Do planets leave chemical fingerprints on their host stars? Clues from wide binaries

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Abstract

As more exoplanets are discovered in the Milky Way, understanding the properties of their host stars is becoming increasingly important. **One key question is whether planets can leave detectable chemical fingerprints in host-star atmospheres.** Wide binaries provide a valuable testbed because their components are expected to share a common formation environment and evolutionary history. We observed four planet-hosting wide-binary systems with IGRINS on the Gemini-South telescope and searched for planetary signatures through differential abundance trends with elemental condensation temperature (T_{cond}). Across our targets, we find positive, nearly flat, and negative abundance trends with T_{cond} trends, suggesting that chemical fingerprints are diverse and system-dependent. Our compilation of literature samples suggests that **extreme T_{cond} slopes may occur more frequently in planet-hosting wide binaries, particularly at large binary separations.**

Paper

Lim et al. 2026

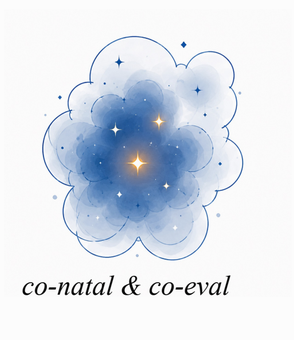
A&A in press

Keywords to read this poster

- **Wide binary:** A binary stellar system with a separation from a few au to several thousand au. Its components are expected to be co-natal, co-eval, and chemically homogeneous. Because of these properties, wide binaries provide powerful laboratories for many astronomical topics, including planet-related chemical signatures.
- **IGRINS:** A high-resolution near-infrared spectrograph formerly mounted on Gemini-South. It simultaneously covers the H-band (1.49 – 1.80 μm) and K-band (1.96 – 2.46 μm) with $R \sim 45{,}000$, providing useful C, N, and O molecular features.
- **Elemental condensation temperature (T_{cond}):** The temperature at which an element condenses from the gas phase into solid material. It is commonly used to distinguish volatile and refractory elements.
- **Volatile elements**, such as C, N, and O, have low T_{cond} and trace gaseous material, while **refractory elements**, such as Fe, Mg, and Si, have high T_{cond} and trace rocky material. Their differential abundance patterns are key diagnostics of possible chemical signatures linked to different planetary materials and architectures.

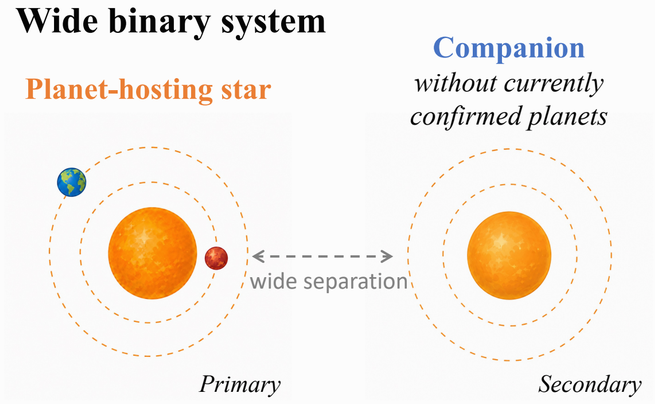
Why wide binaries?

Shared origin



co-natal & co-eval

Wide binary system



- ✓ Same initial conditions
- ✓ Similar Galactic evolution
- ✓ No strong mutual interaction

⇒ Any small chemical difference may trace later processes, including planet-related processes.

