A Cold Giant Planet in a Dynamically Hot, Multi-planet System, imaged with JWST

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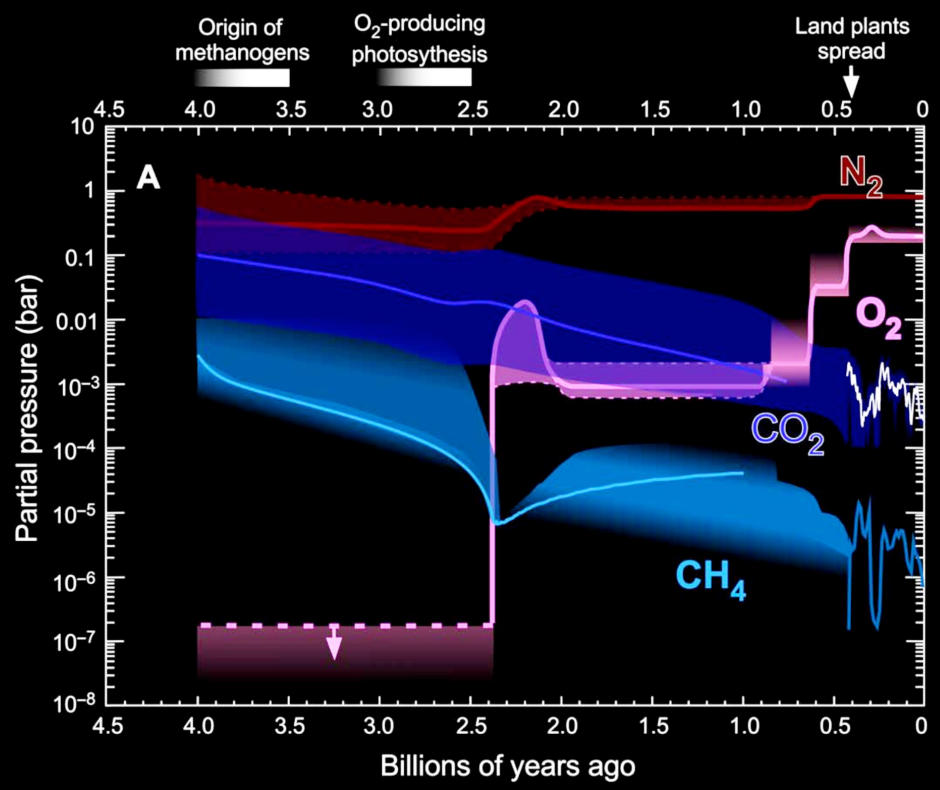
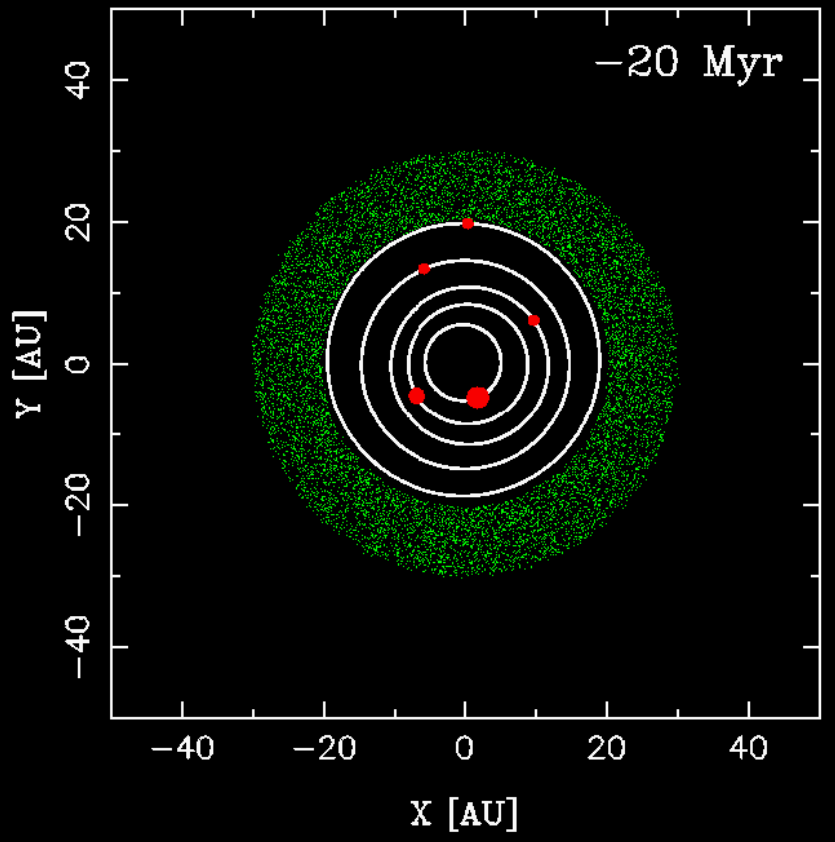
How do Planetary Systems Evolve?

