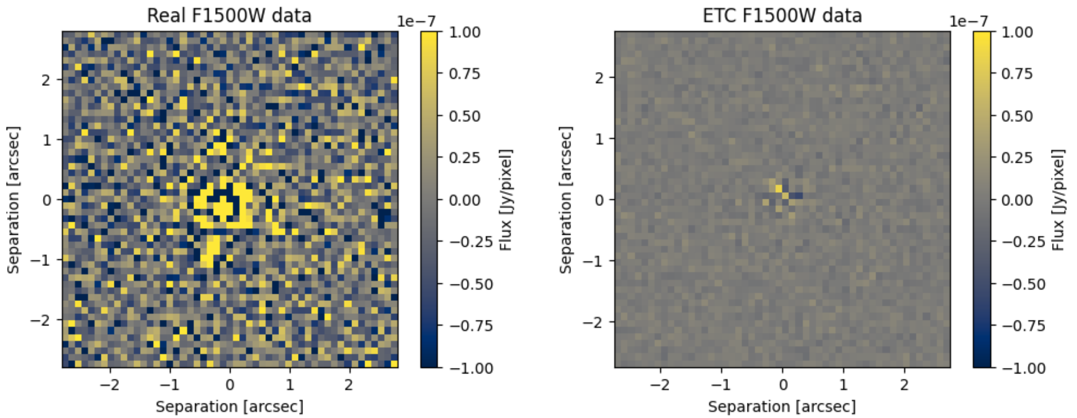
MIRI Direct Imaging of Exoplanets: Coronagraph or Imager?





JWST/MIRI: a powerful instrument for **cold exoplanet** detection

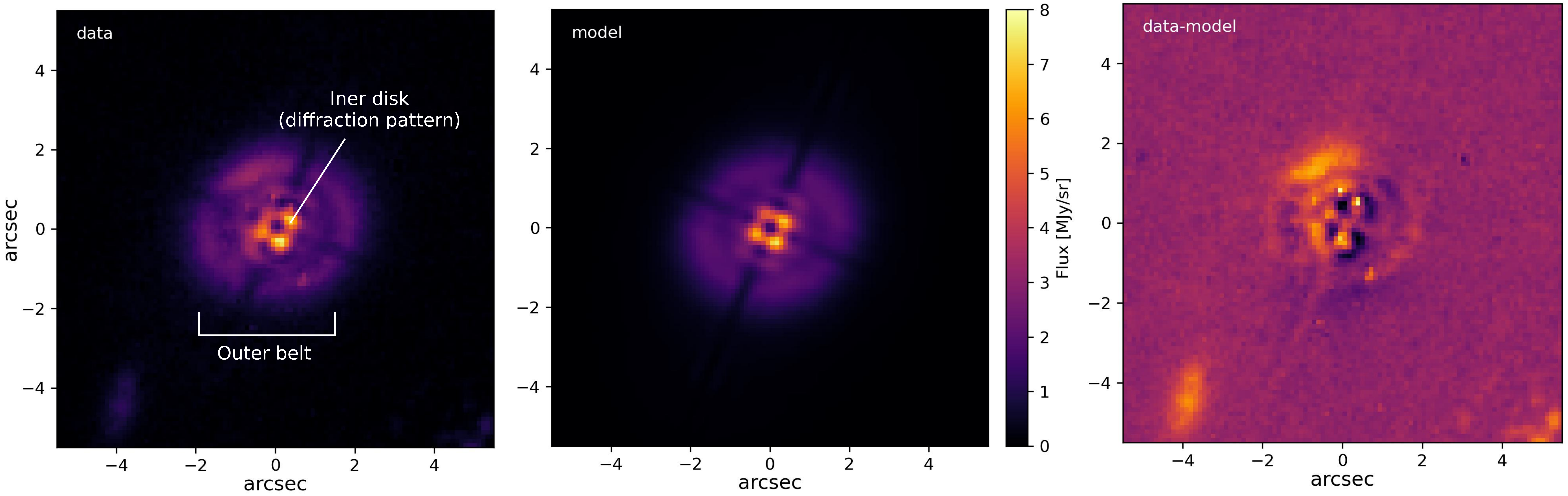
Coronagraphic data: **Eps Indi** and **TWA 7b**
Imager data: **Hot Rocks** transit survey,
used for direct imaging



