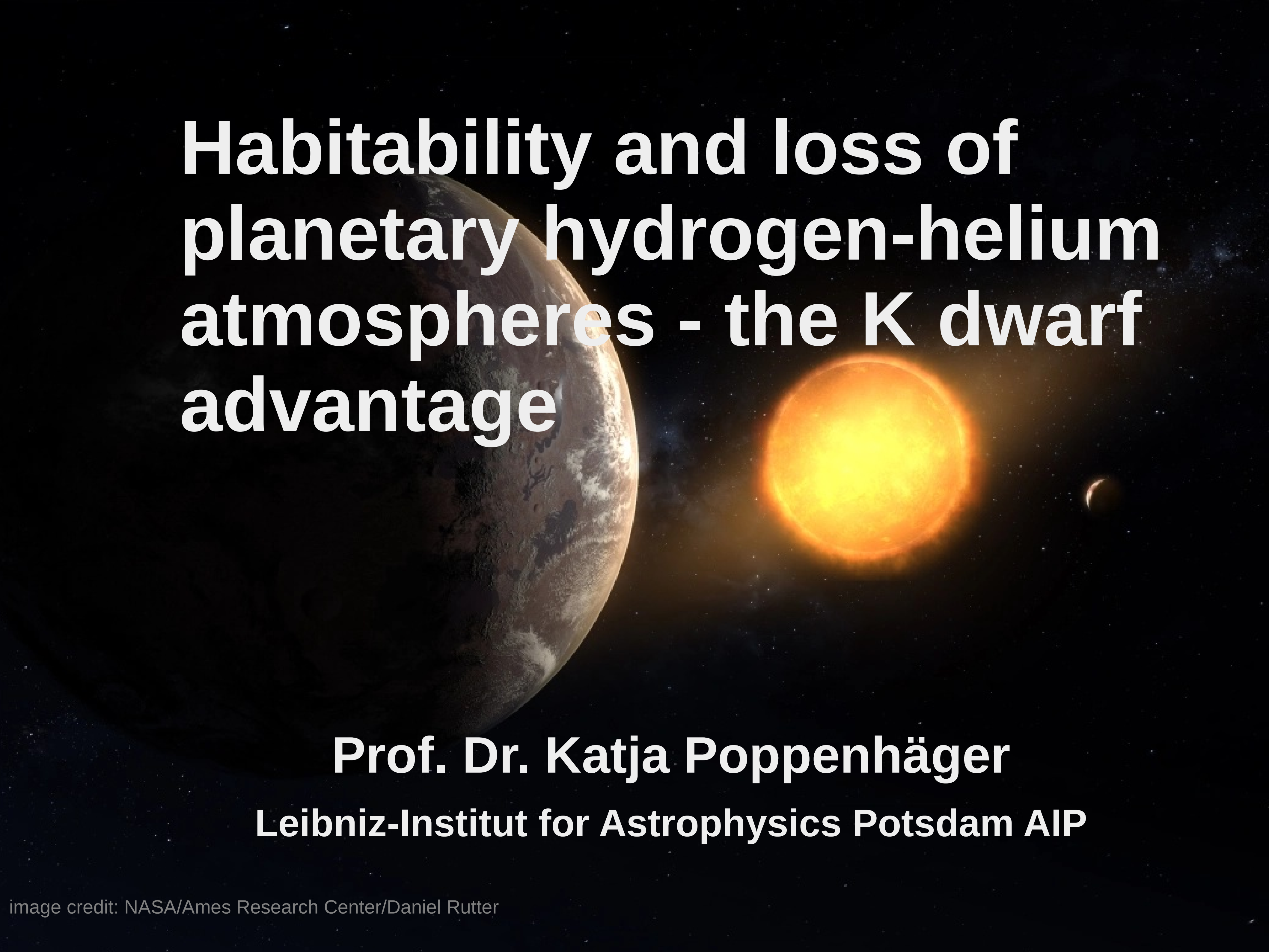


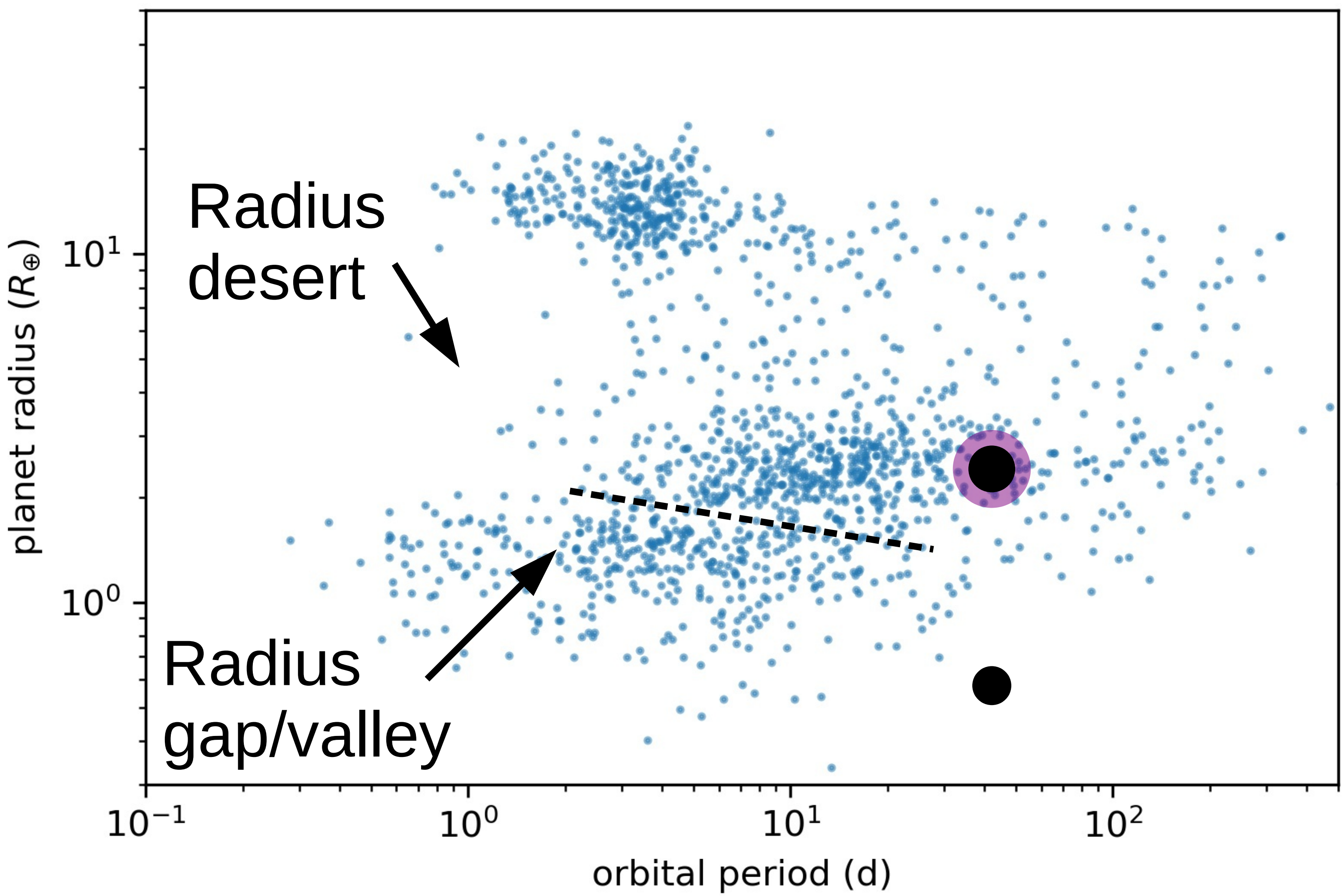
# Habitability and loss of planetary hydrogen-helium atmospheres - the K dwarf advantage