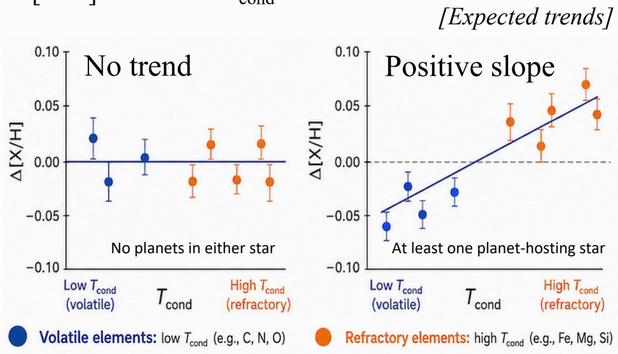
⇒ **Controlled testbed** for detecting planet-related signatures

Differential comparison

$\Delta[X/H] = [X/H]_{primary} - [X/H]_{secondary}$

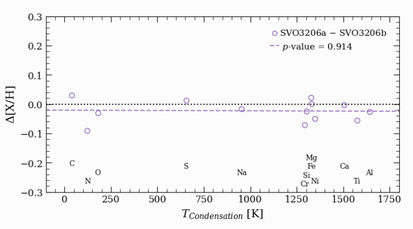
$\Delta[X/H]$ trend with T_{cond}

[Expected trends]

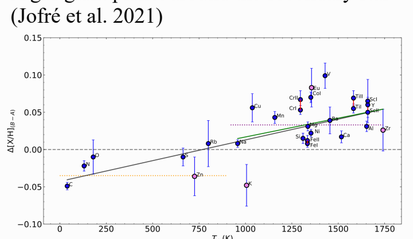


Observed examples

No known planets in both stars (Lim et al. 2024)



A gas giant planet around the secondary star (Jofré et al. 2021)



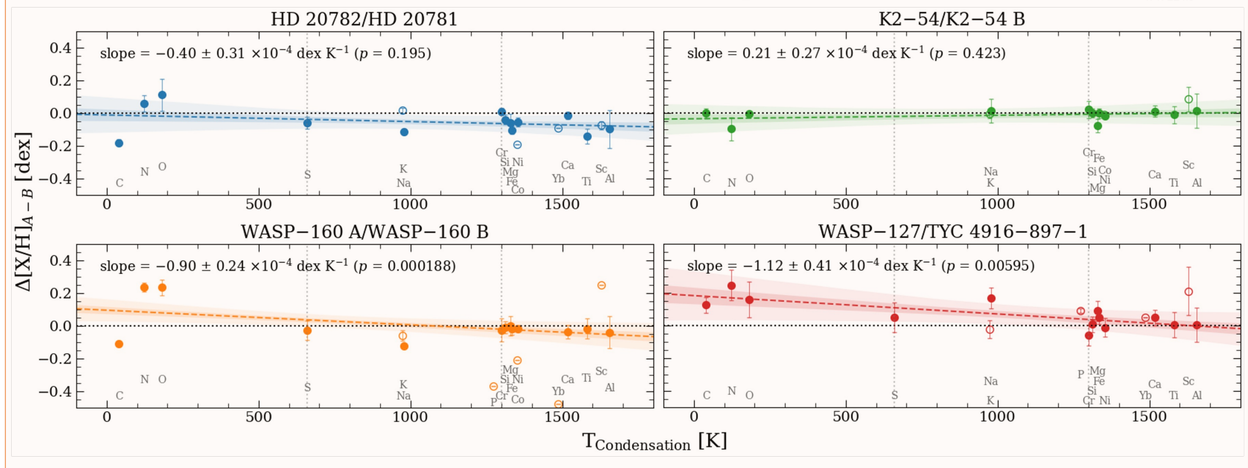
Individual systems: diverse T_{cond} trends

- IGRINS observations of four planet-hosting wide binaries reveal diverse $\Delta[X/H]$ versus T_{cond} trends.

