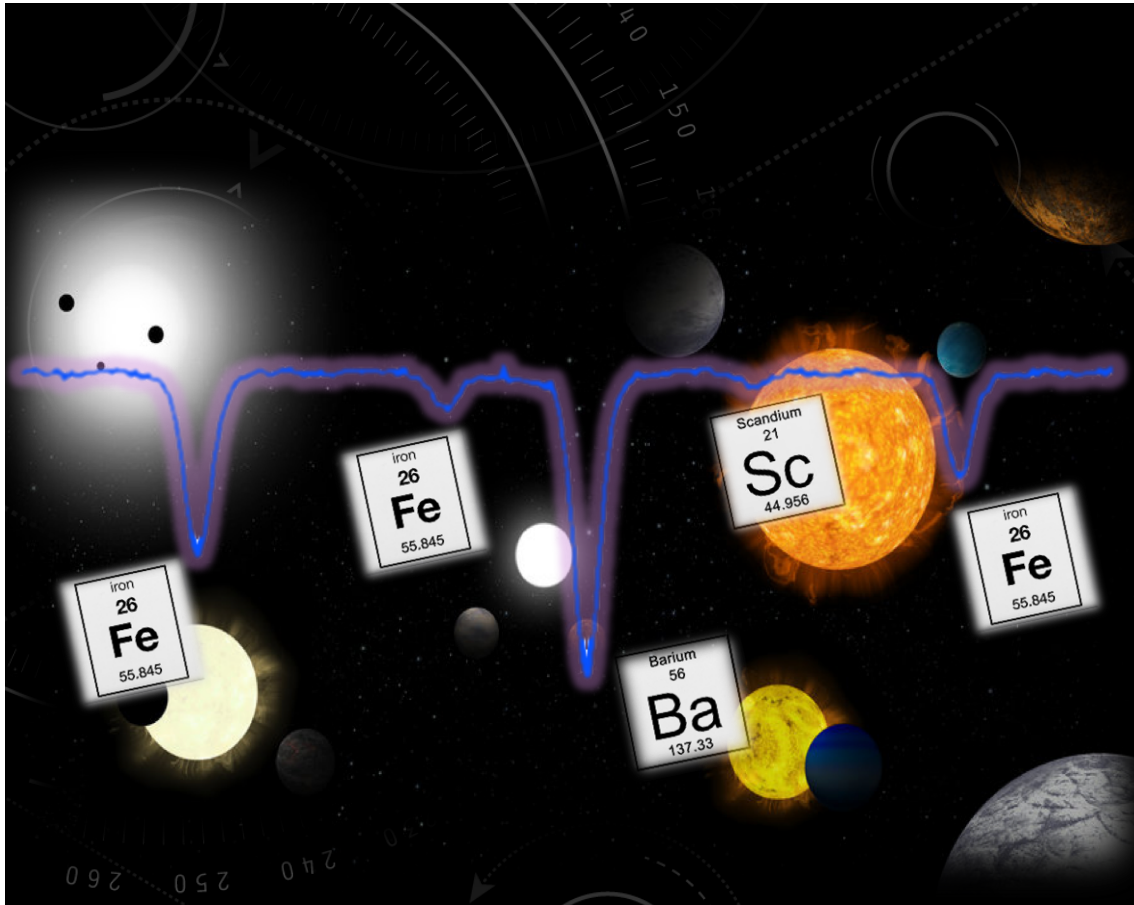

TOWARDS A COMPREHENSIVE VIEW OF PLANET FORMATION:

The role of the host star's metallicity.

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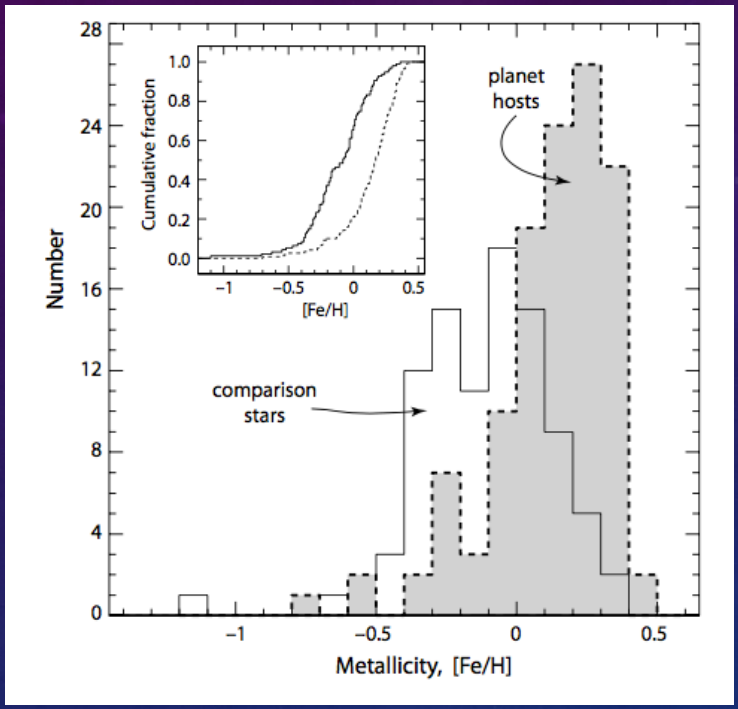
Congresso Nazionale di Astrochimica e Astrobiologia (proto-)planetaria, October 23, 2019

THE PLANET METALLICITY CORRELATION

A WELL KNOWN RELATIONSHIP?

