LINKING STELLAR ABUNDANCES WITH PLANETARY FORMATION:

THE CASE OF BROWN DWARFS.

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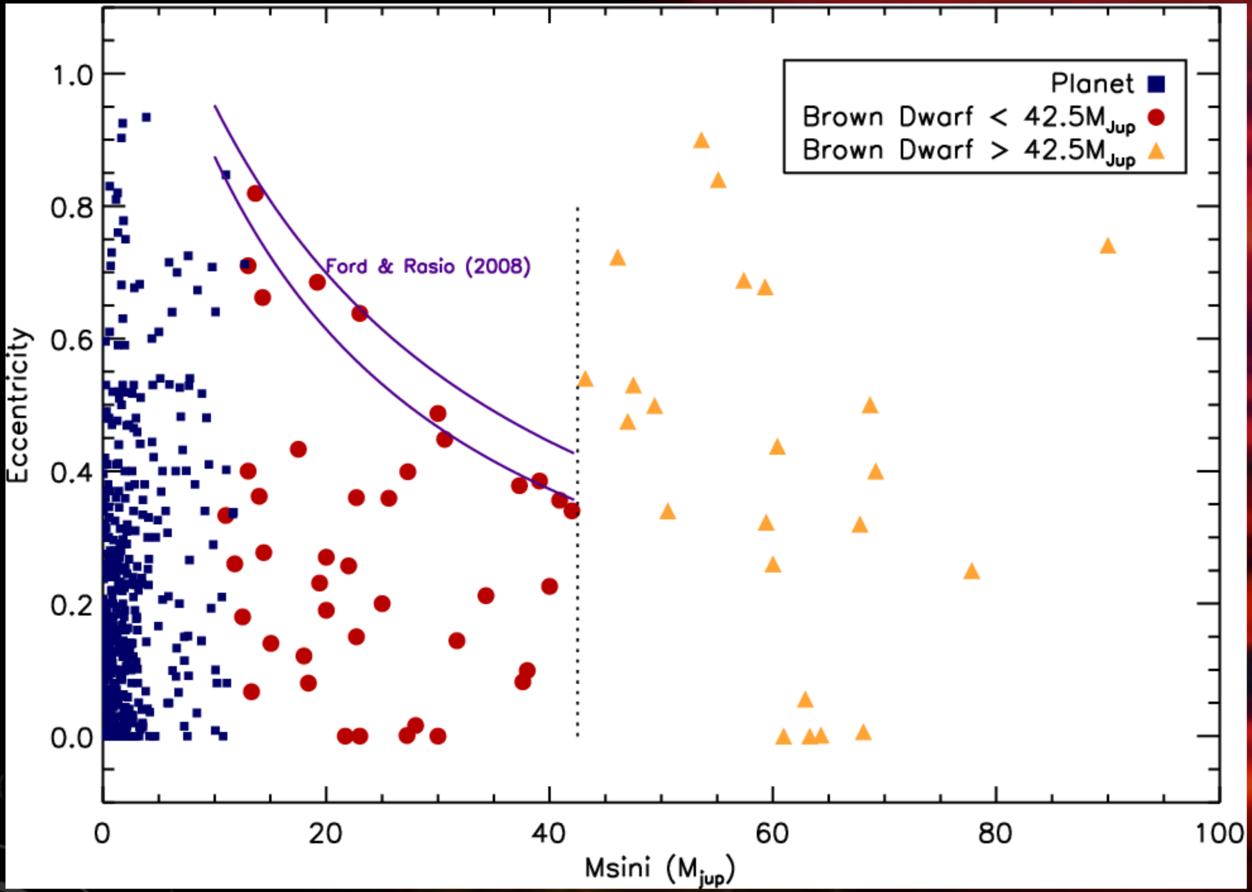
Brown dwarf : a well-established definition?

Canonical definition: from 13 to 80 Jupiter masses



Eccentricity distributions

- BD companions with $m_C sini$ < 42.5 M_{Jup}: consistent with that of massive planets
- BD companions with $m_C sini$ > 42.5 M_{Jup}: consistent with that of binaries

Different formation mechanisms?

From: Statistical properties of brown dwarf companions: implications for different formation mechanisms
Mon Not R Astron Soc. 2014;439(3):2781-2789. doi:10.1093/mnras/stu134

Can the host stars' abundances help us?