Difference between observed noise level and expected noise level

Modeling Coronagraphic Observations with JWST/MIRI

Application to the debris disk HD 181327



MIRI / 4QPM coronagraph

11.4 μm

Inner belt

Modelling

1. Thermal emission of the disk (DDiT+)
2. The diffraction effects of the MIRI coronagraph (STPSF)

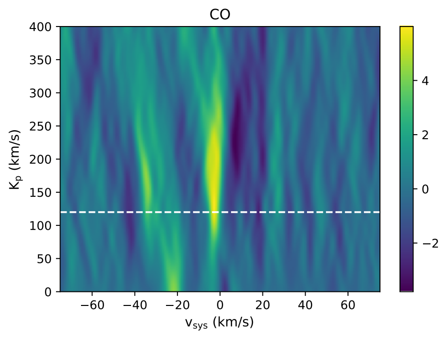
Results

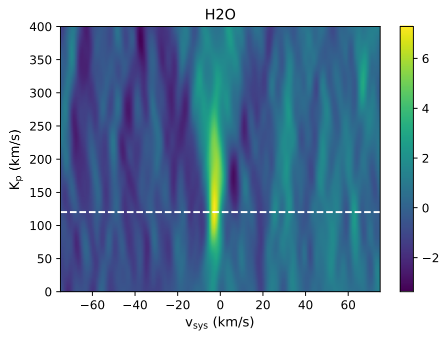
Inner belt at ~15 AU
Outer belt at ~85 AU
Flux asymmetries ? Point sources ?

Characterizing the atmosphere of HIP 67522 b with the combination of VLT/CRIRES+ and JWST/NIRSpec transmission spectra

CHABROL Estelle, *VINATIER Sandrine, DUCROT Elsa, LAVAIL Alexis, DEBRAS Florian, MASSON Adrien*

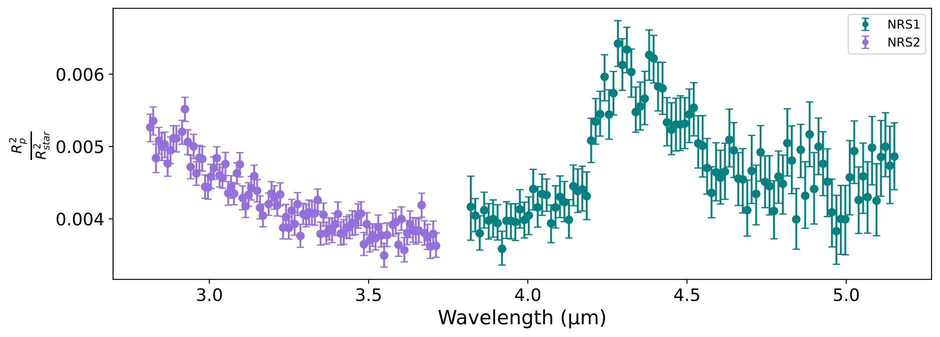
High spectral resolution analysis





Results : detection of CO & H_2O in the atmosphere of HIP 67522 b (Lavail et al. 2026).

Low spectral resolution analysis



Results : CO_2 & H_2O features in the NIRSpec transmission spectra.

Perspectives :

combining high- and low resolution spectroscopy in joint retrievals

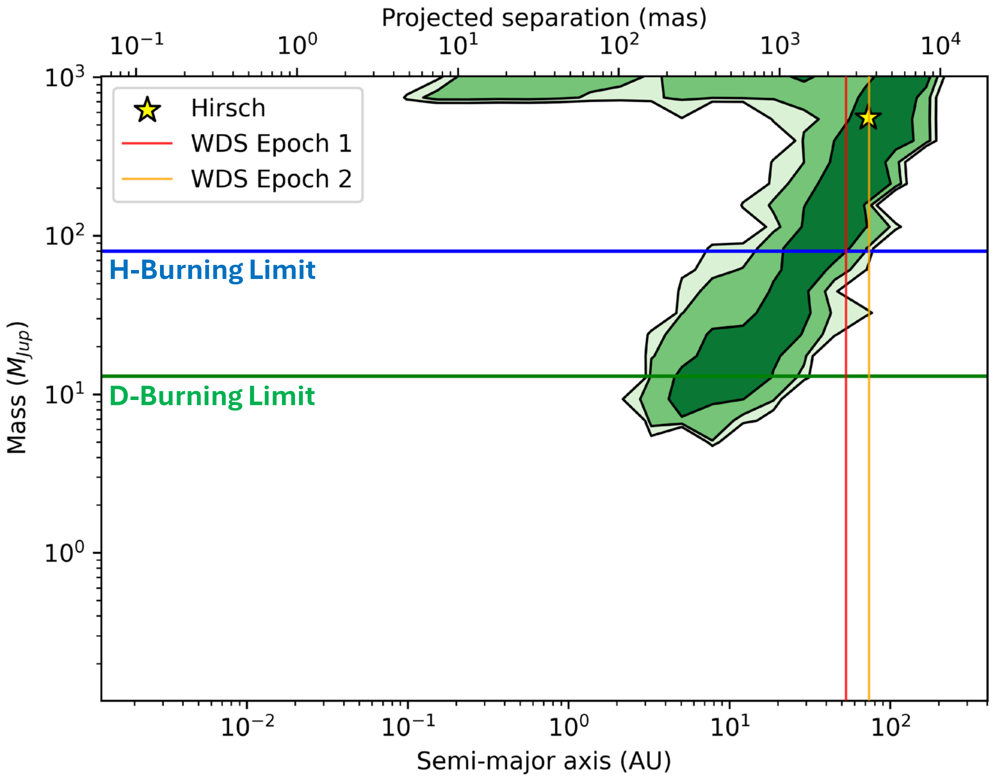
Searching for planetary companions around solar-type stars within 25 pc using *Gaia* astrometry