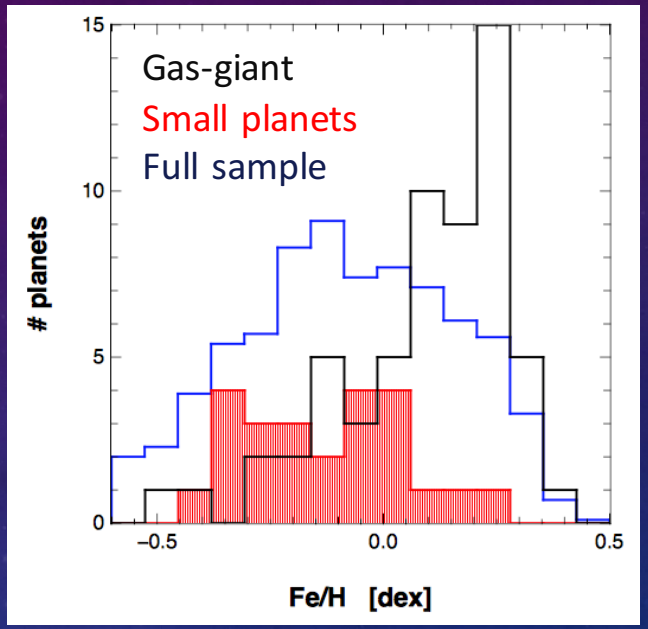
Correlation between high [Fe/H] and the presence of gas-giant planets

Interpreted in the framework of core-accretion models



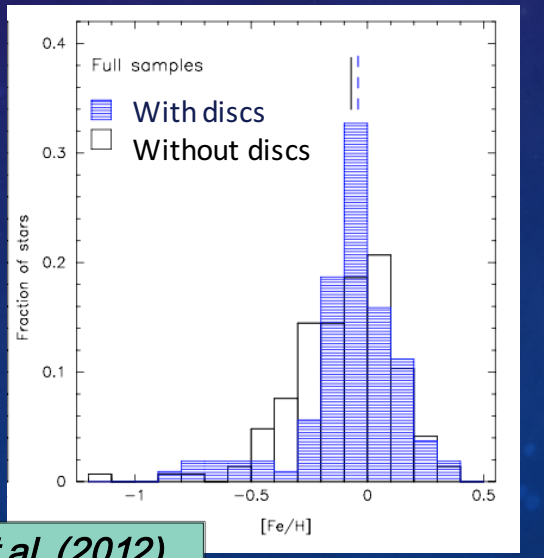
Santos et al. (2005)

More complex than initially thought:



Mayor et al. (2011)

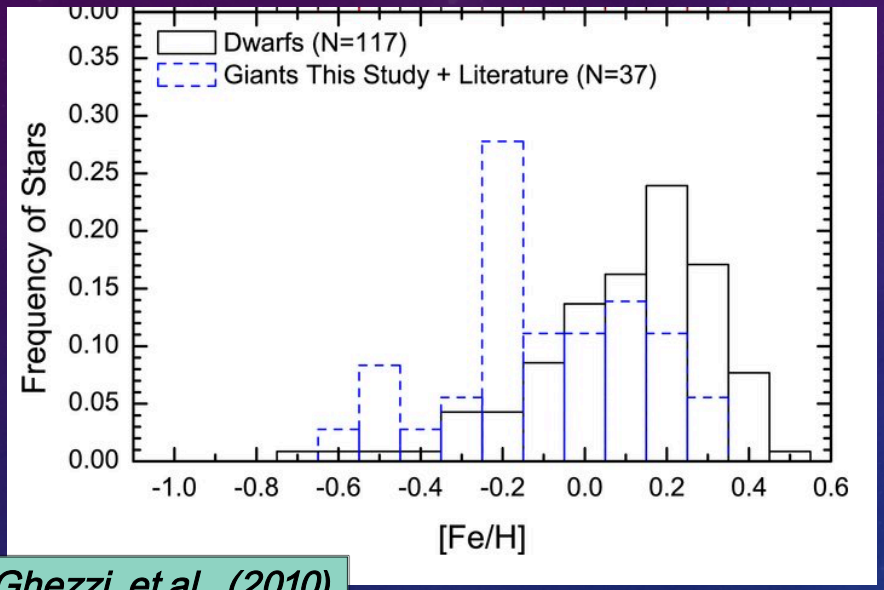
Not followed by stars with debris discs and low-mass planets



Maldonado et al. (2012)

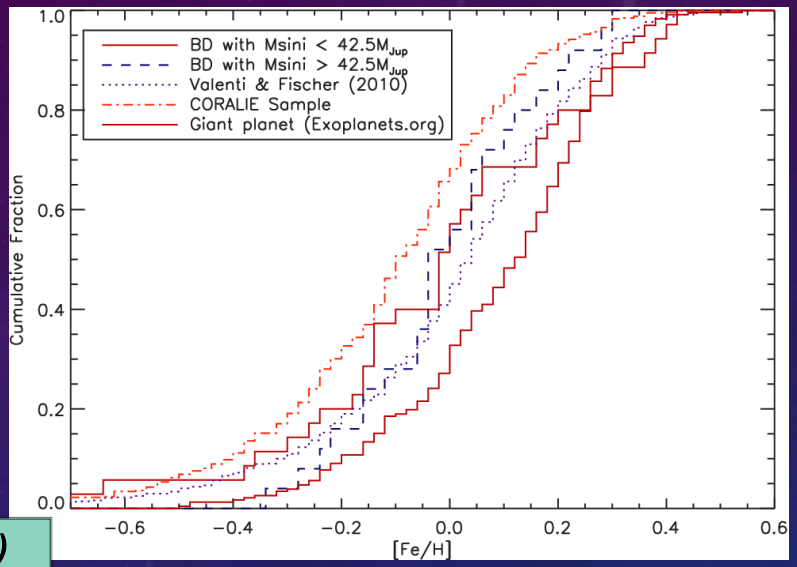
More complex than initially thought:

Controversial in giant stars with planets

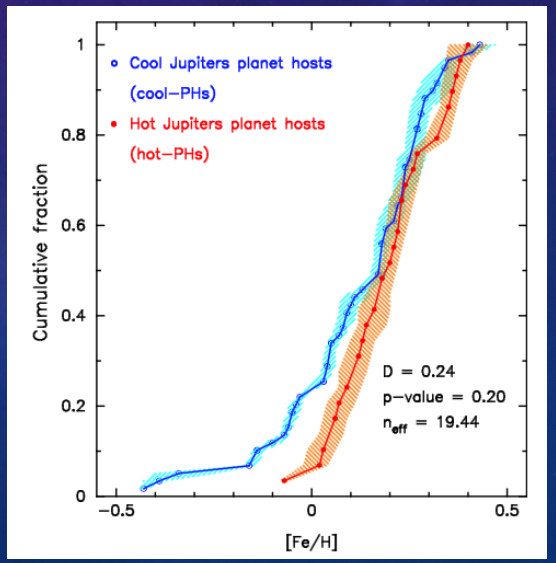


Ghezzi et al. (2010)

Different [Fe/H] for stars with small and massive brown dwarfs ?



Ma & Ge (2014)



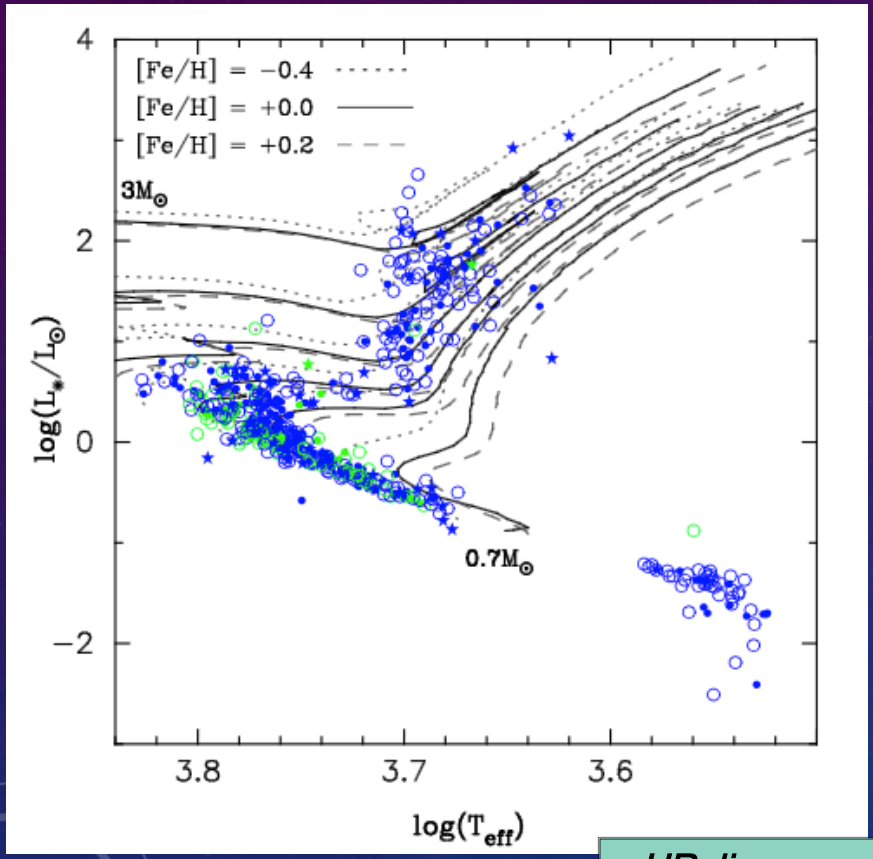
Different [Fe/H] distribution for stars with hot/cool gas-giant planets?

Maldonado et al. (2018)

TOWARDS AN UNIFIED VIEW

CONNECTING STELLAR AND SUBSTELLAR DOMAINS

Need of an unified view:
Maldonado et al. 2019, A&A 624



HR diagram

- ❑ All possible outcomes:

From debris discs to massive brown dwarfs

- ❑ All possible host's stars:

From M dwarfs to early-F, from main-sequence to giants

- ❑ Spectroscopic homogeneous analysis:

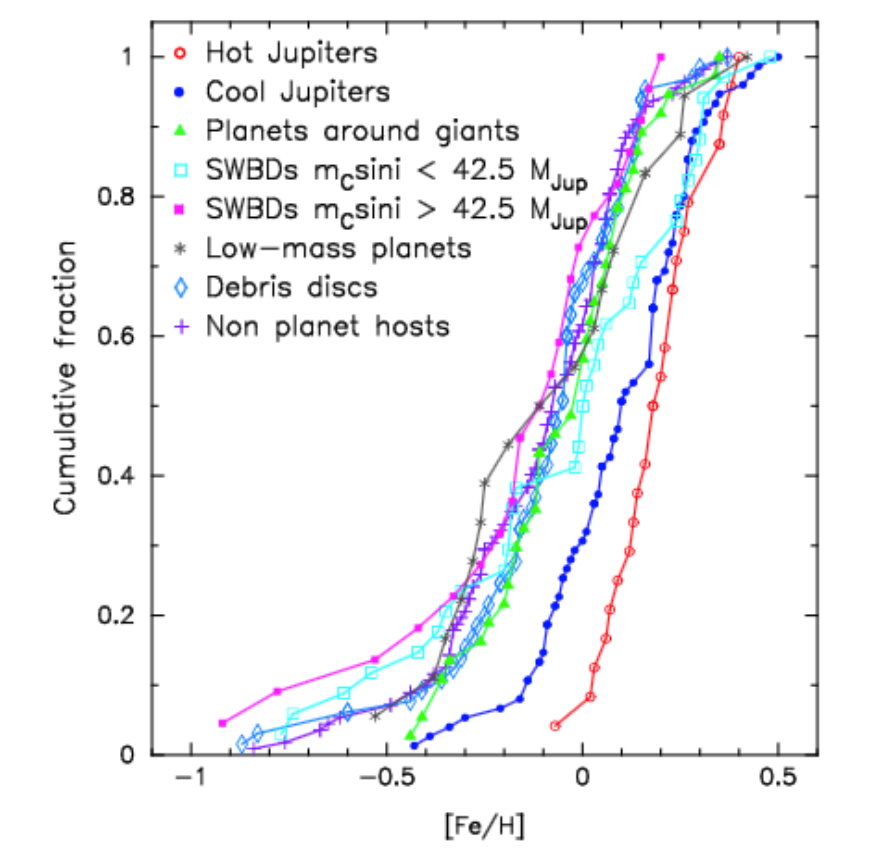
Except for M dwarfs

Type	Number	Notes
Substellar objects (total)	345	95 multiple systems
Brown dwarfs ($10\,M_{\rm Jup} < M_{\rm C}\sin i < 70\,M_{\rm Jup}$)	59	3 systems with 2 BDs 5 systems BD + planet
Low-mass planets ($M_{\rm C}\sin i < 30\,M_{\oplus}$)	78	34 hot ($a < 0.1$ au) 44 cool ($a > 0.1$ au)
Gas-giant planets ($M_{\rm C}\sin i > 30\,M_{\oplus}$)	208	34 hot ($a < 0.1$ au) 174 cool ($a > 0.1$ au)
Debris disc	99	32 debris disc + substellar object

Architecture of the planetary systems

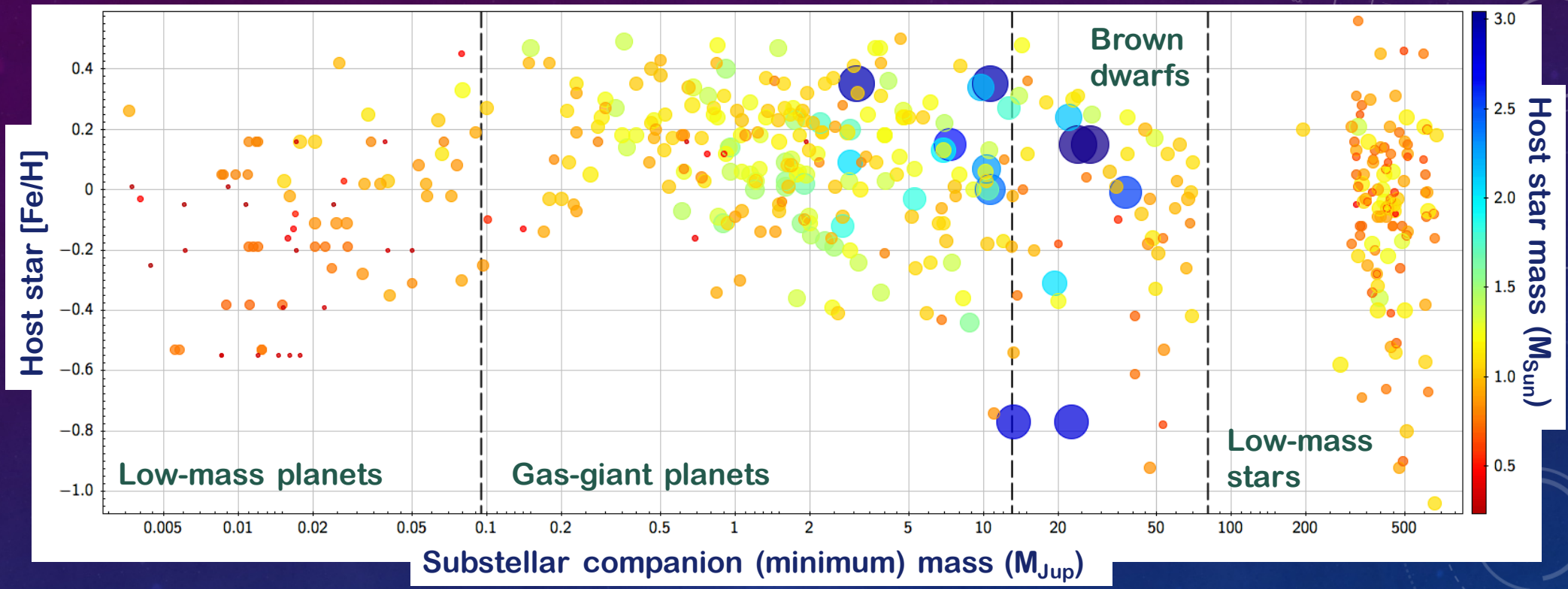
[Fe/H] cumulative distribution function of different subsamples

- Stars with gas giant planets: show high metallicity values
- Rest of samples: metallicity distributions consistent with those of stars without substellar companions