Models of giant planet formation

- Core-accretion: gas-giant planet metallicity correlation
- Disk instability: no metallicity dependence

Previous works: ***Small and inhomogeneous samples***
(e.g. Sahlaman et al. (2011); Ma & Ge (2014); Mata Sánchez et al. (2014))

This work: Homogeneous analysis of a large sample of stars with brown dwarf companions (SWBDs)

$m_C sini < 42.5\ M_{Jup}$: 32 stars

$m_C sini > 42.5\ M_{Jup}$: 21 stars

Spectroscopic Analysis

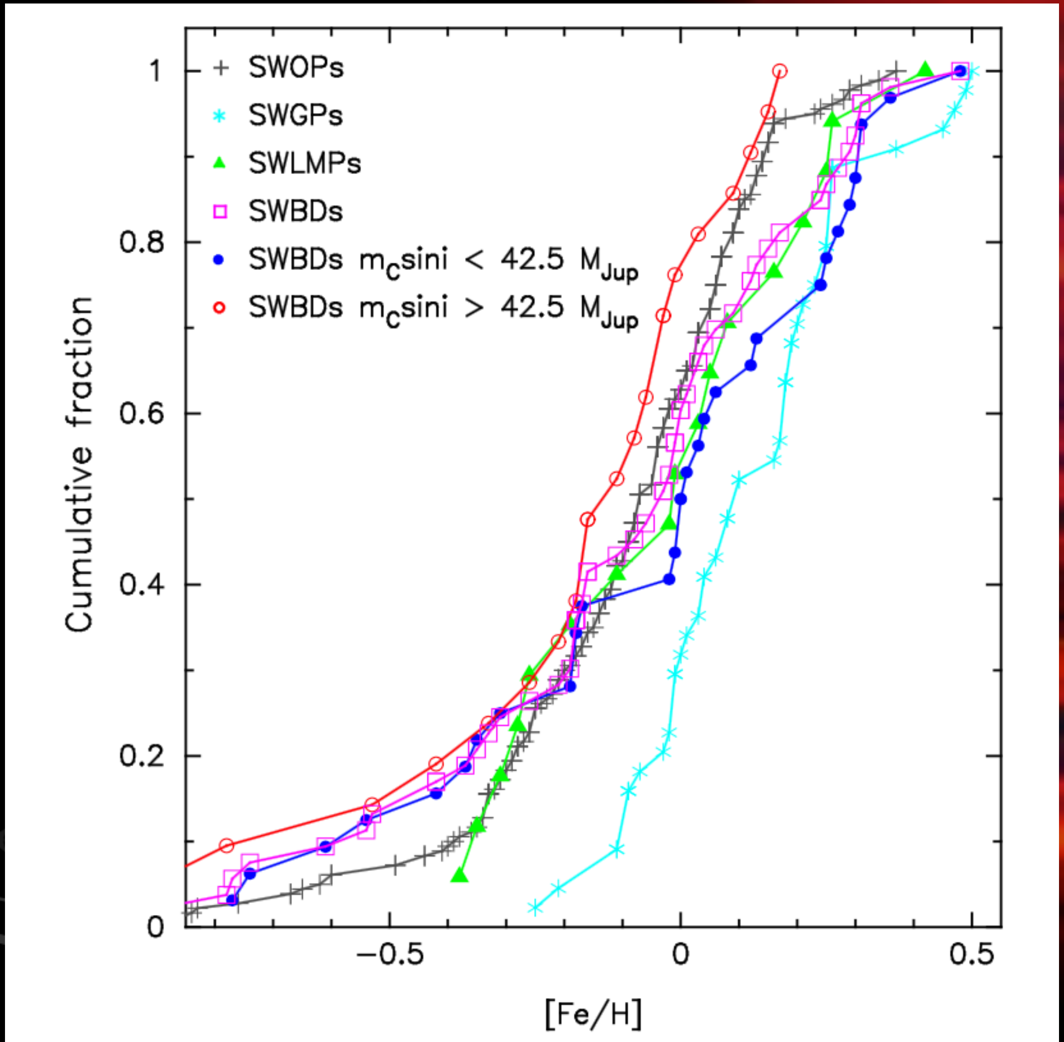
- ❑ Stellar parameters

Iron ionisation and excitation conditions

- ❑ Elemental abundances

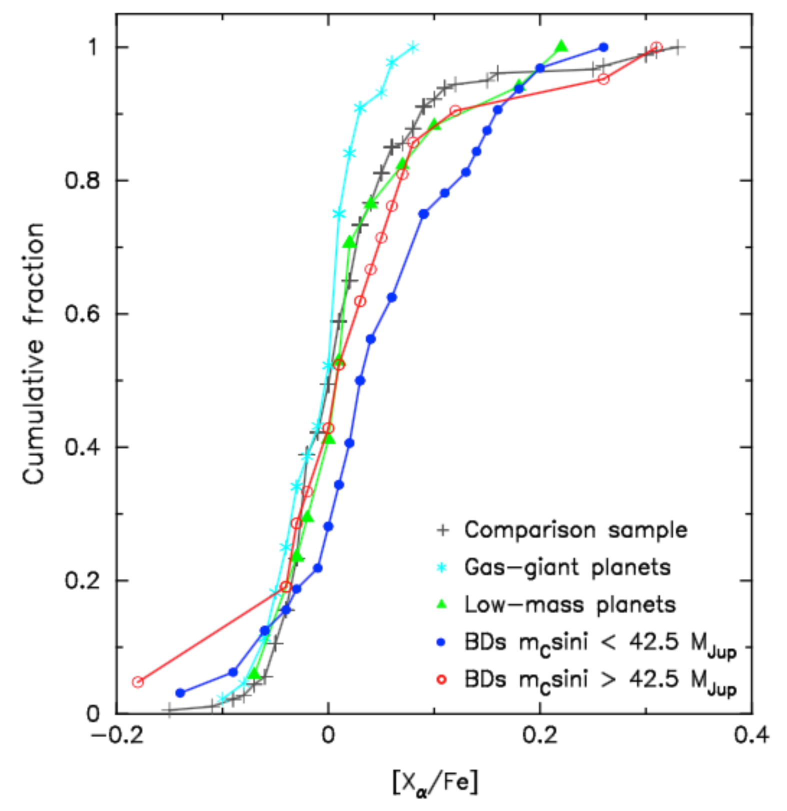
C, O, Na, Mg, Al, Si, S, Ca, Sc, Ti, V, Cr, Mn, Co, Ni, Zn

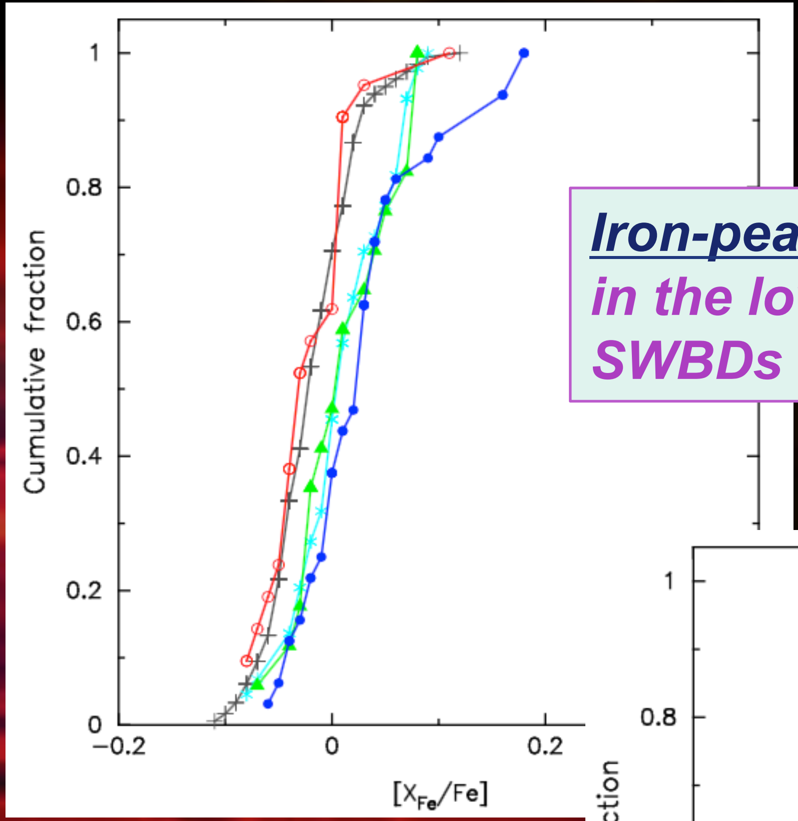
[Fe/H] distributions: Comparison with planets/non-planets hosts