Aniruddha Girish Aramanekoppa (*LIRA, Observatoire de Paris*)

Aim: Detect new giant exoplanets using *Gaia* **renormalized unit weight error** (RUWE) and *Gaia–Hipparcos* **proper motion anomaly** (PMa)

Use the CNS5 sample to select **solar-type stars** within 25 pc with astrometric excess

Search for **bound companions** with the **GaiaPMEX** tool
→ using **RUWE** and **PMa**



Compare **GaiaPMEX** results with catalogues to **exclude known companions**

ONGOING WORK

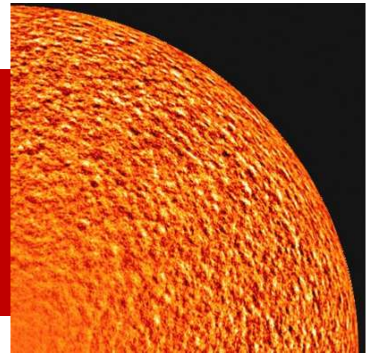
Use archival **RV and direct imaging** surveys to **constrain the properties** of new candidates

New candidates will be prime targets for **future follow-up observations** with JWST, ELT and HWO

erc COBREX
cnrs LIRA Observatoire de Paris | PSL

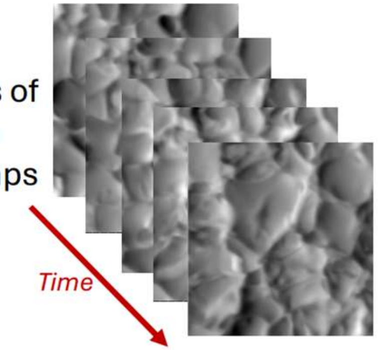
Is the line bisector a reliable indicator of supergranulation-induced radial velocity variations ?

N. Meunier, S. Sulis, L. Bigot, N. O'Sullivan, T. Roudier

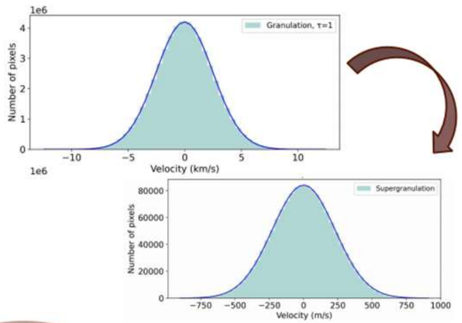


Simulation methodology : from granulation to supergranulation, from local to full disk

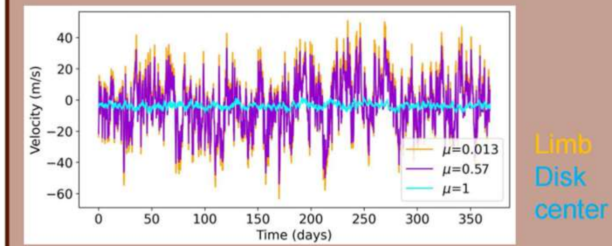
Time series of granulation velocity maps (MHD)

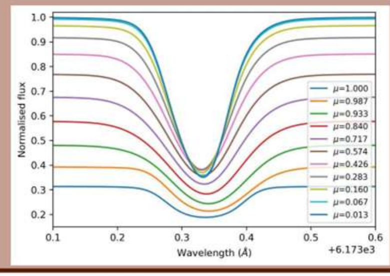


Granulation properties scaled to SG



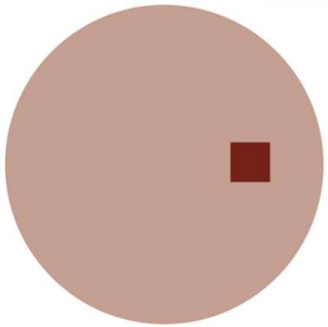
Synthetic time series of ***local*** SG velocities at different μ





Synthetic granulation spectra (6173 Fe line) at different μ

Time series of spectra shifted according to SG properties at different μ



Paving the **full disk**

Time series of integrated spectra representative of SG variations

Meunier, Sulis, Bigot et al in prep

New planetary-mass companions found in debris disks using Gaia

Sven Toucheboeuf[1], Anne-Marie Lagrange[1], Flavien Kiefer[1], Pascal Rubini, Julien Milli[2], Luca Matrà[3], Hervé Beust[2], Clément Perrot[1], Mathilde Mâlin[4], Anthony Boccaletti[1], Christian Wilkinson[1], Philippe Delorme[2]

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Introduction

Debris disks may exhibit structures such as warps, gaps, inner voids, and rings. These are often interpreted as **indirect signatures of planets** (Pearce et al. 2024), but may also be attributed to alternative mechanisms that do not involve planets (Lyra & Kuchner 2013). However, if planets are responsible for these structures, they have not been detected in most cases.