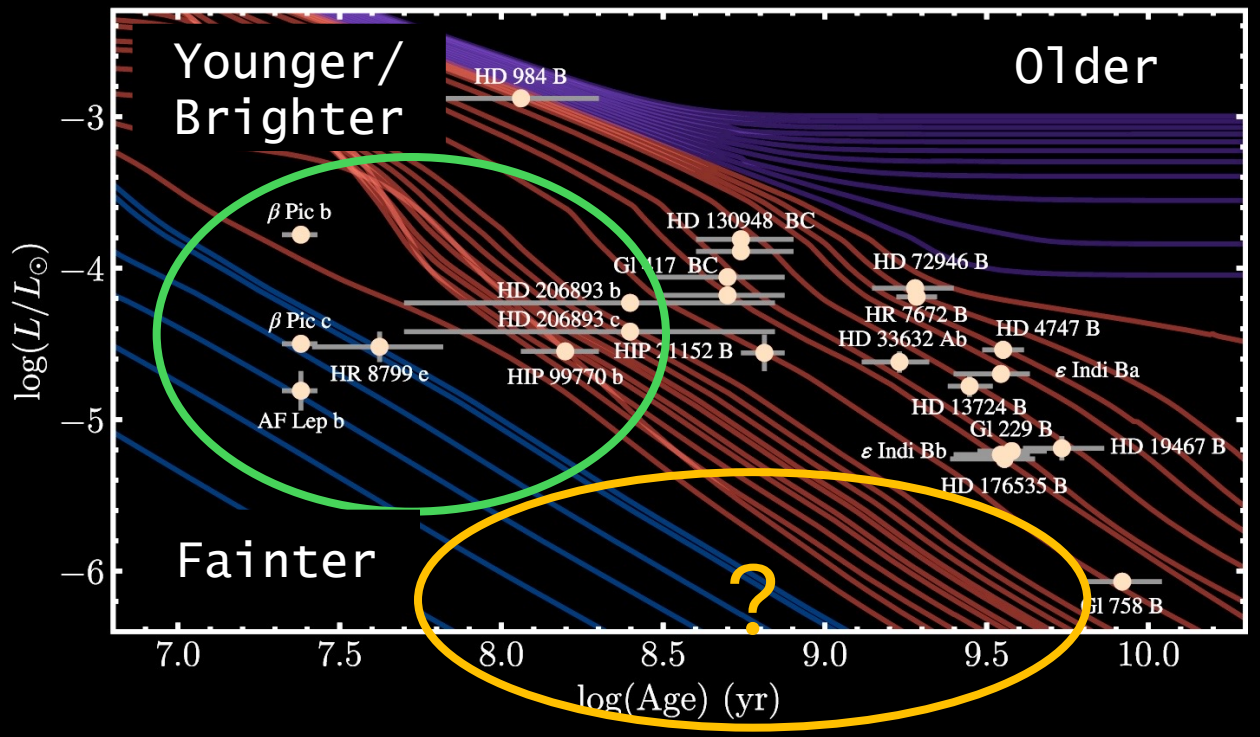


Earth's atmospheric composition over time
(Caitling & Zahnle 2020)