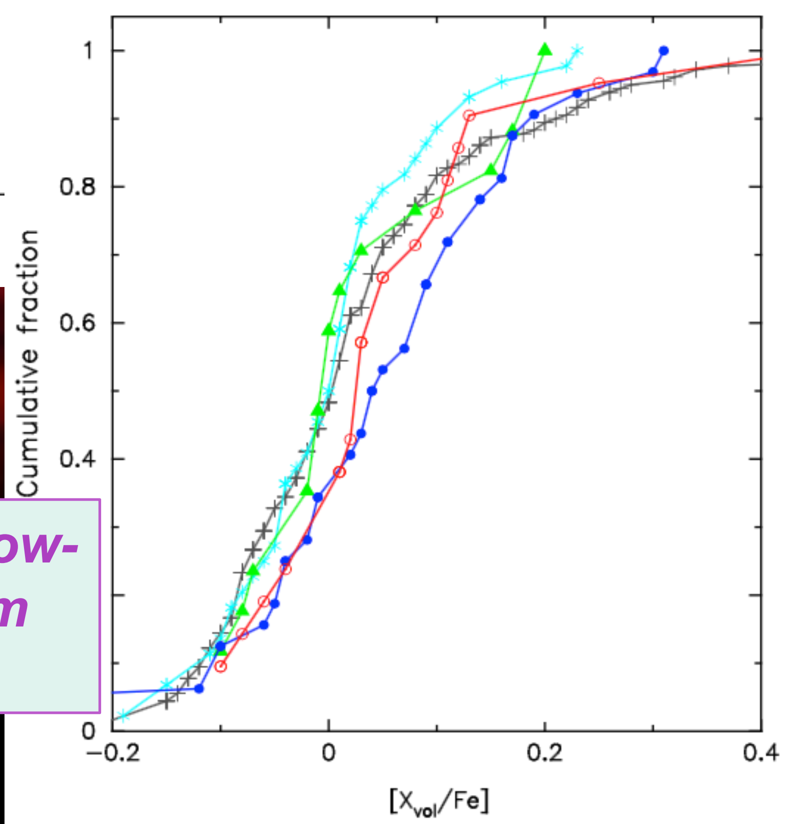
- SWBDs do not follow the trend of SWGPs
- SWBDs with $m_C$sini < 42.5 M_{Jup} show higher [Fe/H] than SWBDs with $m_C$sini > 42.5 M_{Jup}
- [Fe/H] < -0.20 dex: similar metallicities for both SWBDs subsamples