Gaia opens a new mass-separation parameter space to detect giant planets, typically between 0.1 au and 10 au.

Sample and methods

Our sample is composed of the 74 systems with resolved belts studied in Matrà et al. (2025) and 20 additional systems with resolved disks not included in Matrà et al. (2025) found from the literature.

A tool named **GaiaPMEX** has been developed to detect and characterize companions using astrometric data (Kiefer et al. 2025a,b). We run GaiaPMEX on each system. For detections, **we use RV and HCI data when available to better constrain the companion's mass and separation**. For non-detections, we consider a sub-sample of emblematic systems and systems with disks displaying well-defined ring-like structures, and **present detection limits** produced by a Monte Carlo framework **using astrometric, RV, and HCI data**. For the remaining systems, we present the detection limits using only astrometric data.

Detections

We detect five companions at a 3σ significance: one stellar companion around HD 54341, one stellar or brown dwarf (BD) around HD 146897, one previously known planet around HD 206893, and **two previously undetected planets** around HD 106906 and HD 107146. We also find hints for companions (significance > 2σ) around HD 120326, TWA 7, and BD+45° 598.

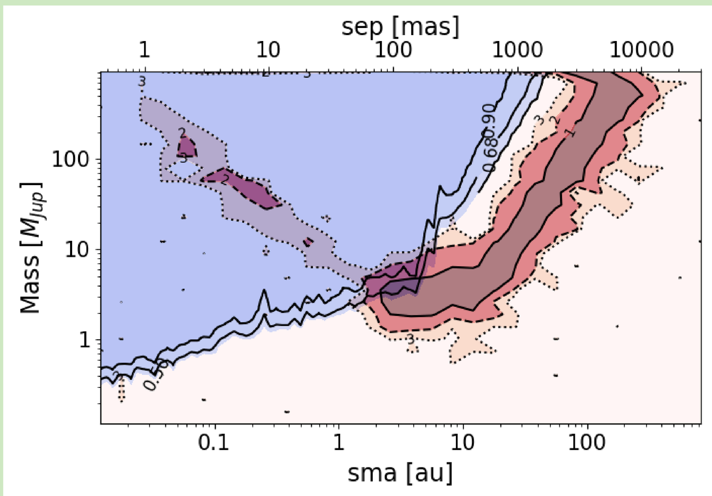

Fig. 2: HD 107146 GaiaPMEX solutions (red) superimposed with exclusions (blue) set by RV data

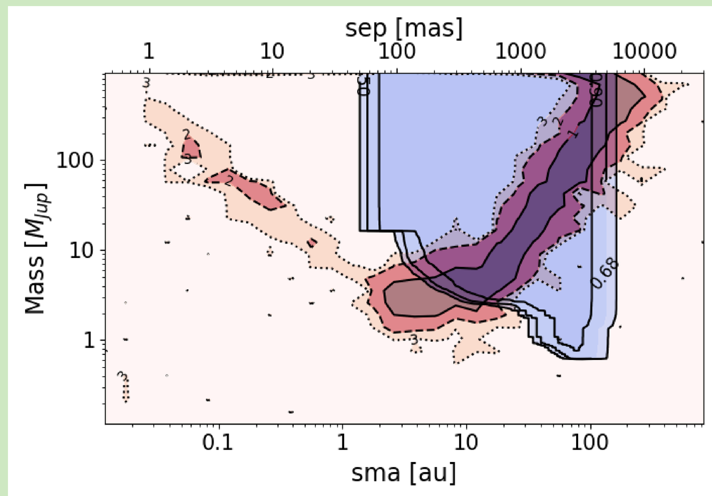

Fig. 3: HD 107146 GaiaPMEX solutions (red) superimposed with exclusions (blue) set by HCI data