**Prof. Dr. Katja Poppenhäger**

**Leibniz-Institut for Astrophysics Potsdam AIP**

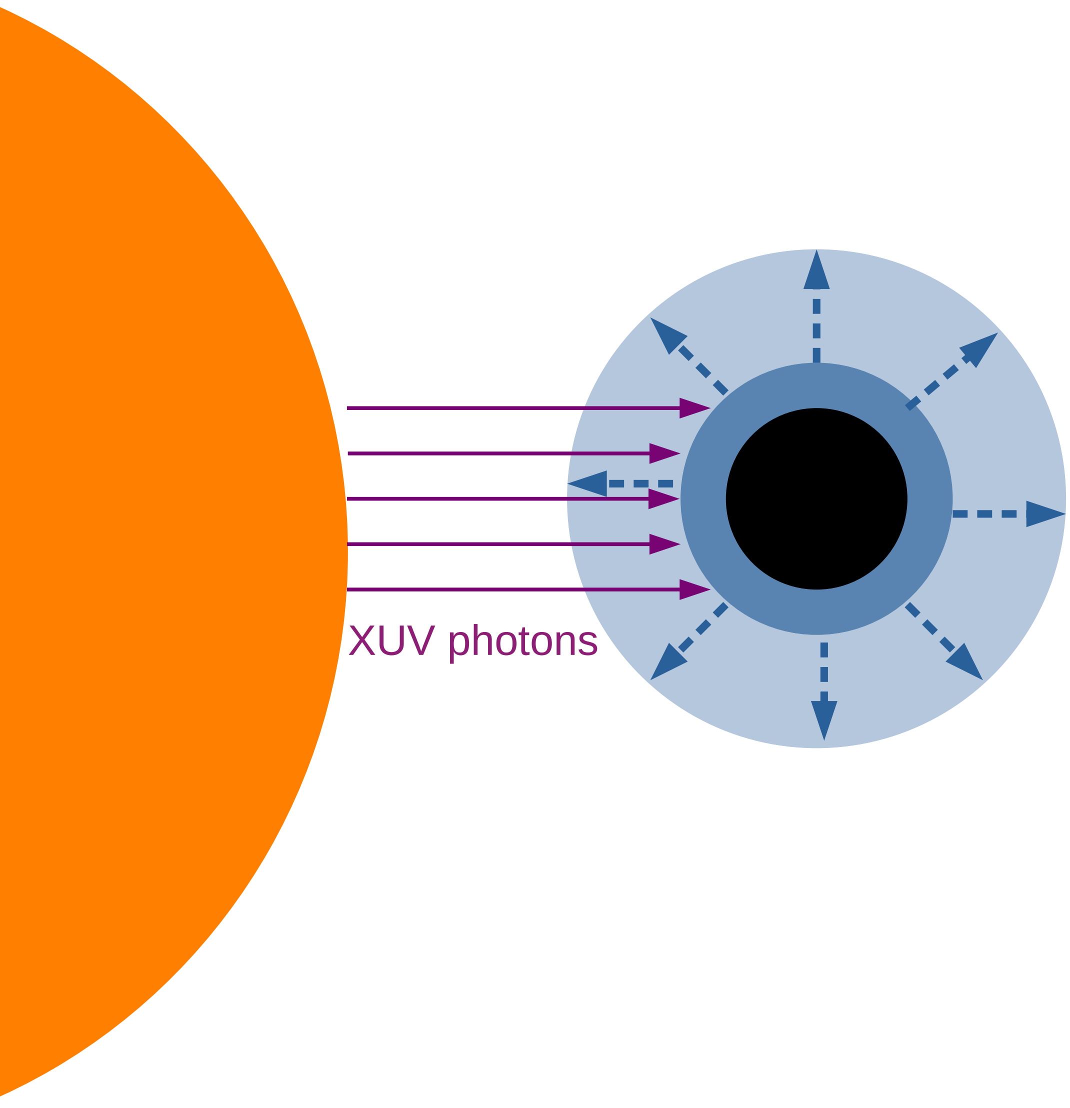
image credit: NASA/Ames Research Center/Daniel Rutter

# From H/He envelopes to rocky planets




See Fulton et al. (2017), van Eylen et al. (2018); see also Berger et al. (2020), Gupta & Schlichting (2020), Loyd et al. (2020)