- [Fe/H] > -0.20 dex: SWBDs with $m_C$sini < 42.5 M_{Jup} shifts towards higher metallicities

Other chemical signatures:
α, Fe-peak, and volatiles





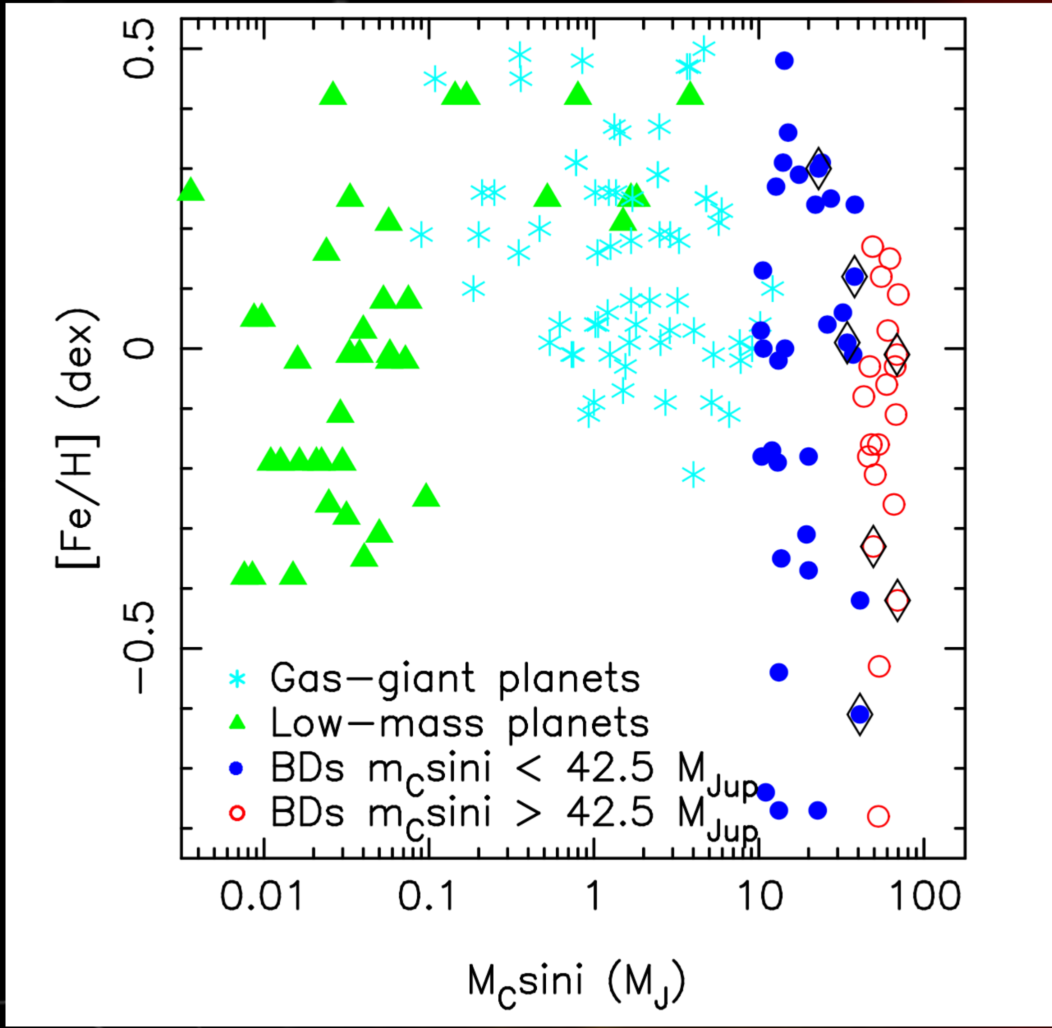
Iron-peak: *Larger abundances in the low-mass range SWBDs*