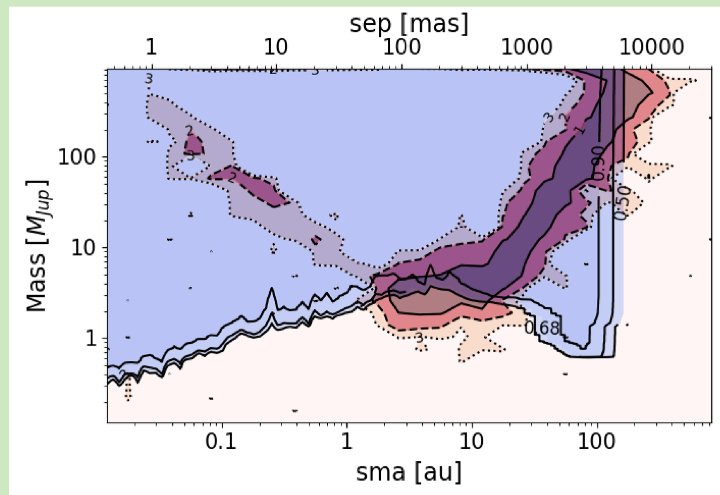

Fig. 4: Combination of the RV and HCI exclusions for HD 107146

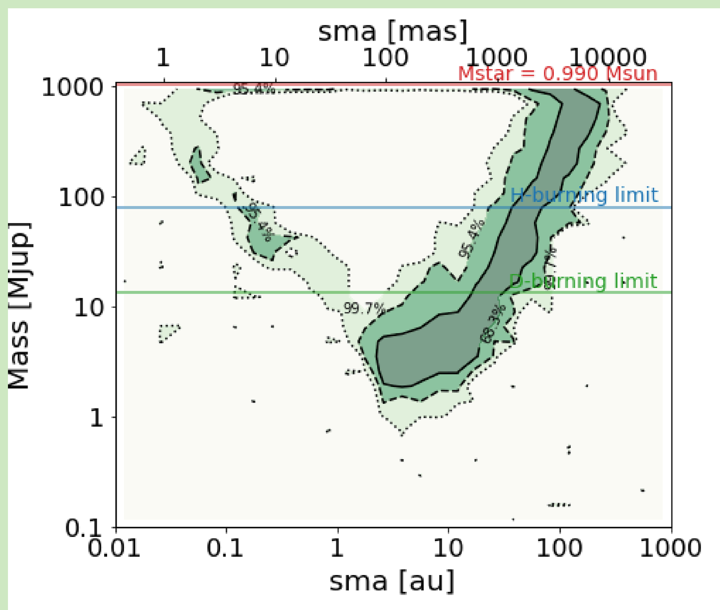

Fig. 1: GaiaPMEX solutions for the detected companion around HD 107146

Constraining the solution: the example of HD107146

HD107146 hosts a 100 au-wide debris disk with an inner edge at 50 au in millimeter images (Marino et al. 2018, Matrà et al. 2025). Pearce et al. (2024) found the **inner edge to be steep enough to be compatible with planet sculpting**. No planets have been detected in this system.

Using OHP/SOPHIE RV data and SPHERE and JWST HCI data, we exclude the vast majority of the degenerate solutions. The stellar-mass solutions at separations > 5'' can also be excluded, as such a binary star would have been detected previously. The remaining solutions indicate a **2-6 M_J planet orbiting between 2 and 10 au**.

HD107146 b alone cannot sculpt the inner edge of the disk, but could excite smaller planets at larger separations that could sculpt the inner disk. A direct detection of HD107146 b would only be possible with the upcoming ELT.

Detection limits

To compute detection limits, we use the code PyMESS, a Monte Carlo framework that allows us to **combine exclusions from RV, HCI, and GaiaPMEX data** (Lannier et al. 2016, Lagrange et al. 2025). While RV and HCI detection limits were already available, the use of astrometry allows to exclude significantly lower masses in the 0.1-10 au range, allowing for more complete detection limits. These detection limits will help better study these systems.