# H/He loss driven by X-ray and EUV photons from the stellar corona



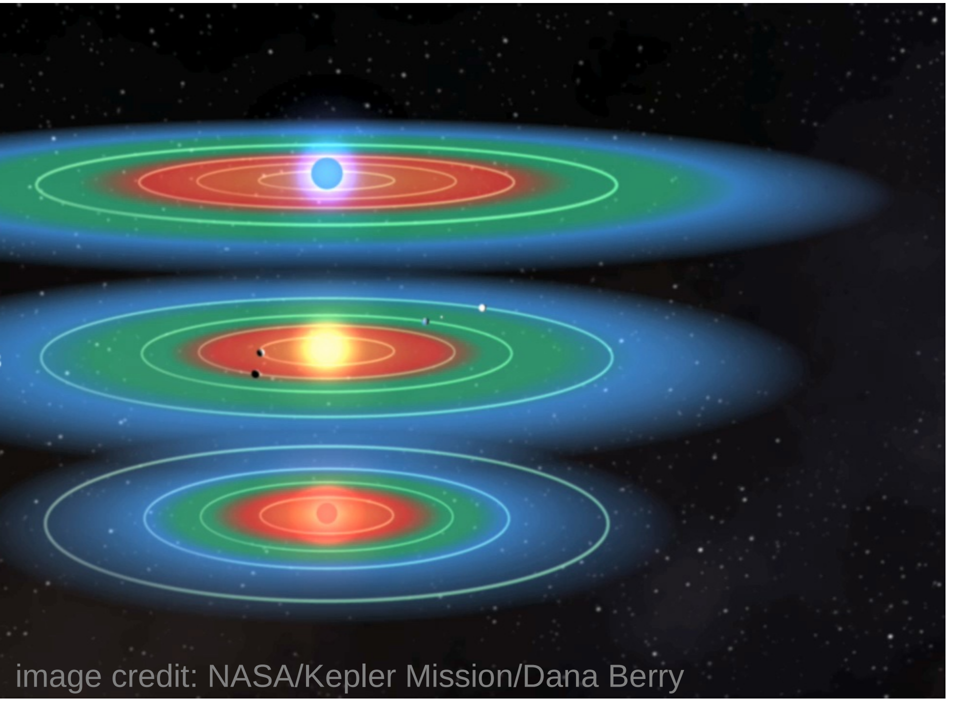

Simple framework (not always applicable!): Energy-limited escape driven by X-ray and extreme-UV (EUV) photons

See for example Lammer et al. (2003), Lecavelier des Etangs et al. (2004), Erkaev et al. (2007), Owen & Jackson (2012)

# Habitable zones and coronal $L_X/L_{bol}$

Habitable zones defined to first order by bolometric flux Fbol

$F_X/F_{bol} = L_X/L_{bol}$ = standard X-ray quantity.
Immediately defines the X-ray irradiation in the habitable zone!



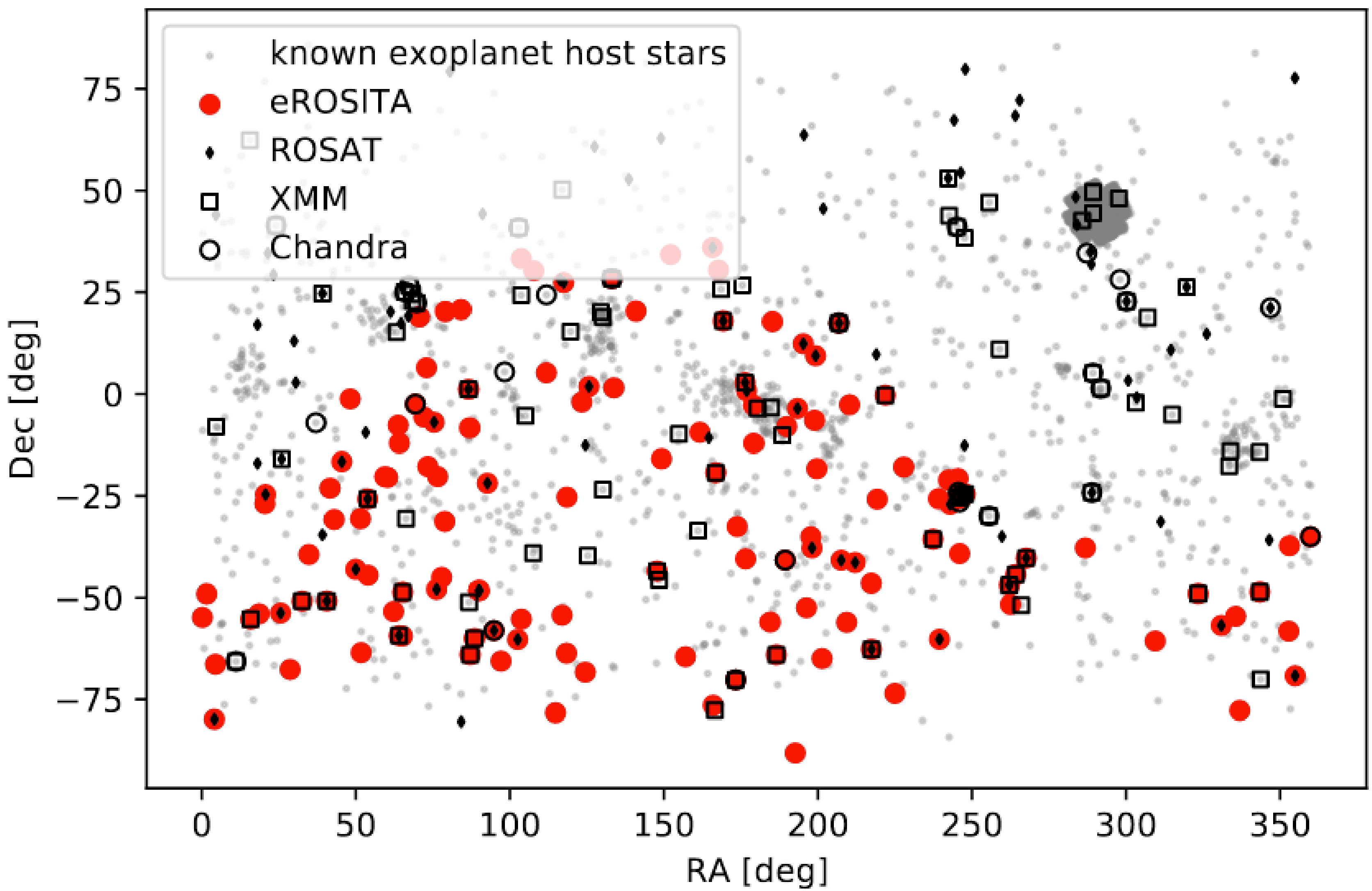

"Typical" $L_X/L_{bol}$:

G dwarfs: $10^{-6}$

K dwarfs: $10^{-5}$

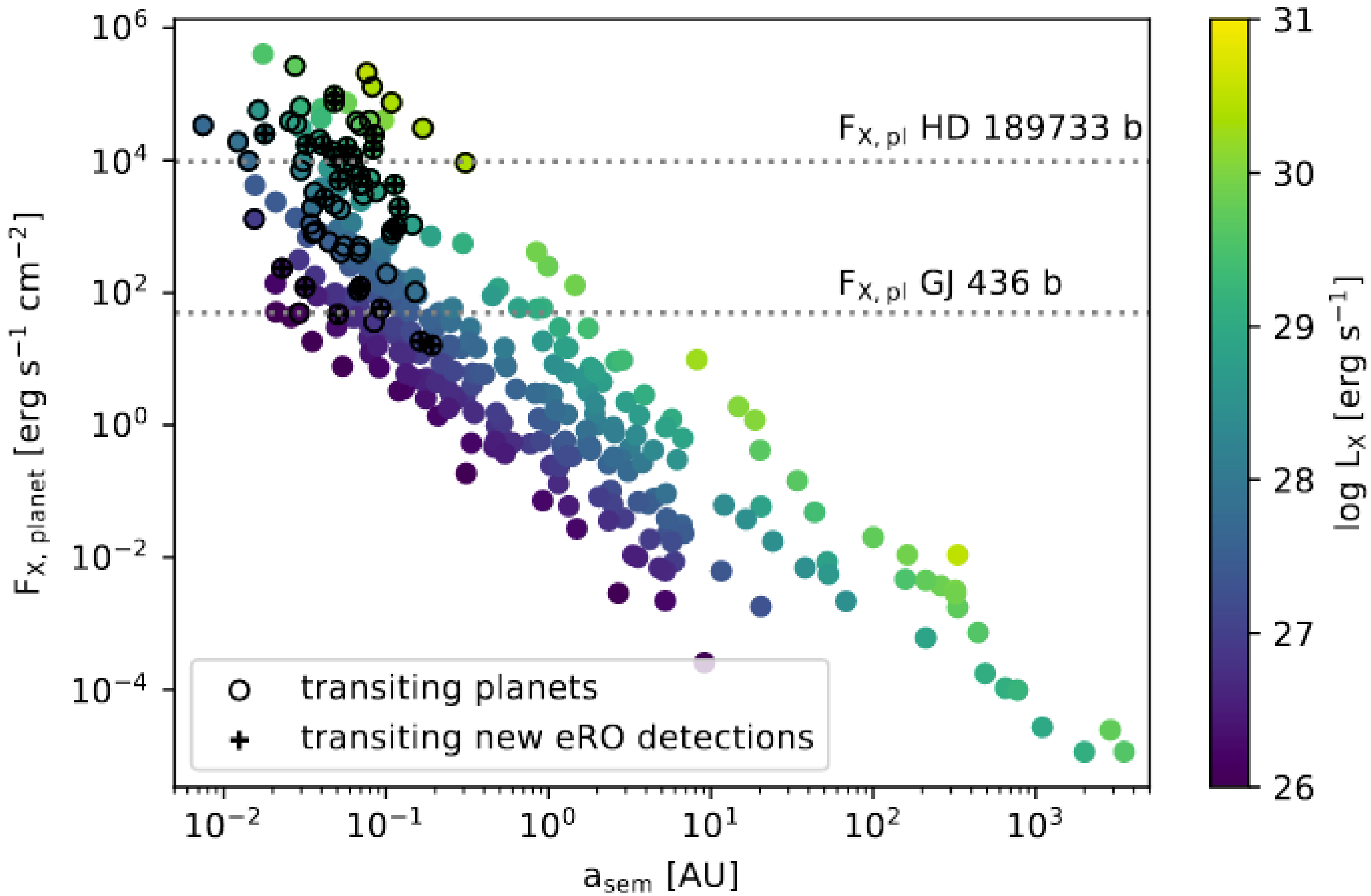
M dwarfs: $10^{-4}$

# X-ray/EUV catalog of exoplanet host stars




New eROSITA catalog: ~300 exoplanet hosts with X-ray/EUV luminosity (Foster, Poppenhaeger et al. accepted 2021)

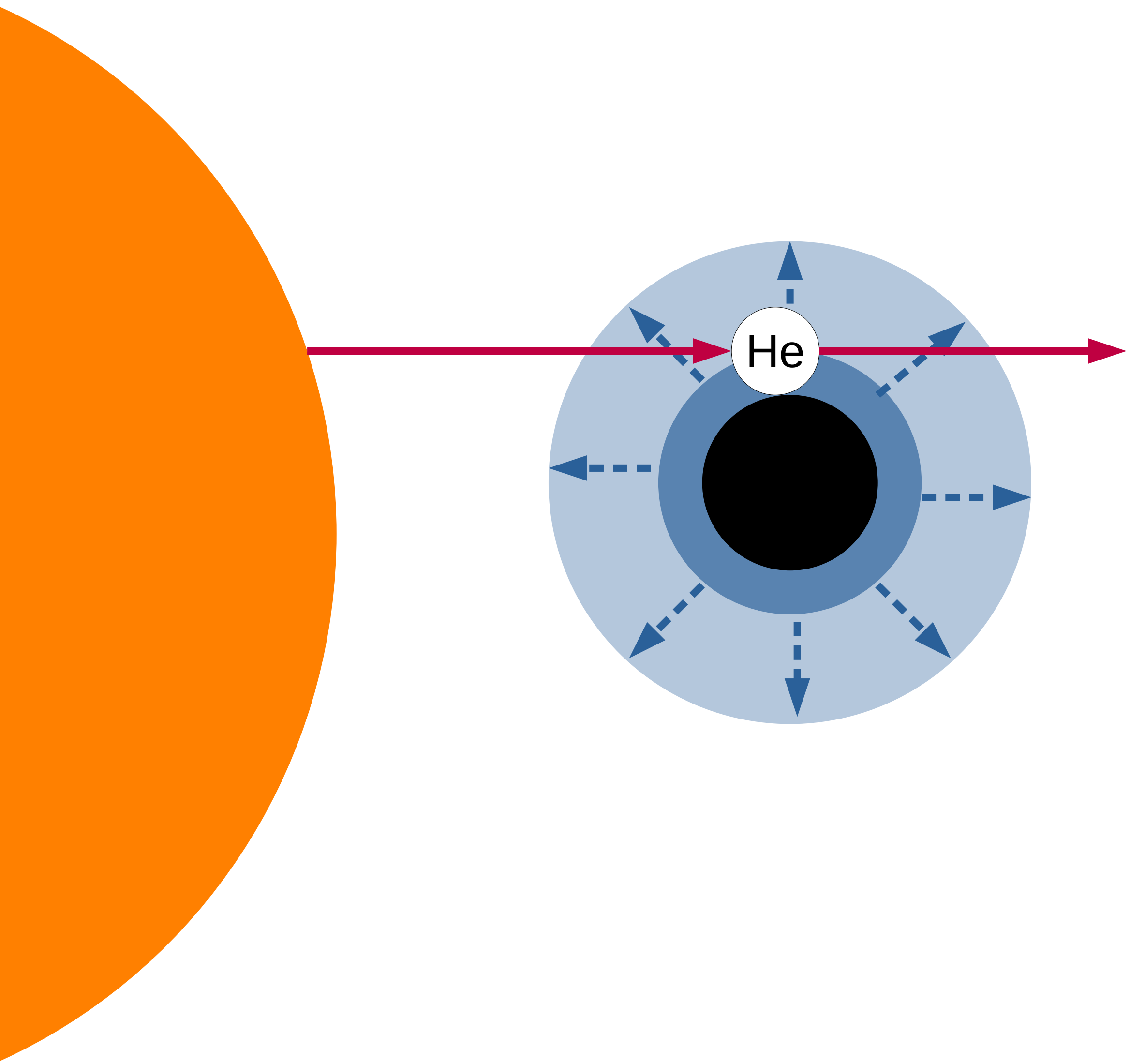
# X-ray/EUV catalog of exoplanet host stars