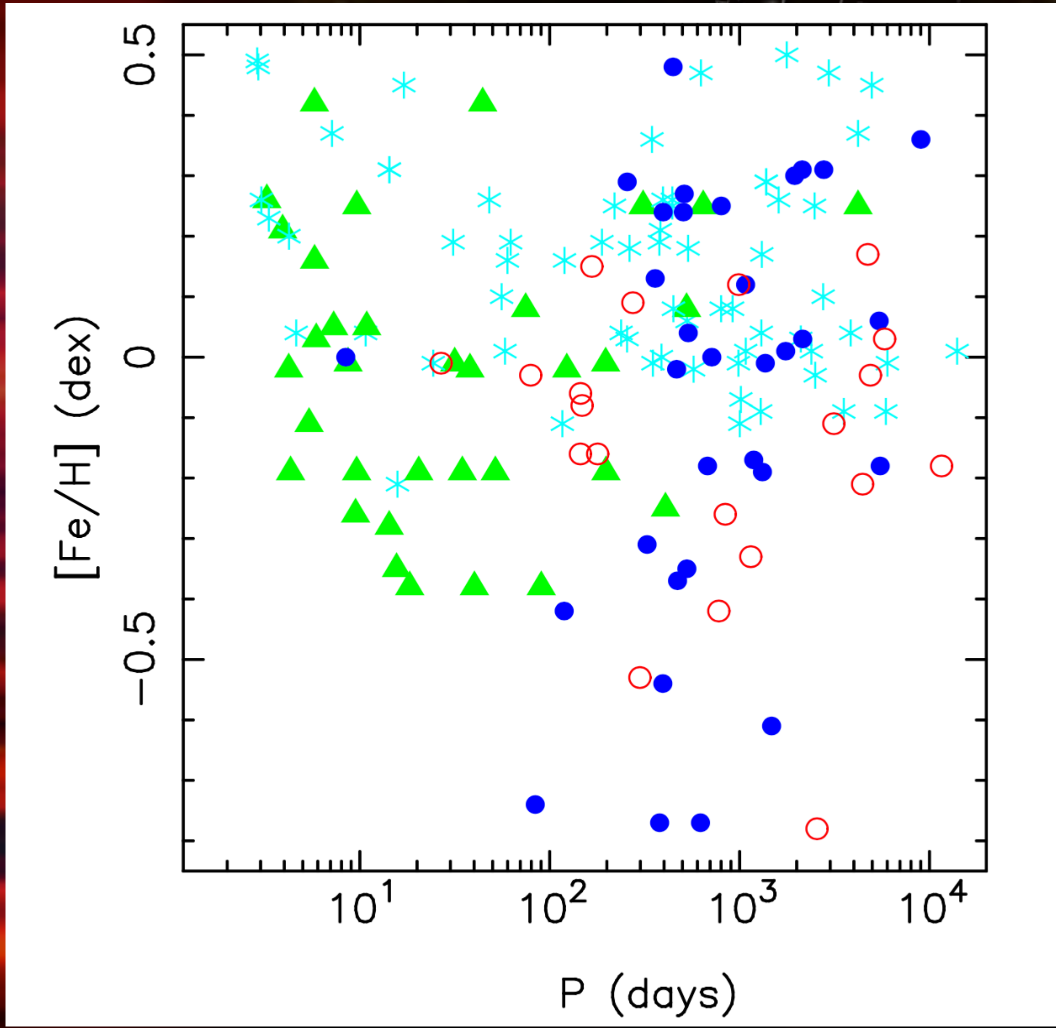


Volatiles: *SWBDs in the low-mass range, different from SWGPs?*

Alpha: *SWBDs in the low-mass range, different from SWGPs*

Stellar abundances and brown dwarf properties