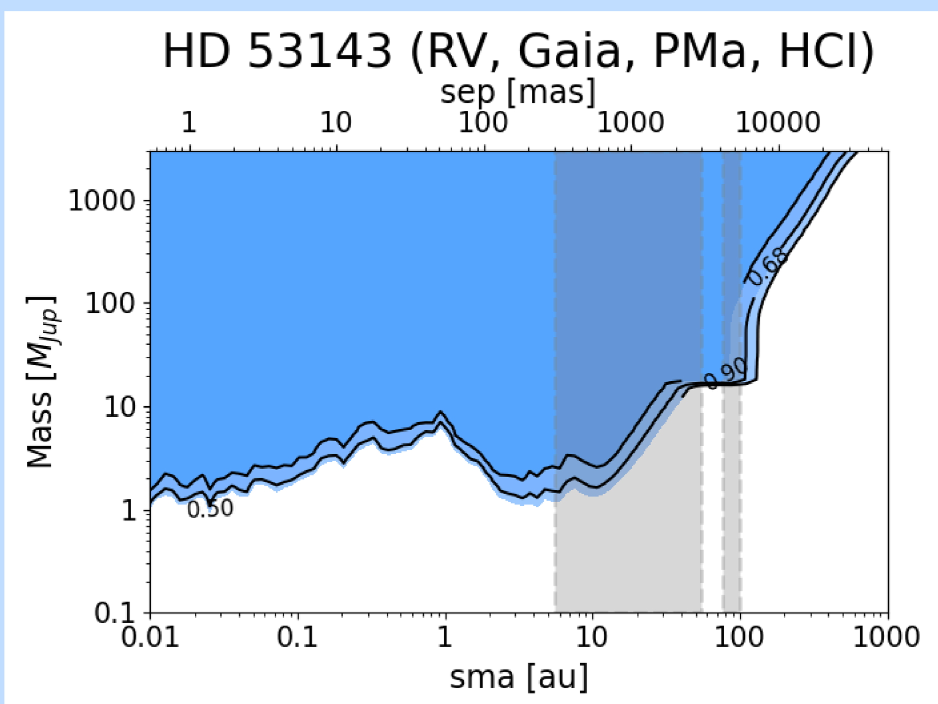

Fig. 5: Detection limits for HD 53143 using HARPS RV, GaiaPMEX, and SPHERE HCI data. Location of debris disk in gray.

Conclusion

Our search for companions around stars with debris disks resulted in the unambiguous detection of five companions, of which four are first discoveries (HD54341, HD 106906, HD 107146, HD 146897). We also find hints for companions in three systems (HD120326, TWA 7, and BD+45° 598). The Gaia DR4 should confirm and fully characterize the three possible companions.

JWST and VLTI/Gravity may be able to image some of the detected companions, while the remaining will require the capabilities of the ELT.

Our lowest-yet detection limits demonstrate the value of combining RV, HCI, and astrometric data.

Acknowledgements

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Coupling Atmospheric Fractionation and Mass Loss: Implications for Sub-Neptunes

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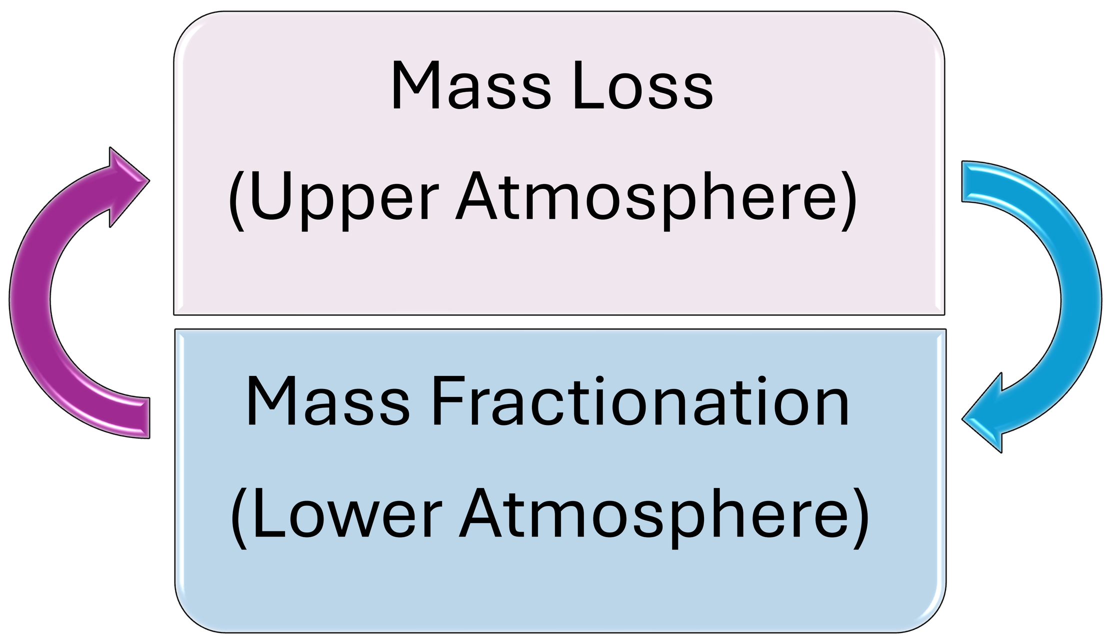
1. INTRODUCTION & CONTEXT

Sub-Neptunes are the most abundant class of exoplanets found in the universe [1], yet they have no analogue in our own Solar System. Understanding their atmospheres and the underlying physical processes remains of prime interest.

In particular, we examine how **gravitational fractionation** in the middle atmosphere above the homopause affects **atmospheric loss** occurring in the upper atmosphere in water rich Sub-Neptunes.



2. CHEMICAL NETWORK

We used an updated C-H-He-O chemical network which includes 33 species including 16 neutrals, 17 ions and electron.