Many transiting exoplanets with higher XUV irradiation than HD 189733 b or GJ 436 b!

(Foster, Poppenhaeger et al. 2021)

# Observing helium in exoplanet atmospheres

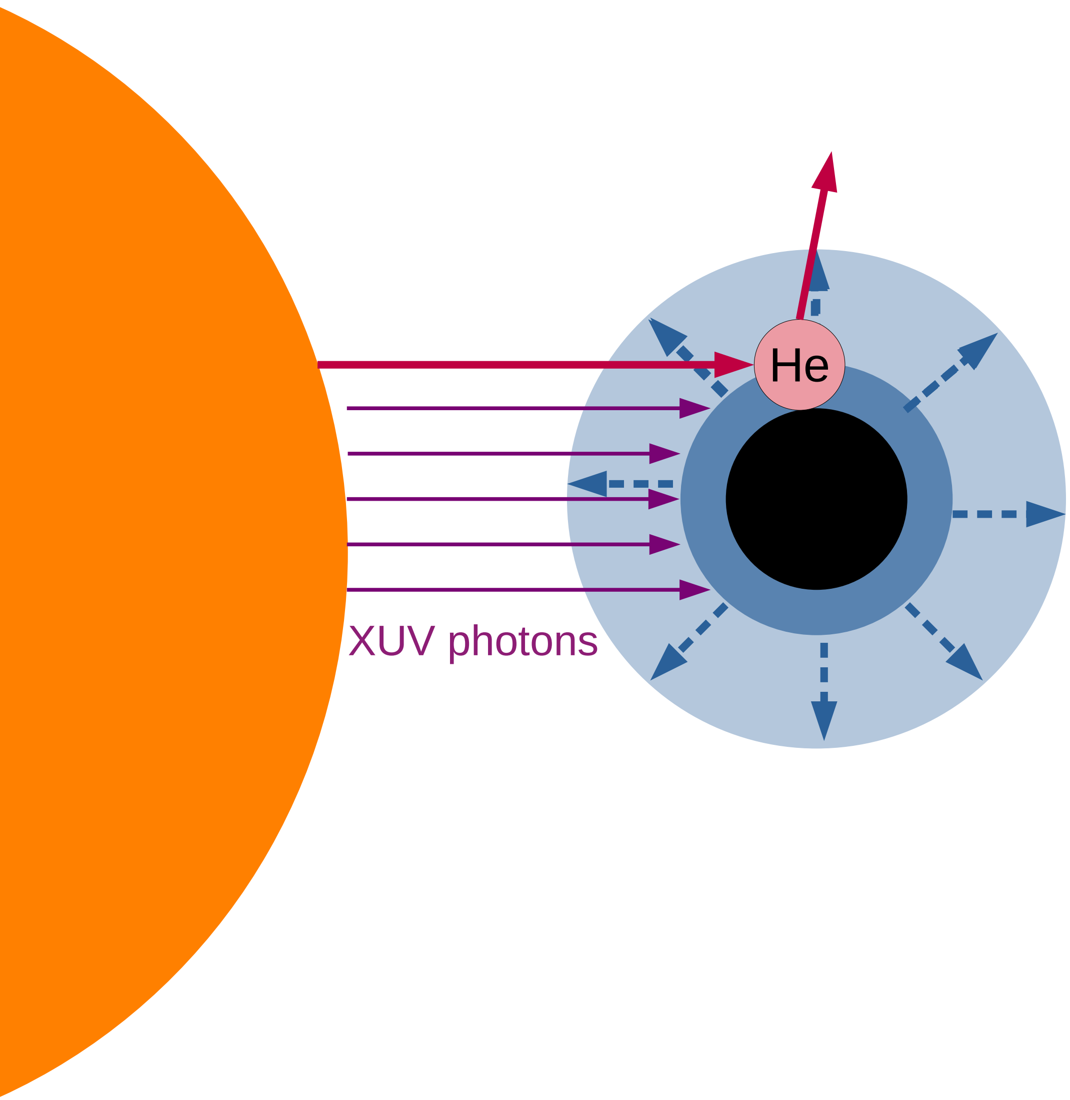



Need to excite helium in exoplanet atmosphere first to make it absorb in infrared He lines (stellar EUV photons make that happen!)

-> expect correlation of EUV irradiation and observed He transit depth

see Oklopcic & Hirata (2018)

# Observing helium in exoplanet atmospheres




Need to excite helium in exoplanet atmosphere first to make it absorb in infrared He lines (stellar EUV photons make that happen!)