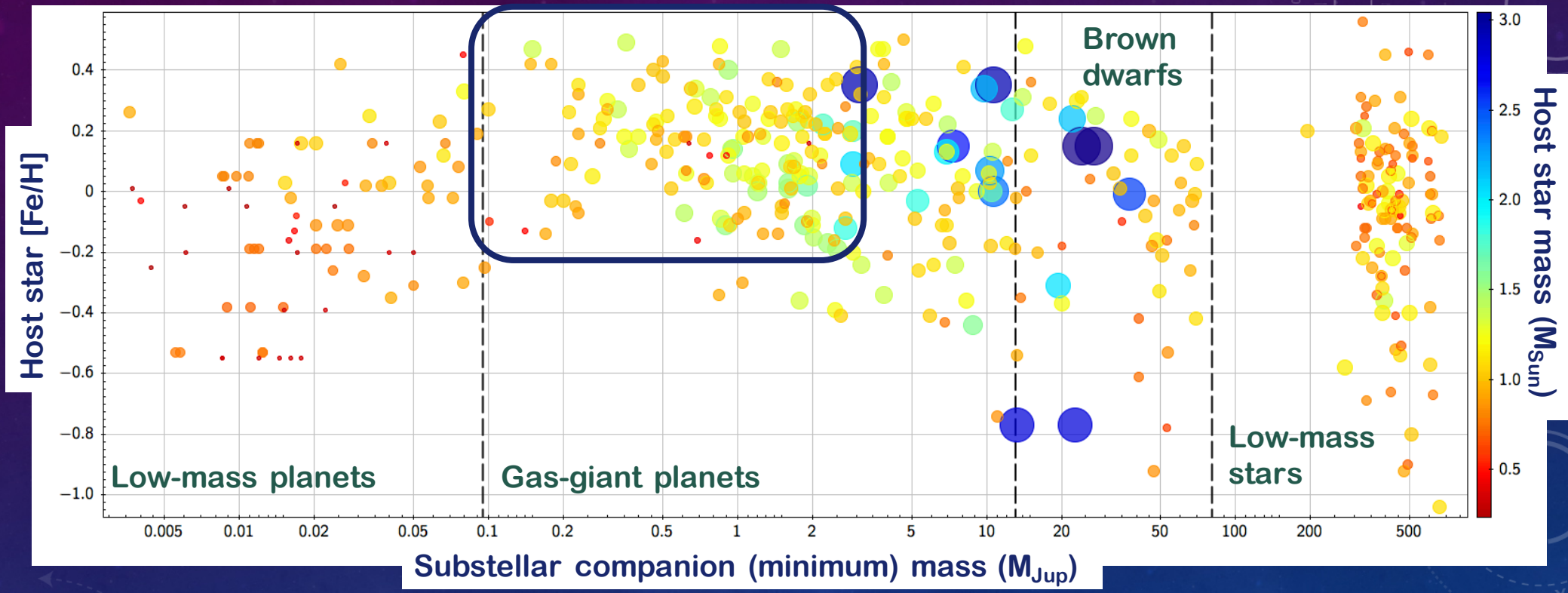
[Fe/H] cumulative frequencies

Evidence for a non universal planet formation mechanism

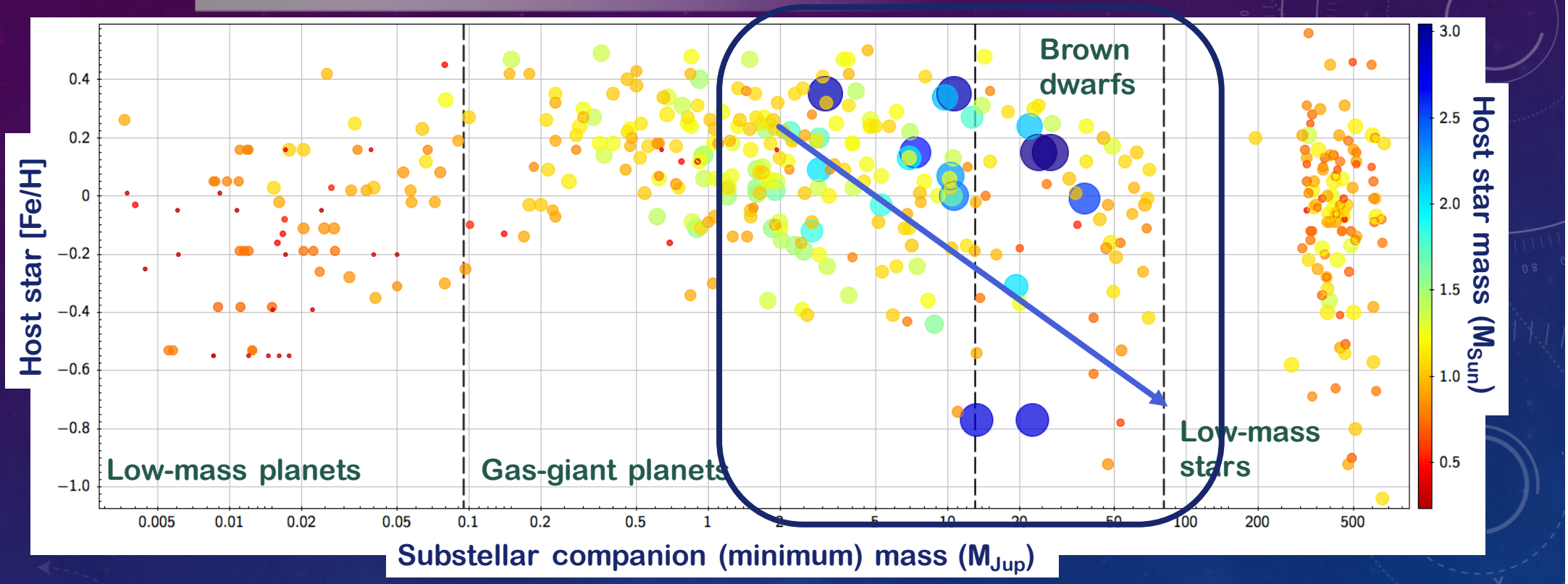


- Tendency towards lower metallicity of the host star as the mass of the substellar companion increases
- More massive planets tend to orbit around more massive stars