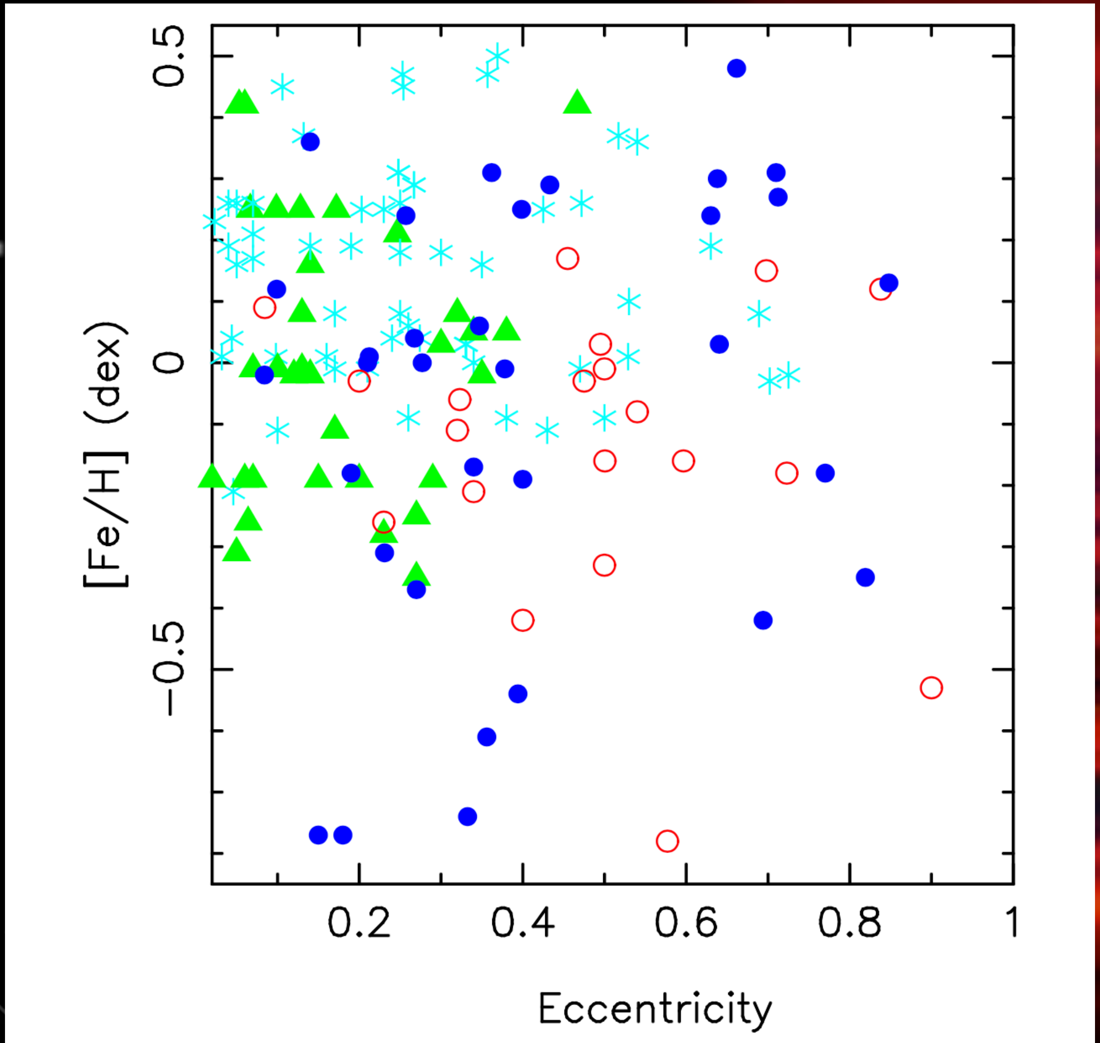


Mass: ***No high [Fe/H] in SWBDs***

Period: ***Brown dwarf desert***

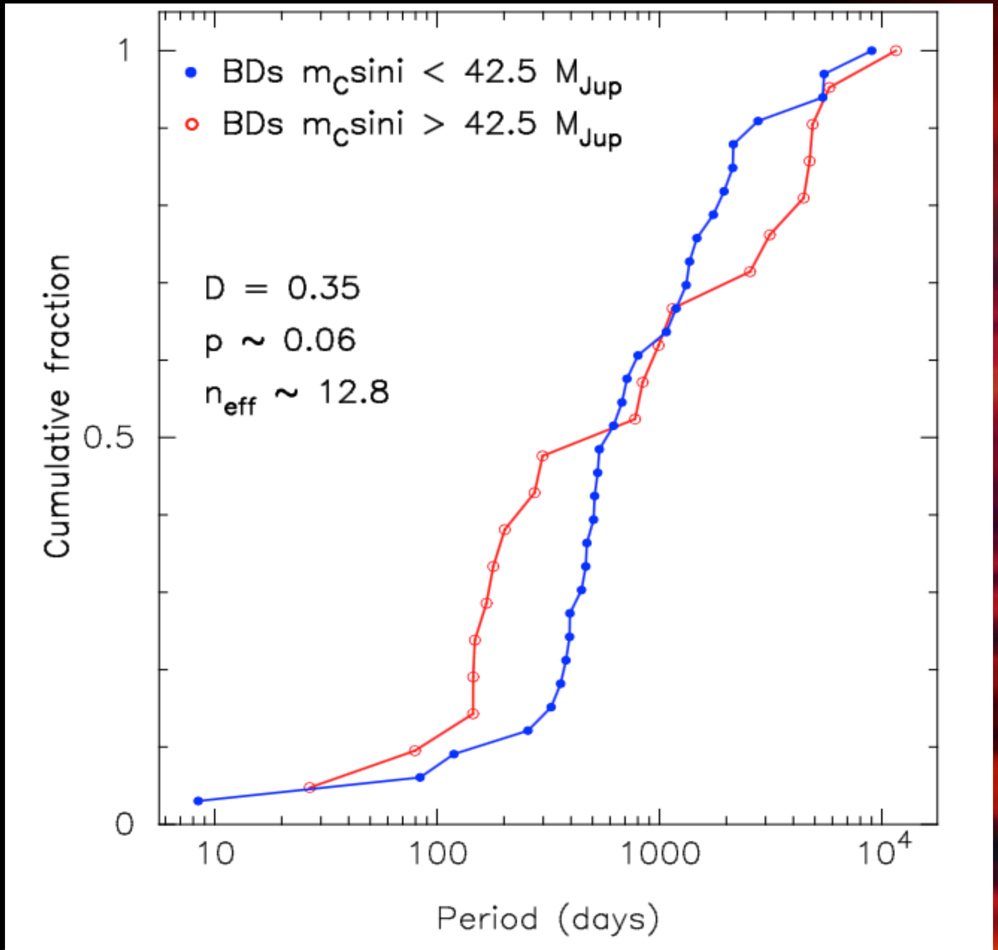
~82% BDs with periods longer than 200 days