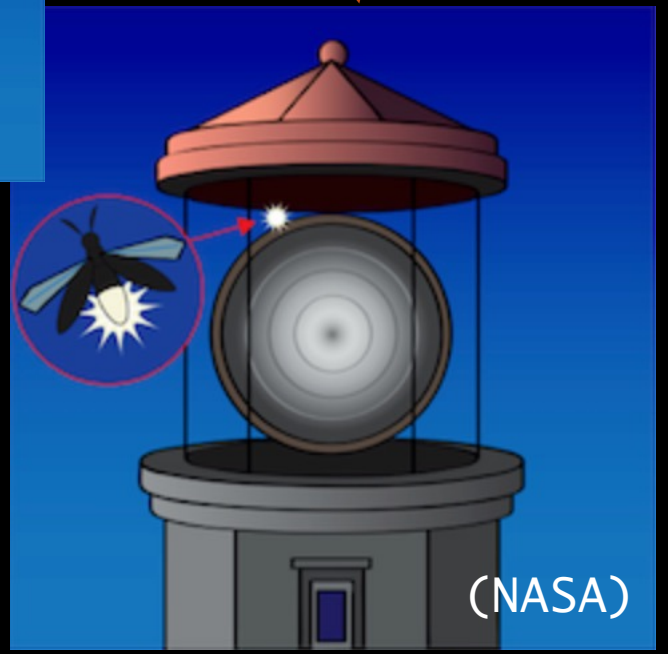
Scattering of a putative 5th solar system giant
(David Nesvorny / SWRI)

Fireflies next to lighthouses



Giant planet/brown dwarf brightness vs time
(Plot from Franson & Bowler 2023,
models from Burrows et al. 1997)