CO_2	H_2O	CO_2^+	H_3^+
CO	H_2O_{ice}	O_2^+	HO_2^+
O_2	HO_2	HCO_2^+	HeH^+
$O_2(^1\Delta)$	OH	HCO^+	$H_2O_2^+$
$O(^1D)$	H_2O_2	H^+	$H_3O_2^+$
$O(^3P)$	$O(^1S)$	H_2^+	He^+
O_3	He	OH^+	e^-
H	CO^+	H_2O^+	
H_2	O^+	H_3O^+	

Fig. 1: List of chemical species included in the model

Reactions: The model comprises of a total of 254 reactions with 37 photolysis reactions, 201 bimolecular reactions and 16 termolecular reactions. [2,3,4]

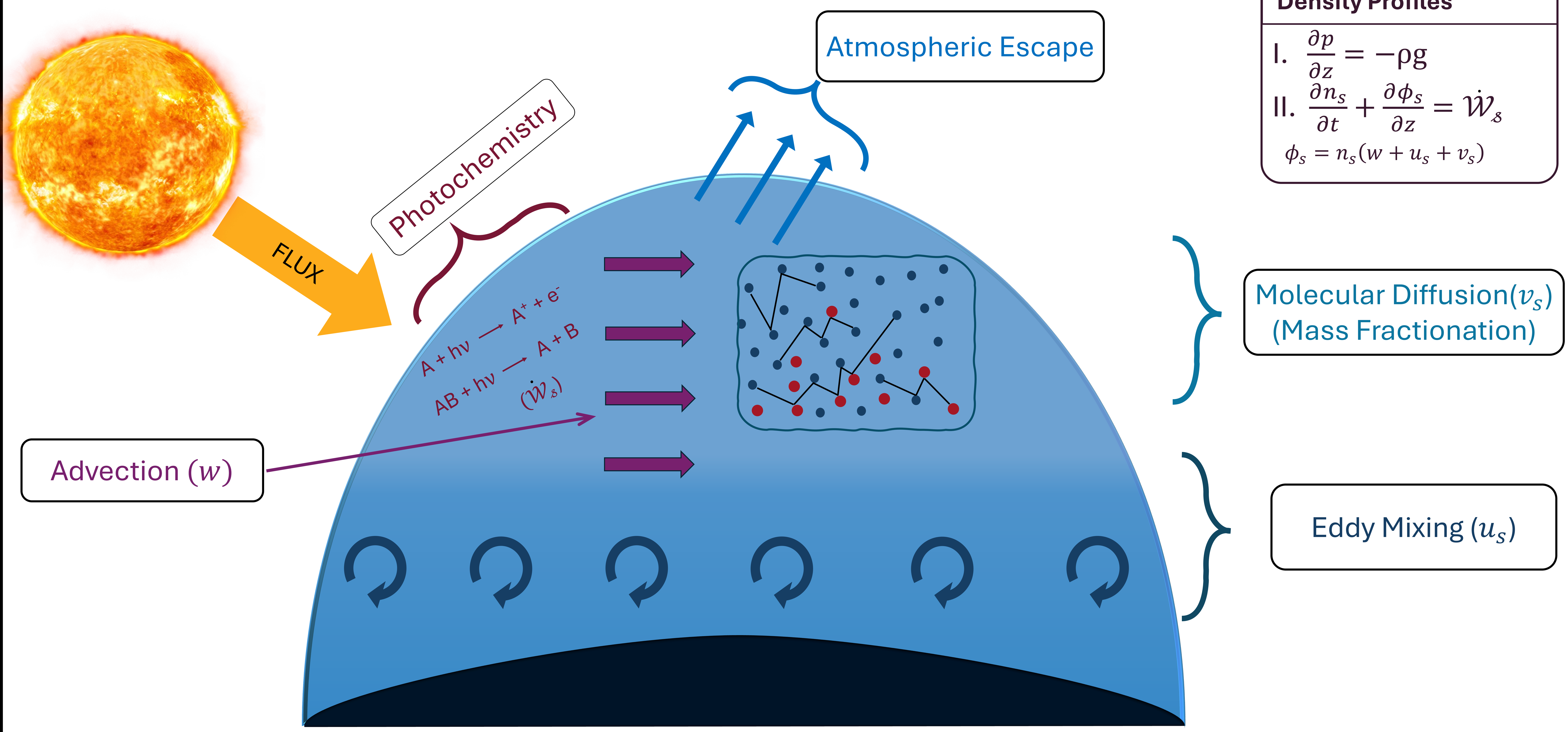
3. PLANETARY ATMOSPHERE: 1D PHOTOCHEMICAL MODEL

Density Profiles

I. $\frac{\partial p}{\partial z} = -\rho g$

II. $\frac{\partial n_s}{\partial t} + \frac{\partial \phi_s}{\partial z} = \dot{\mathcal{W}}_s$

$\phi_s = n_s(w + u_s + v_s)$



➢ Our self-consistent model explicitly incorporates all these processes, addressing a key limitation of existing fractionation models. [5,6,7,8]