Stellar abundances and brown dwarf properties

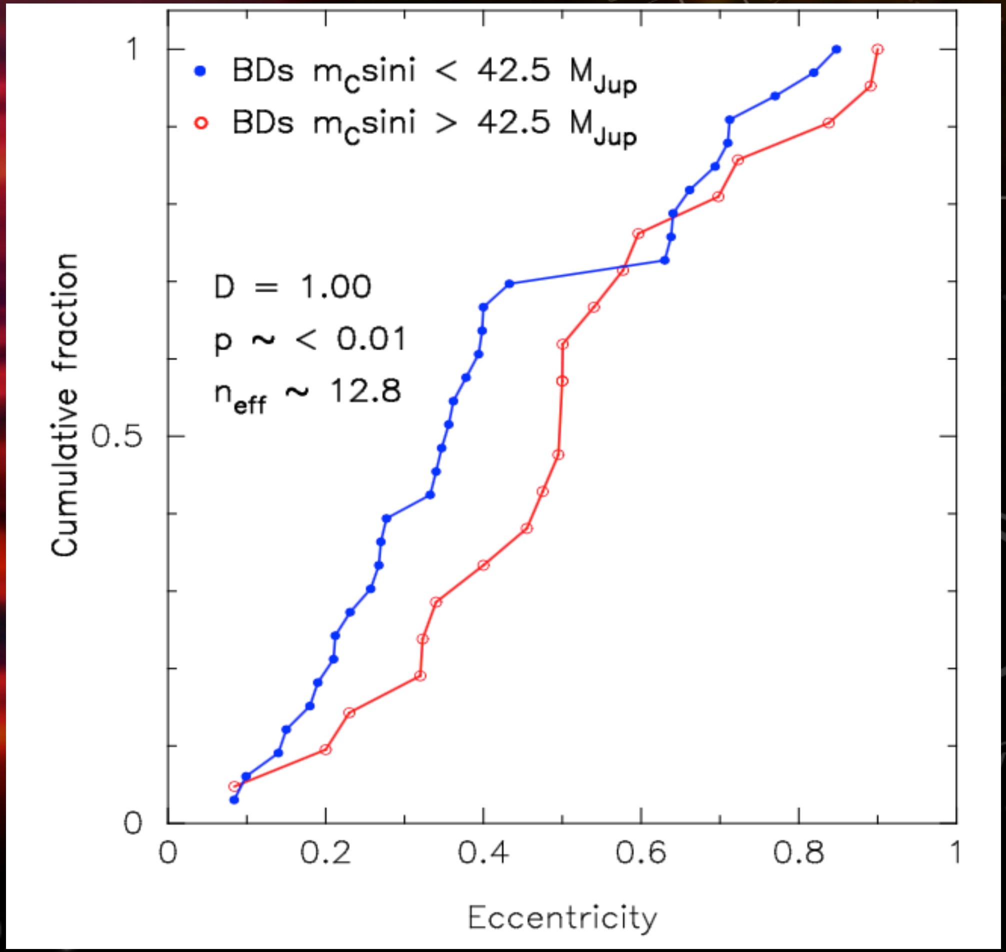


Eccentricity: *Low values for SWBDs with $m_C \sin i$ < 42.5 M_{Jup}*

Period and eccentricity distributions



Higher eccentricities in SWBDs with $m_C sini$ > 42.5 M_{Jup} (p-value ~ 10^{-16})

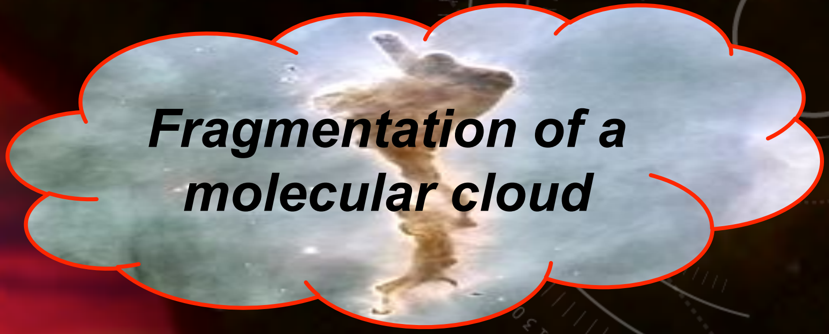


Periods shorter than ~ 1000 days: SWBDs with $m_C sini$ > 42.5 M_{Jup} shows shorter values (p-value ~ 6%)

Implications: Formation mechanisms

Massive brown dwarfs

- ❑ No hint of metal enrichment in their parent stars
- ❑ Larger eccentricities (consistent with that of binaries)



Low-mass brown dwarfs

- ❑ Slightly higher metallicities and abundances than SWBDs with masses above 42.5 M_{Jup}
- ❑ Different period/eccentricity distributions

Different formation mechanism from massive BDs

- ❑ No metal-rich signature, only for metallicities above ~ +0.20 dex

- ○ ***Gravitational instability, gravoturbulent fragmentation, at low metallicities***
- ○ ***High metallicities: Core accretion***

SUMMARY

Chemical analysis of a large sample of SWBDs

- ❑ **SWBDs:** Do not follow the gas-giant planet metallicity correlation
- ❑ **Stars harbouring massive BDs:** Similar metallicity and abundance distributions than stars without known planets
- ❑ **Stars harbouring less-massive BDs:** Slightly higher metallicity and abundances
- ❑ **Differences in period and eccentricities**

- ○ **Low mass BDs:** core-accretion (high metallicities) / gravitational instability (lower metallicities)
- ○ **Massive BDs:** no metallicity dependent formation (fragmentation of molecular clumps)

Ref. Maldonado & Villaver (2017, A&A 602, A38)