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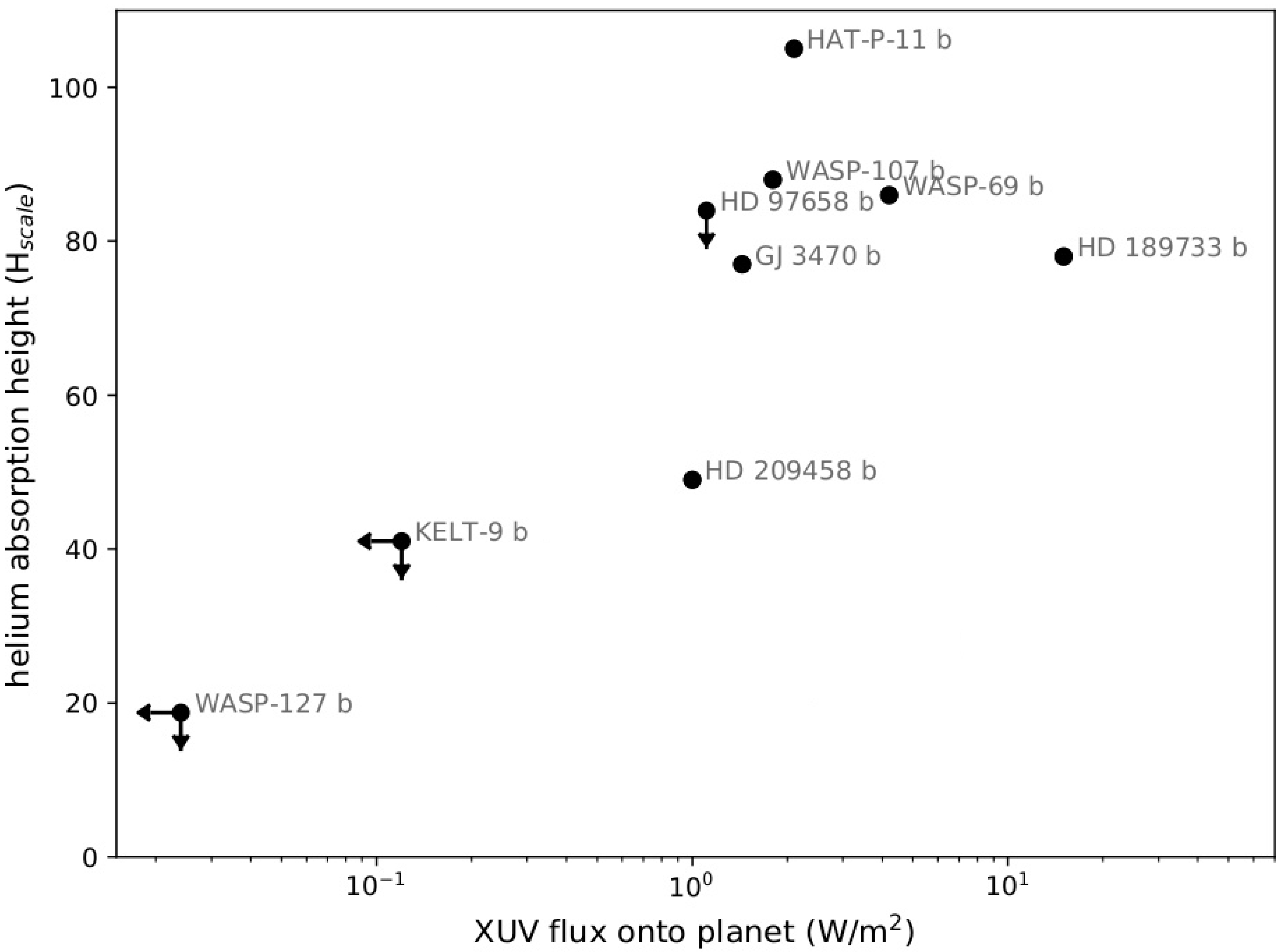