Coronagraphs,
machine learning,
optical modeling

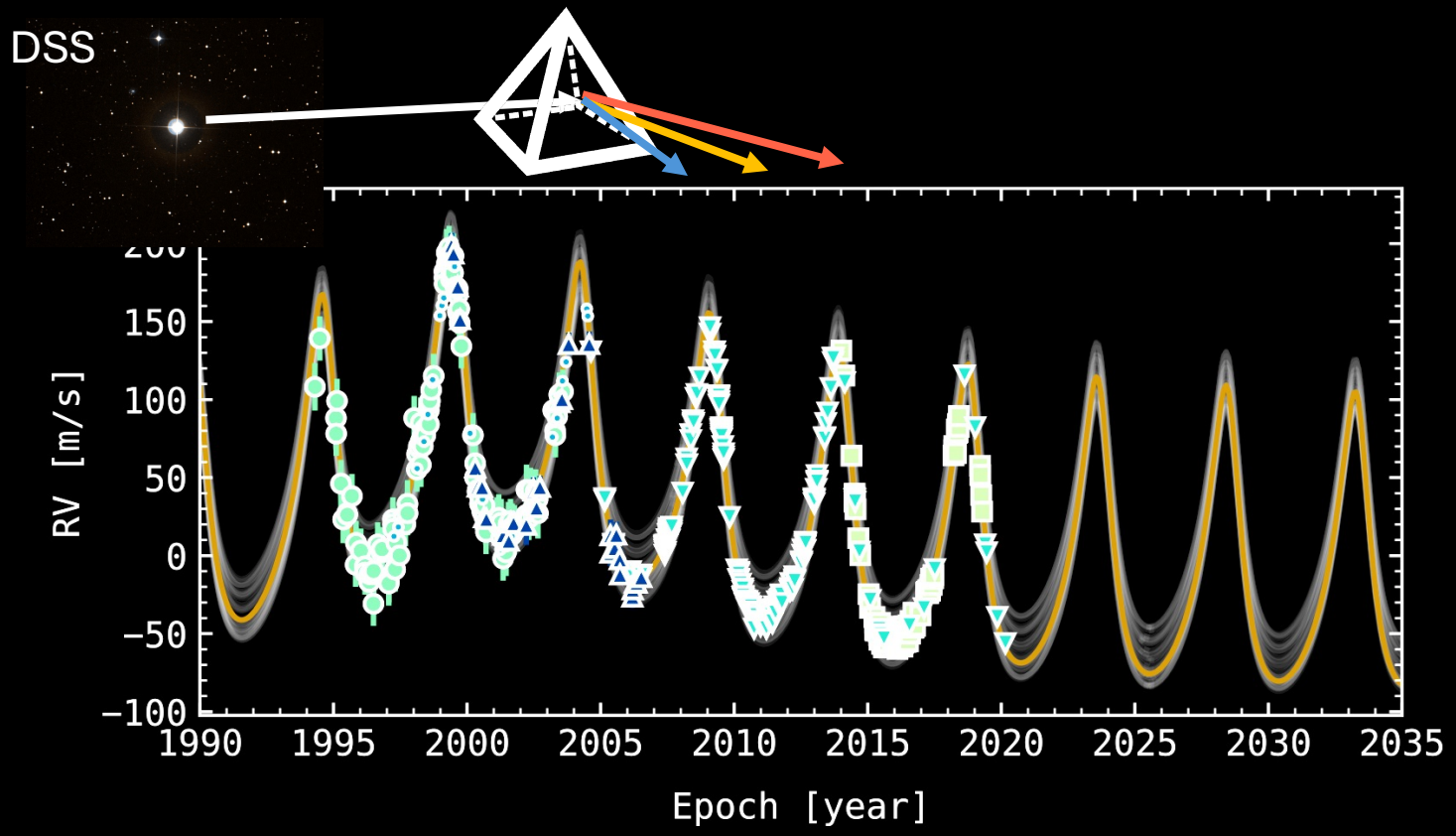


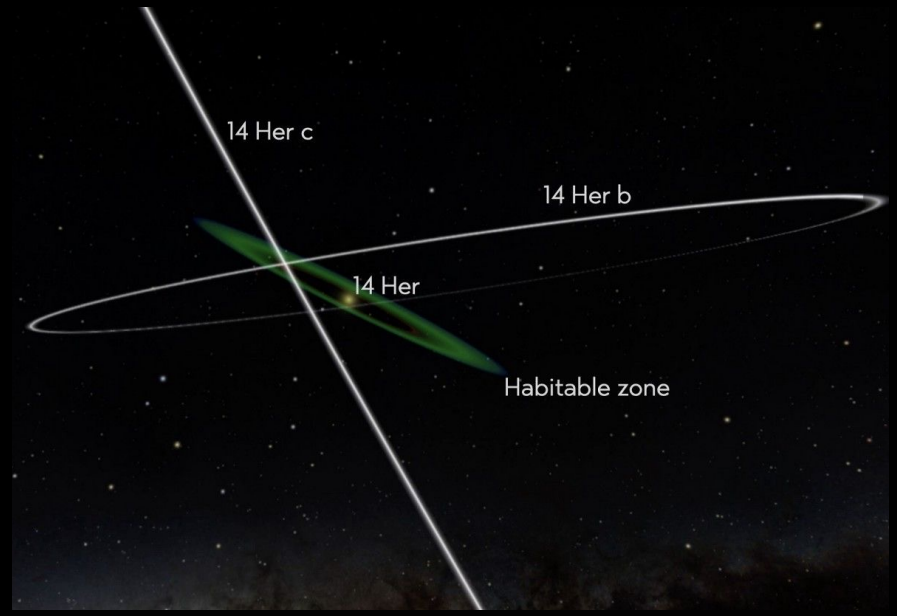
Direct imaging with JWST

- With JWST, we can image at much longer wavelengths (redder colors) than before, and colder planets are brighter at redder wavelengths.
- Still, we need to find nearby star systems with planets that orbit far away enough from their bright host to be imaged.