Planets between ~ 30 M_{Earth} and ~ 2 M_{Jup}
High metallicities: core-accretion

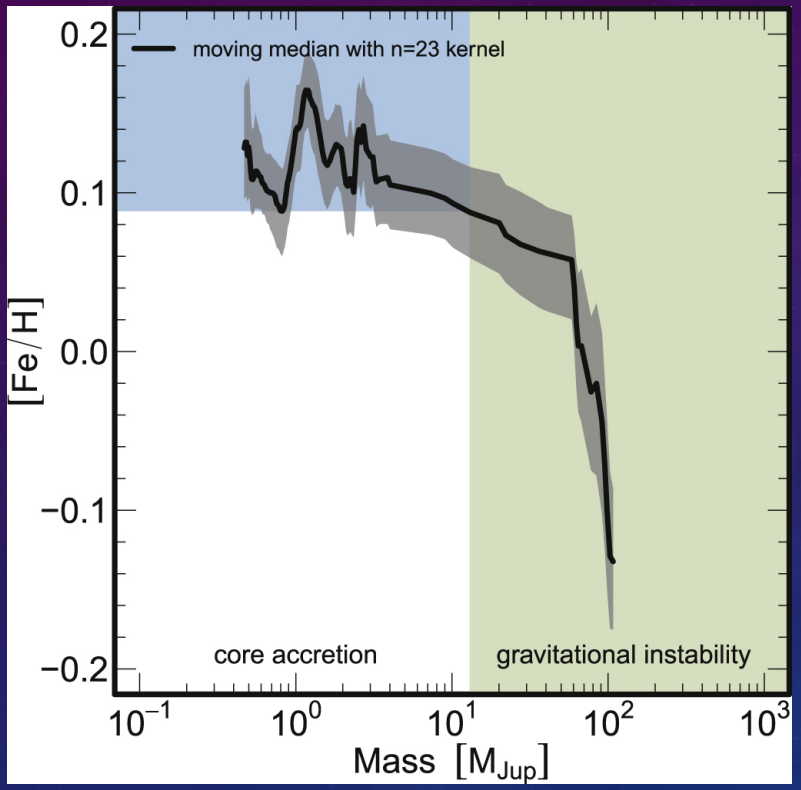


More massive substellar companions
Non-metallicity dependent formation mechanism

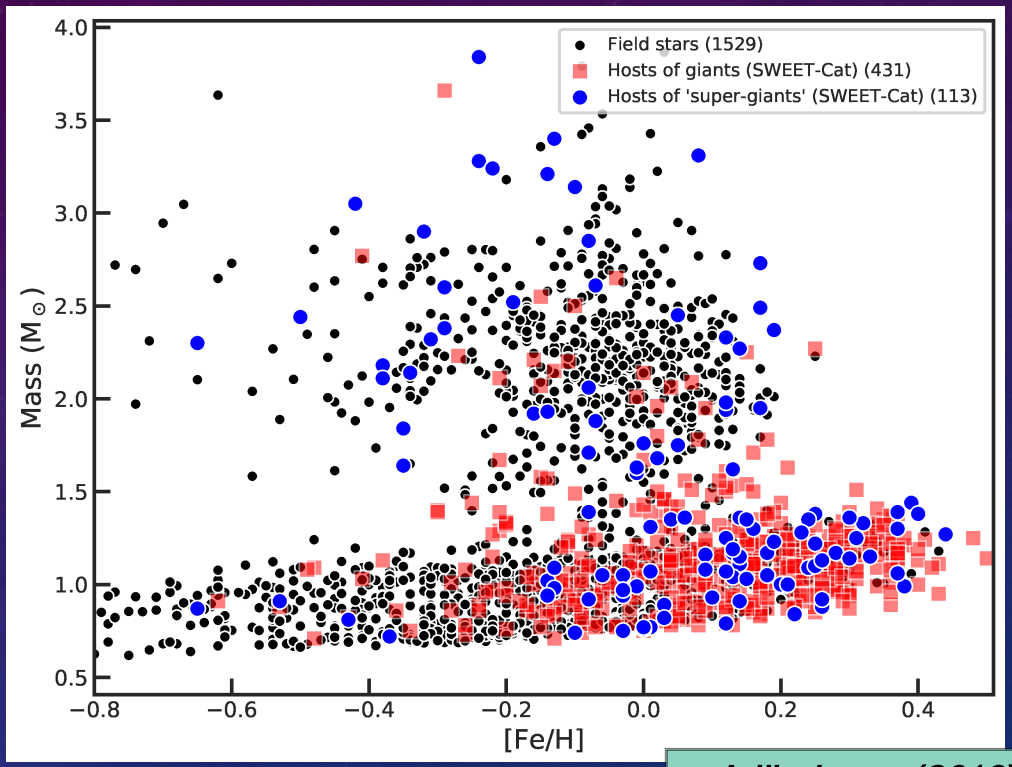


Consistency with recent works

Mass at which substellar companions no longer preferentially orbit metal-rich stars between 4 and 10 M_{Jup}



Schlaufman (2018)