4. FUTURE WORK

I. Can Sub-Neptunes sustain hydrogen rich atmospheres via diffusion-limited mass loss ?

II. Or is there enrichment of Sub-Neptune atmospheres due to the preferential loss of hydrogen caused by fractionation?

III. Crossover mass constraint i.e what is limiting mass above which particles are too heavy to be dragged along with lighter escaping species like hydrogen?

IV. How does the fractionation of lighter species produced due to photodissociation of heavier species like H_2O modulate escape fluxes.

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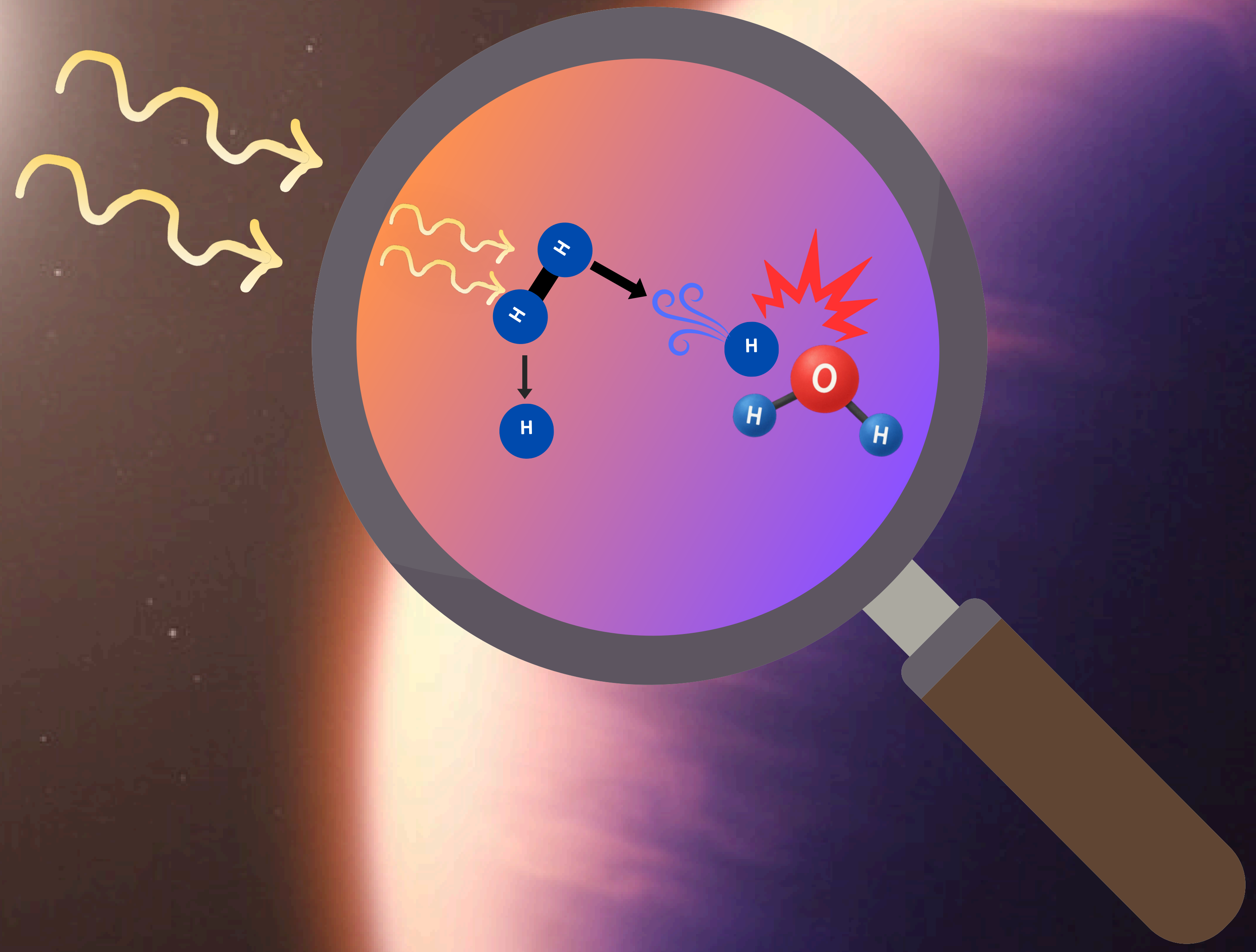
Non-thermal chemistry in exoplanet's atmosphere



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