14 Her System Overview

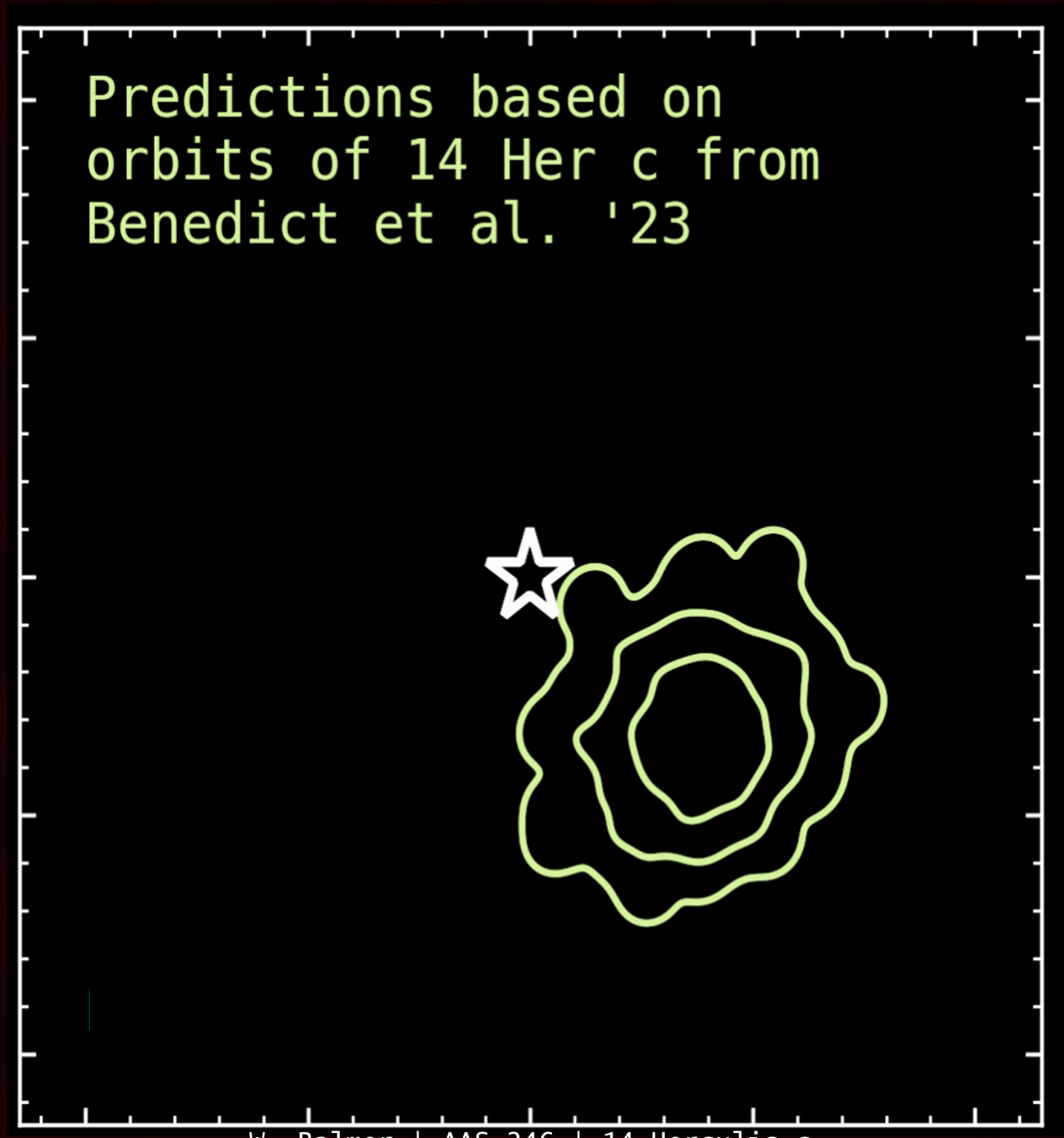
Indirect measurements (radial velocities, astrometry) imply that there are two gas giant planets on misaligned orbits around this nearby, old (solar system age) star