System (Primary/Secodnary)	Host	Planet type	Host trend*
HD 20782 / HD 20781	Primary Secondary	1 gas giant 1 super-Earth & 3 Neptune-like	Volatile ⇔ Refractory ⇑
WASP-160 A / WASP-160 B	Secondary	1 gas giant	Volatile ⇓ Refractory ⇑
K2-54 / K2-54 B	Primary	1 Neptune-like	Volatile ⇔ Refractory ⇔
WASP-127 / TYC 4916-897-1	Primary	1 gas giant	Volatile ⇑ Refractory ⇔

** **Host trend** indicates the abundance pattern of the planet-hosting star relative to its companion (⇑: enhanced; ⇔: similar; ⇓: depleted). For HD 20782/HD 20781, HD 20781 is adopted as the reference host because it hosts multiple planets.*

[Abundance differences between the two components as a function of T_{cond}]

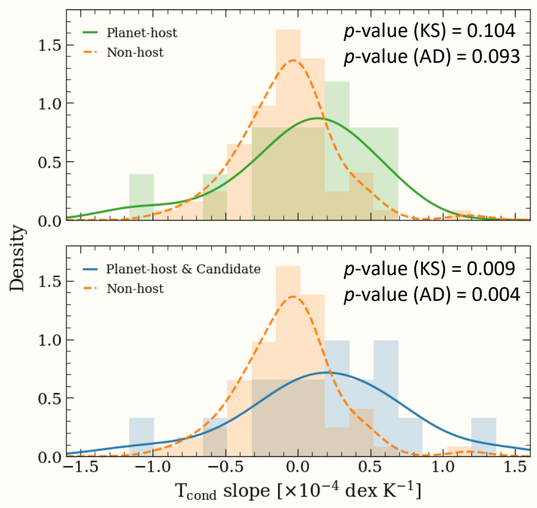


- Chemical patterns in planet-hosting wide binaries vary from system to system.
  ⇒ **Multiple possible origins** (planet-related or non-planet-related processes)

Planet-hosting vs. non-planet-hosting binaries

[Comparison of T_{cond} slope distributions]

- Literature compilation:
  - ❑ 15 planet-hosting wide binaries
  - ❑ 3 candidate planet-hosting wide binaries
  - ❑ 73 non-planet-hosting wide binaries
- Non-planet-hosting: no currently confirmed planets
- Kolmogorov-Smirnov (KS) and Anderson-Darling (AD) suggest a possible difference between the two groups.

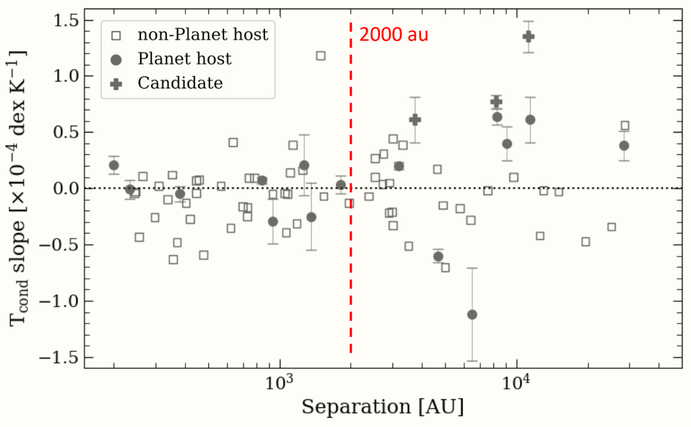


[T_{cond} slopes as a function of binary separation]

- Planet-hosting systems with separations > 2000 au tend to show more extreme T_{cond} slopes.
- The figure and table show increased scatter (std. dev.).

separation	< 2000 au	> 2000 au
Non-host	0.32 (35)	0.33 (38)
Planet host	**0.18** (8)	**0.62** (7)

** Values in parentheses indicate sample sizes.*



- Close pairs may undergo dynamical or chemical interactions that dilute or erase planet-related signatures.

Take-home message

- **Do planets leave chemical fingerprints on their host stars? ⇒ The answer remains unclear, but our results suggest possible clues.**
- Wide binaries are valuable testbeds for tracing potential planet-related signatures. ⇒ However, their chemical patterns vary from system to system.
- Planet-hosting and non-planet-hosting wide binaries show possible differences in their T_{cond} slope distributions.
- Extreme T_{cond} slopes appear more frequently among planet-hosting wide binaries, especially at large binary separations.