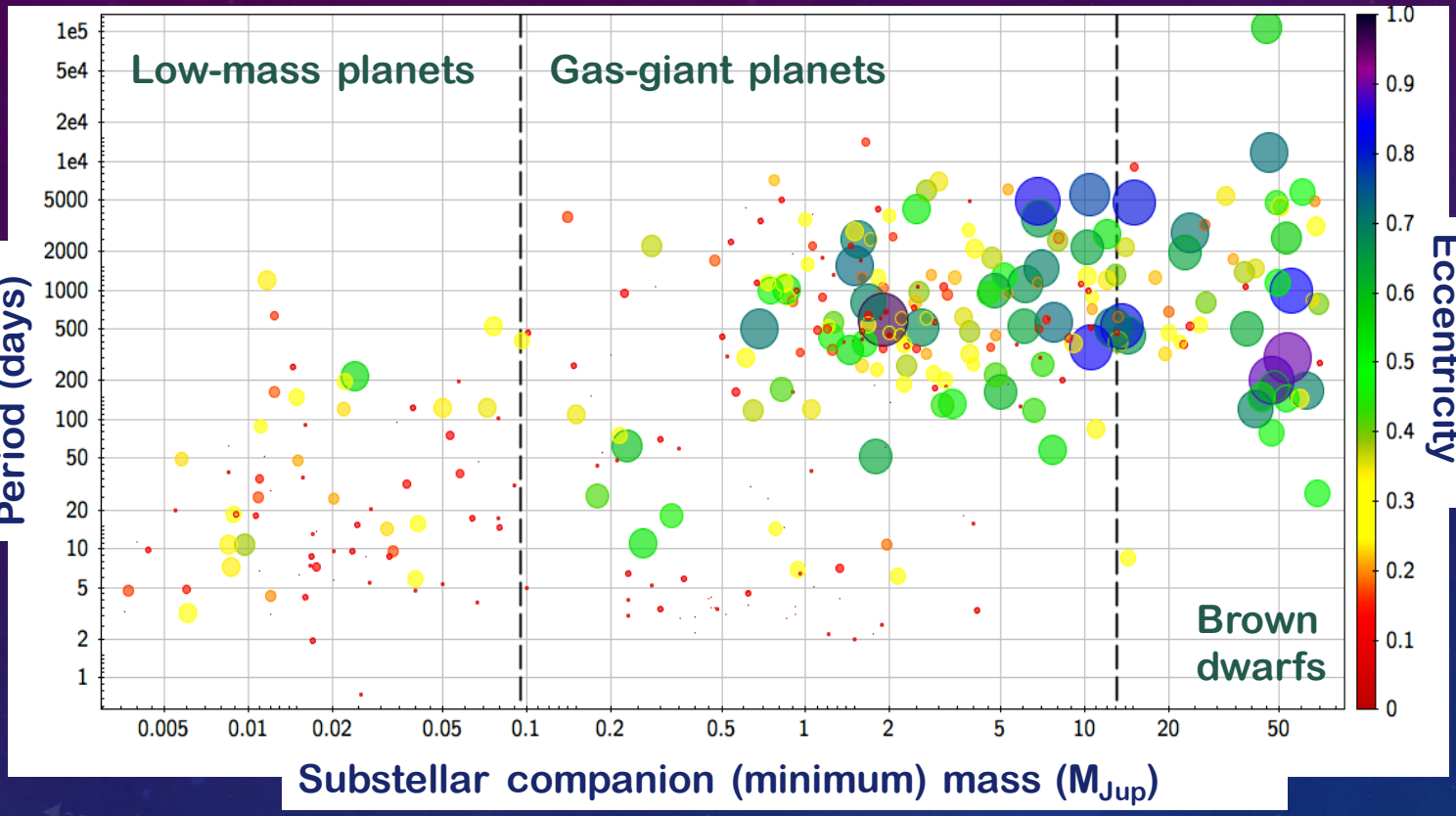


Adibekyan (2019)

No evidence for different formation mechanisms of planets with masses above and below 4 M_{Jup}

High-mass planets can be formed through different channels depending on the (disc) stellar mass

Consistency with period-eccentricity distributions



More massive substellar companions show larger periods and eccentricities

As we move towards more massive substellar companions:

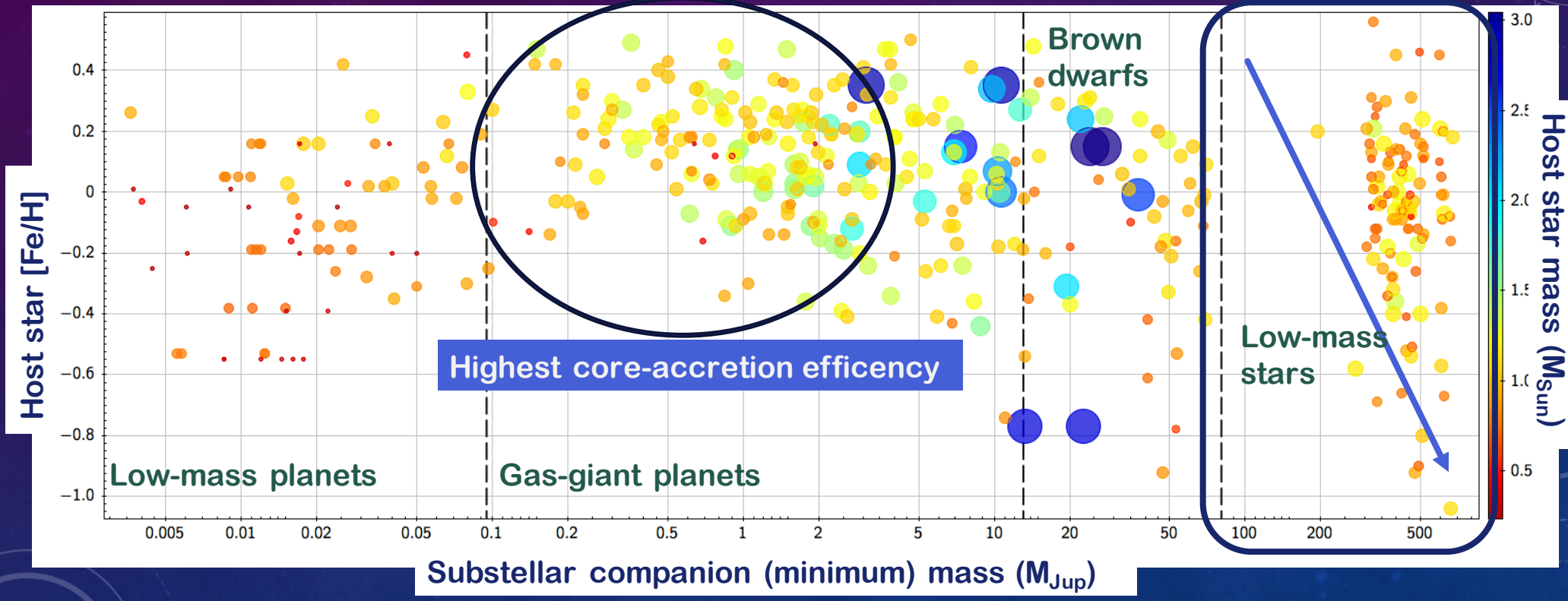
- their host stars show a wider (towards negative values) range of metallicities and higher stellar masses
- planets (or BDs) show longer periods and eccentricities