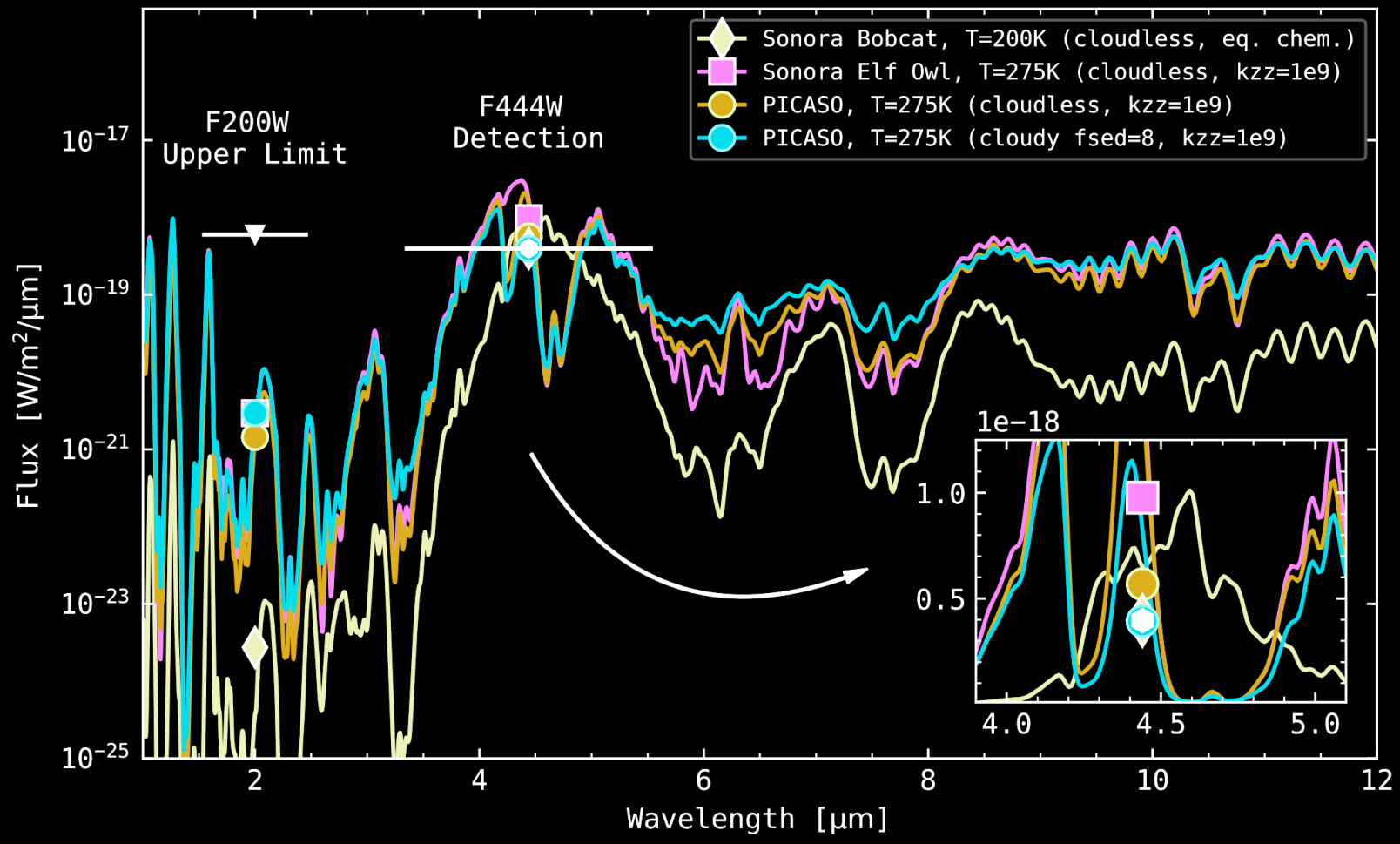
OpenSpace, AMNH

14 Her c predicted location



14 Her c direct image

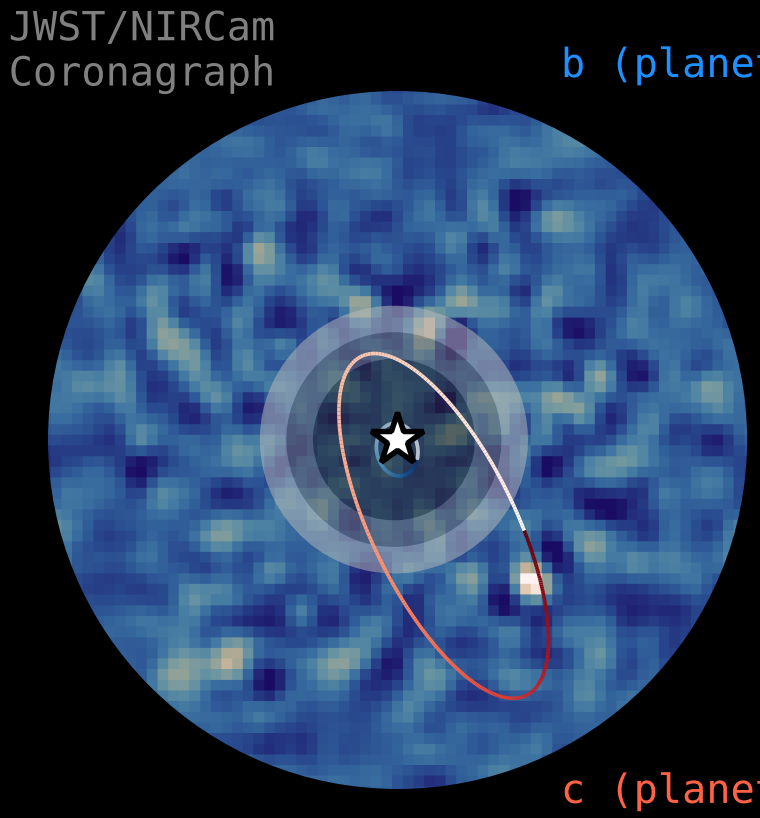
Cloudy, with a chance of wind