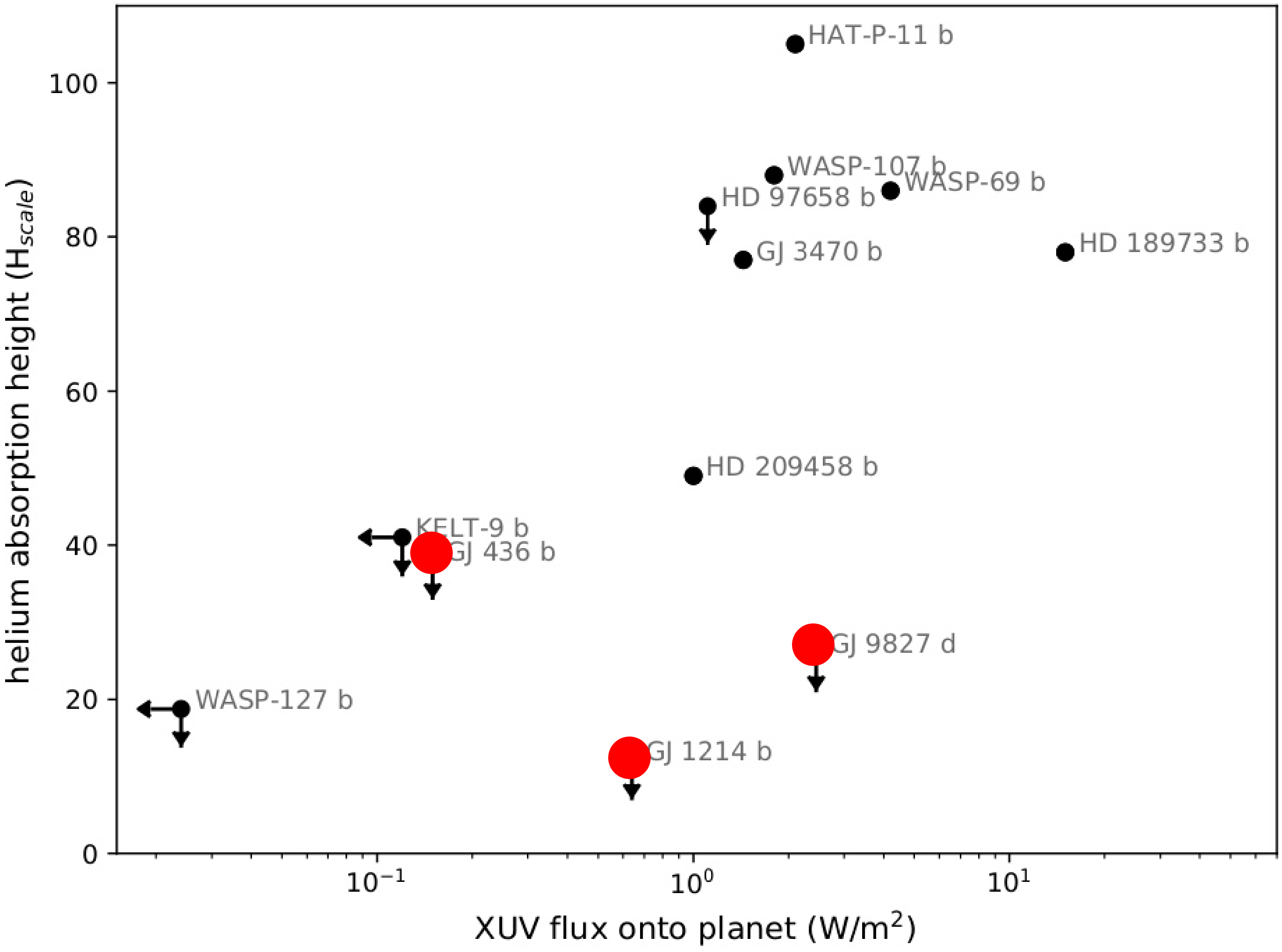
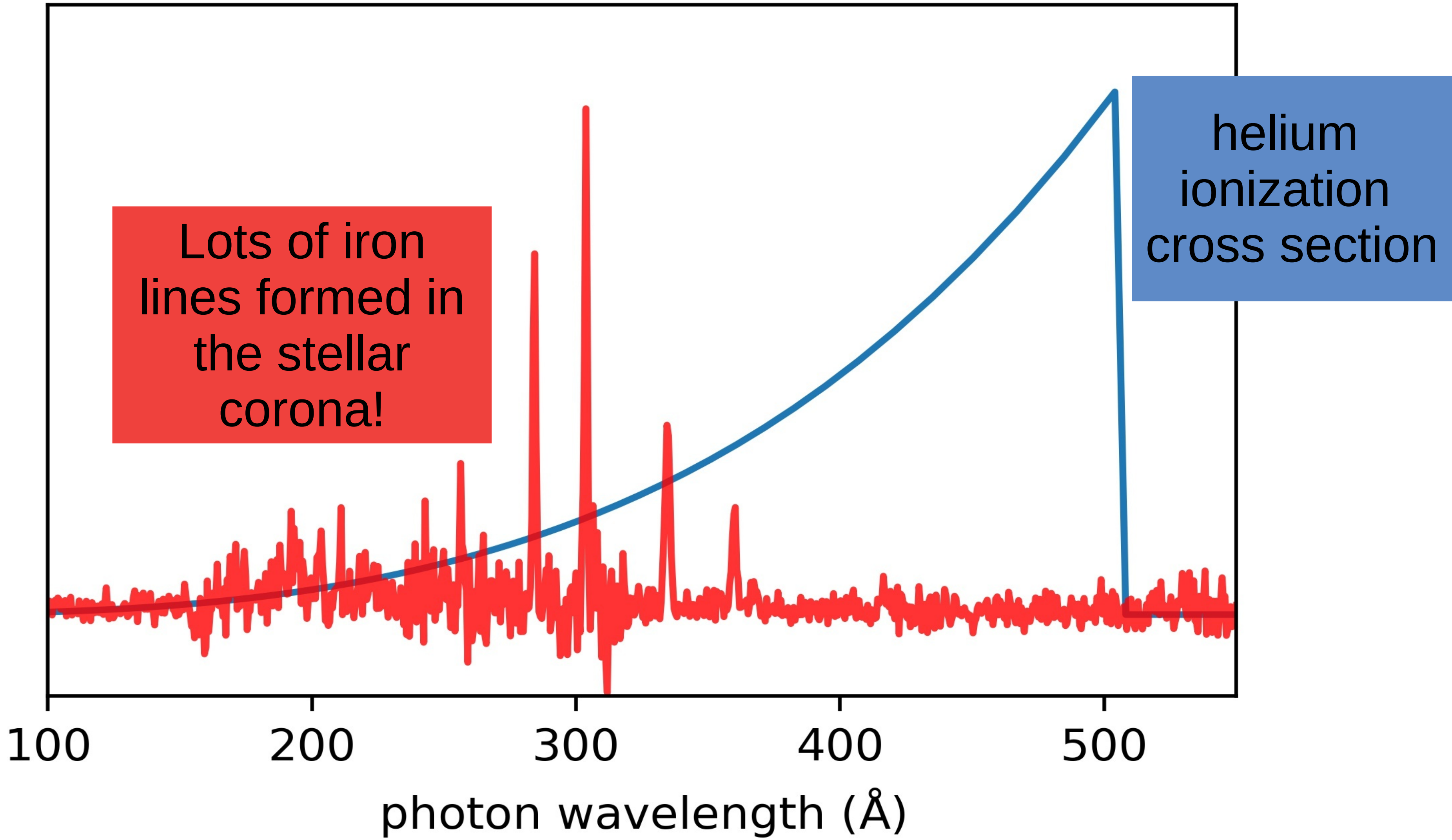
# Planetary helium radius / XUV correlation