The higher the mass of the substellar companion, the higher the probability that it is formed by a non-metallicity-dependent formation mechanism

Planet metallicity correlation in context I

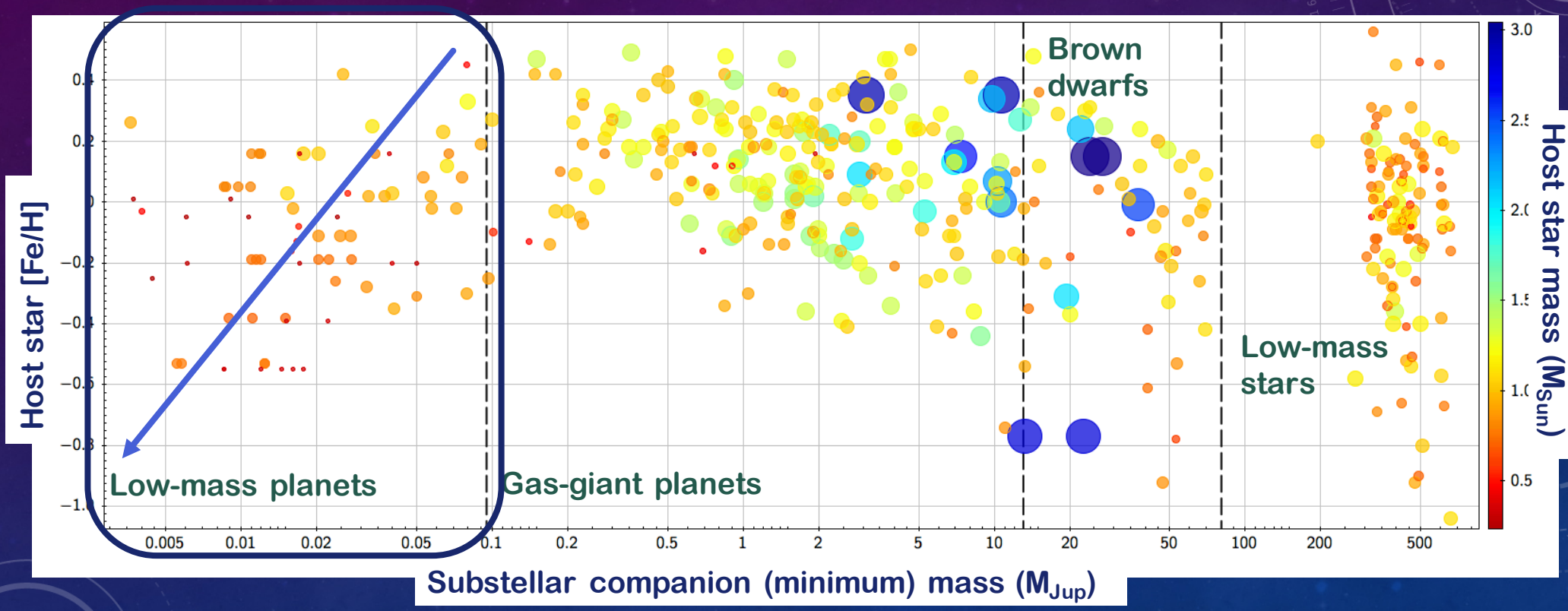
Tendency towards a wider rage of metllicities continues in the low-mass stellar range

Continuity between stellar and substellar companions



Planet metallicity correlation in context II

Tendency in the low-mass planets domain?
Low-metallicities → longer timescales to form a core → only small planets and planetesimals



SUMMARY

TAKE AWAY MESSAGES

SUMMARY

Continuity between the formation of substellar and stellar companions driven by the metallicity of the host star: **(Maldonado et al. 2019, A&A 624)**

- Planetesimals and low-mass planets: trends with metallicity might be need confirmation, still may be formed by the core-accretion method
- Hot-Jupiters: the core-accretion formation mechanism achieves its maximum efficiency for planets with masses between 0.2 and 2 M_{Jup}
- Massive substellar objects and low-mass binary companions: the range of the star's metallicity increases towards lower values, both kinds of object tend to share similar formation mechanisms