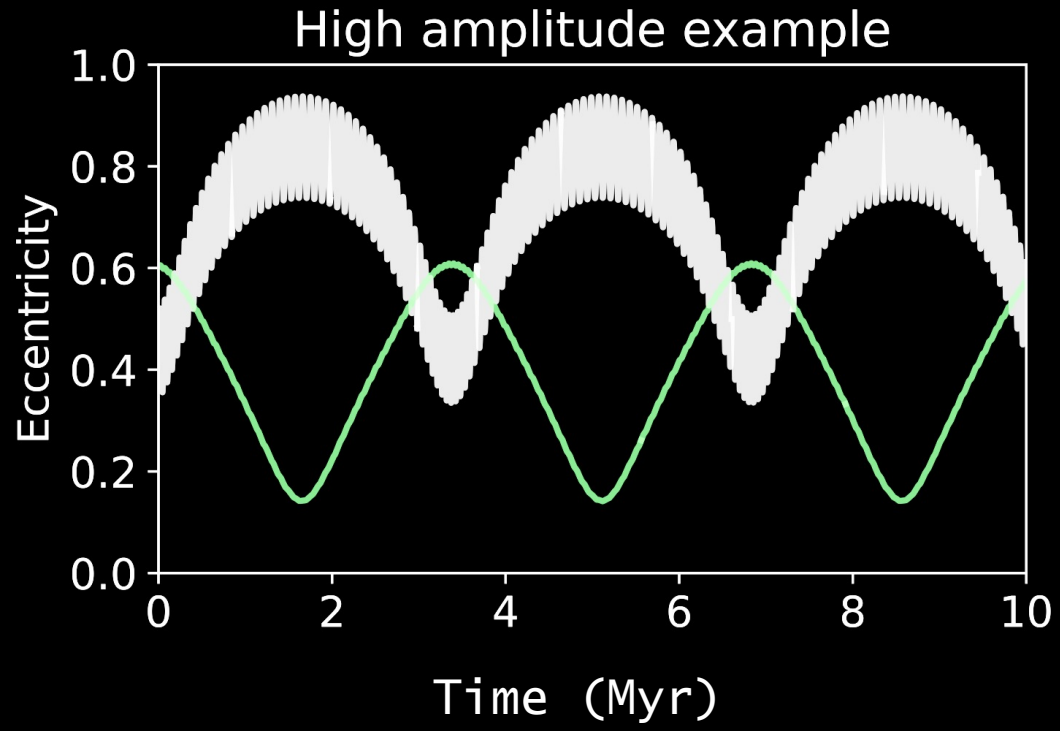


- One of the coldest planets directly imaged to date
- Strong updrafts and water-ice clouds likely made the planet slightly fainter than what we predicted