# Planets around M dwarfs tend to be outliers!

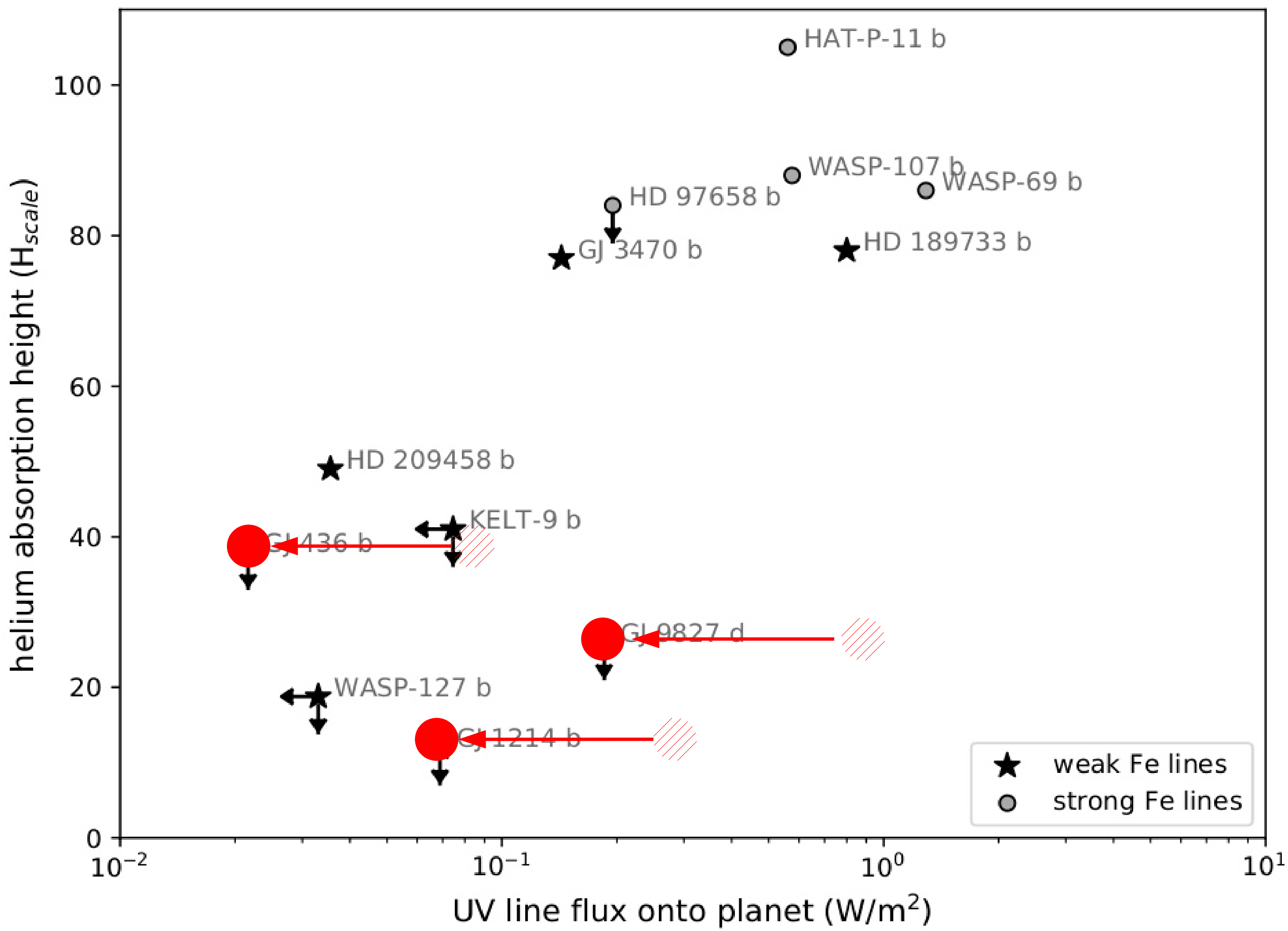


# What actually ionizes the exoplanetary helium?




Poppenhaeger (2021), submitted

# Correcting for coronal iron = more accurate way to estimate planetary helium depth!




Coronal abundances of stars are not the same as photospheric abundances - so-called "FIP effect" causes abundance shifts for iron.

M dwarfs tend to be low in coronal iron,

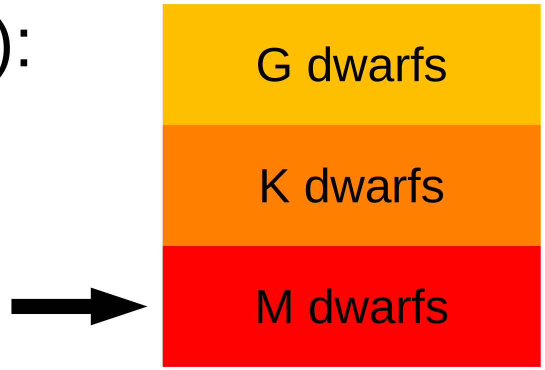
K and G dwarfs (and the Sun) tend to be high in coronal iron!

(see Wood et al. 2018, for example)

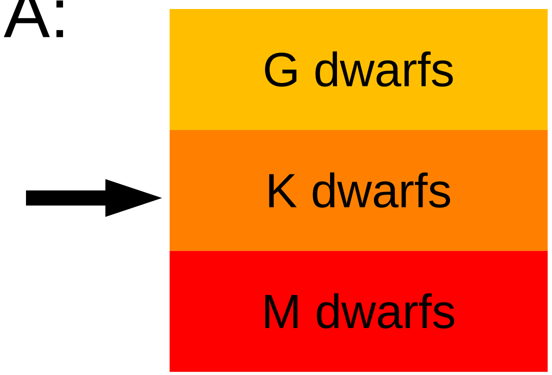
Poppenhaeger (2021), submitted

# Conclusion: The K dwarf sweet spot

Broadband XUV irradiation (~10-1000 Å):
makes atmospheric evaporation happen




Narrowband EUV irradiation at 200-500 Å:
makes atmosphere **visible to us** in
infrared helium lines



# Conclusion: The K dwarf sweet spot

XUV-driven atmospheric evaporation:

catalog for ~300 exoplanets (Foster et al., A&A accepted 2021)

https://ui.adsabs.harvard.edu/abs/2021arXiv210614550F

catalog preliminarily hosted on group website:

https://tinyurl.com/eky8xpy7

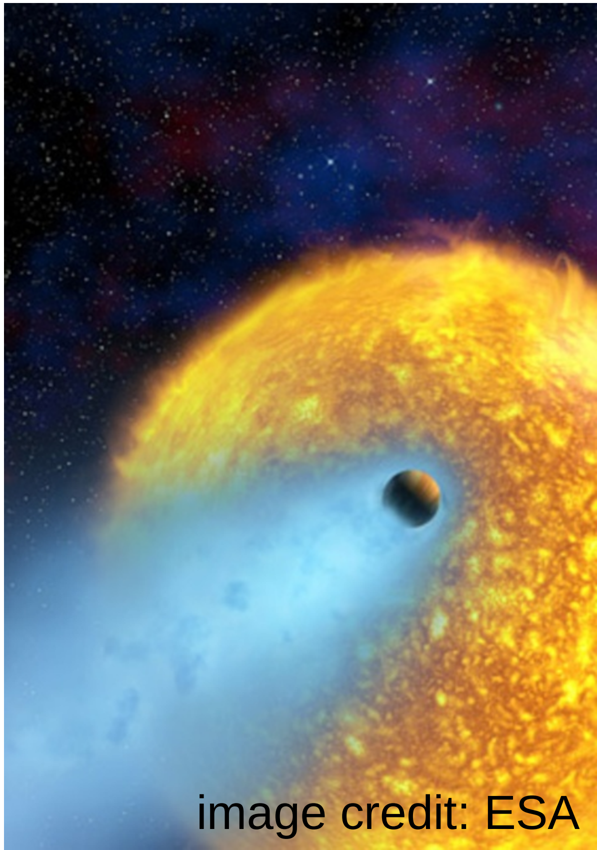


image credit: ESA