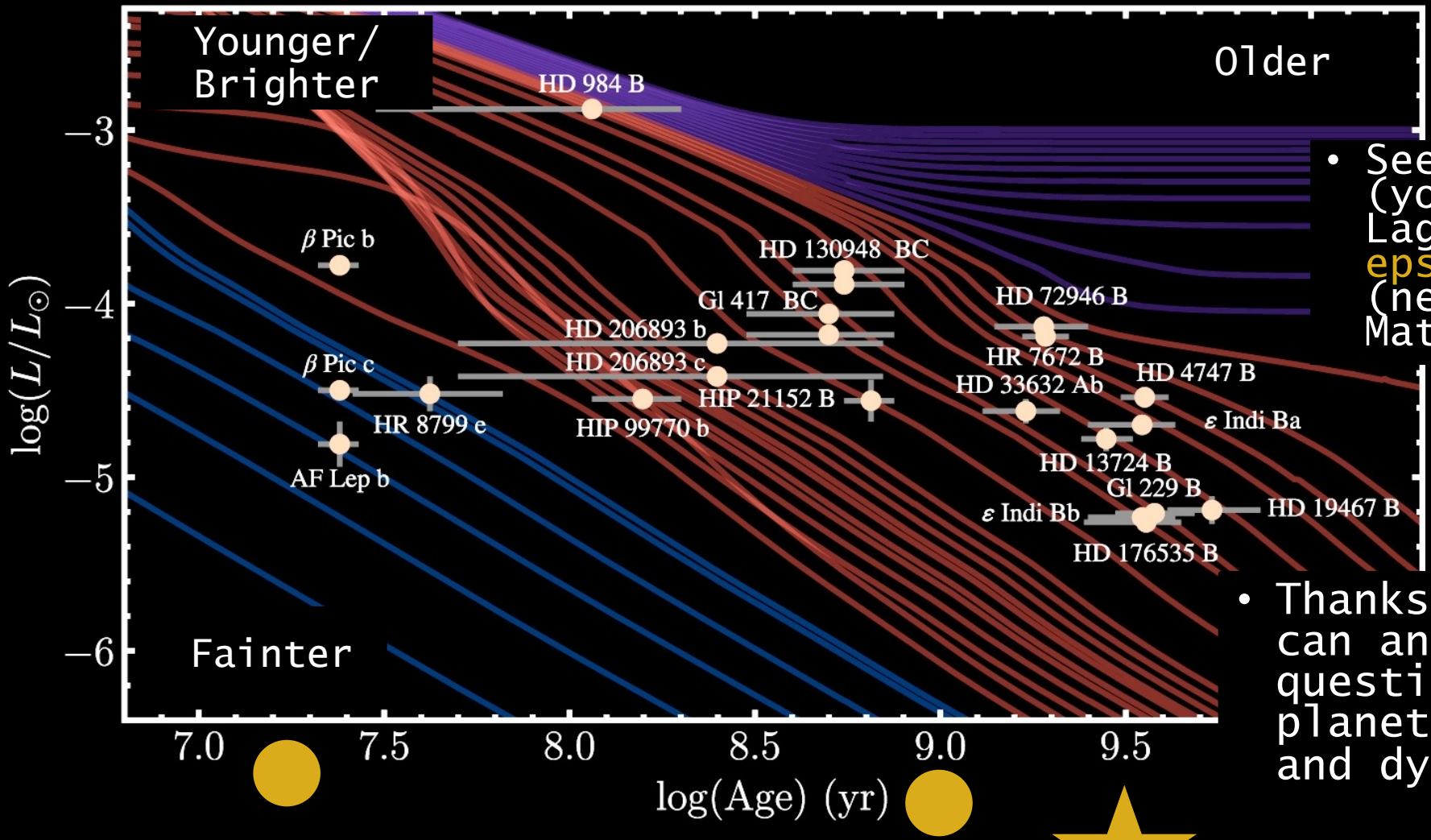
A dynamically hot system

Large, but stable, oscillations between planets. Likely c was scattered out to current orbit





One of the oldest, faintest planets imaged



- See also TWA 7b (young & cold, Lagrange+25) and eps Indi Ab (nearby and cold, Matthews+24)
- Thanks to JWST, we can answer new questions about planetary atmospheres and dynamics