

Habitability and Diversity

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**Radio Exploration of Planetary Habitability,
Palm Springs, May 8-12, 2017**



Outline

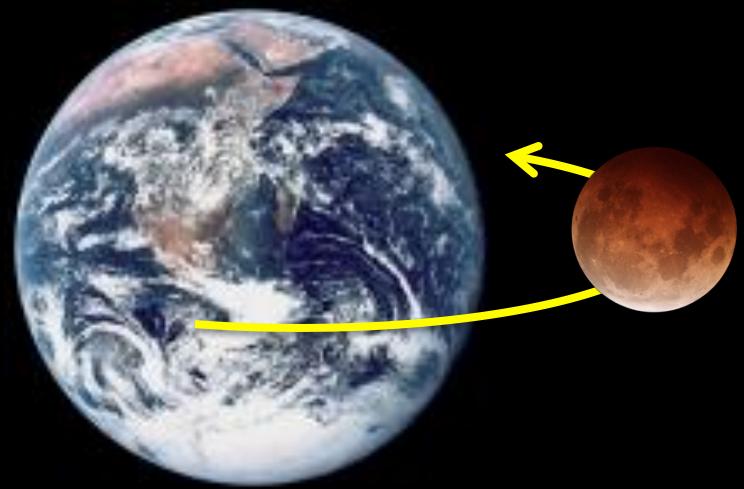
- Not a summary
- No advice/guideline
- Biased view
- Incomplete and arbitrary
- Personal preference
- From your work and my fantasy
- Some curiosity and trivia
- No profound news



Diversity of Planets



NASA



Same size, similar composition, similar orbit, similar amounts of CO₂, N₂, ... but:

Stagnant lid, no plate tectonics
or episodic plate tectonics?

no water

slow rotation

no dynamo (anymore?)

plate tectonics

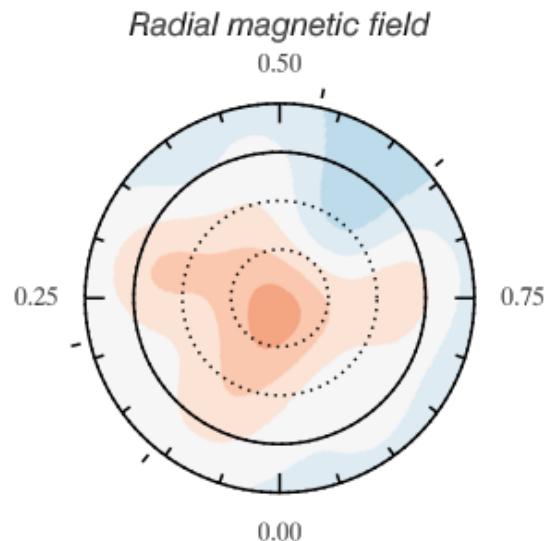
water oceans

rapid rotation

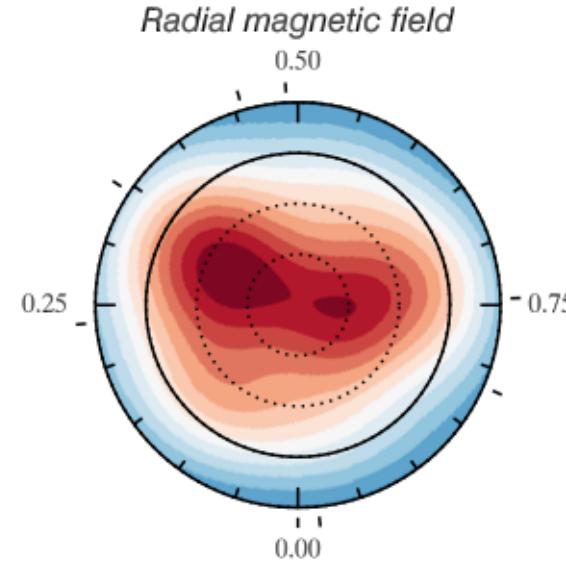
magnetic dynamo

Moon??

Diversity of Stars



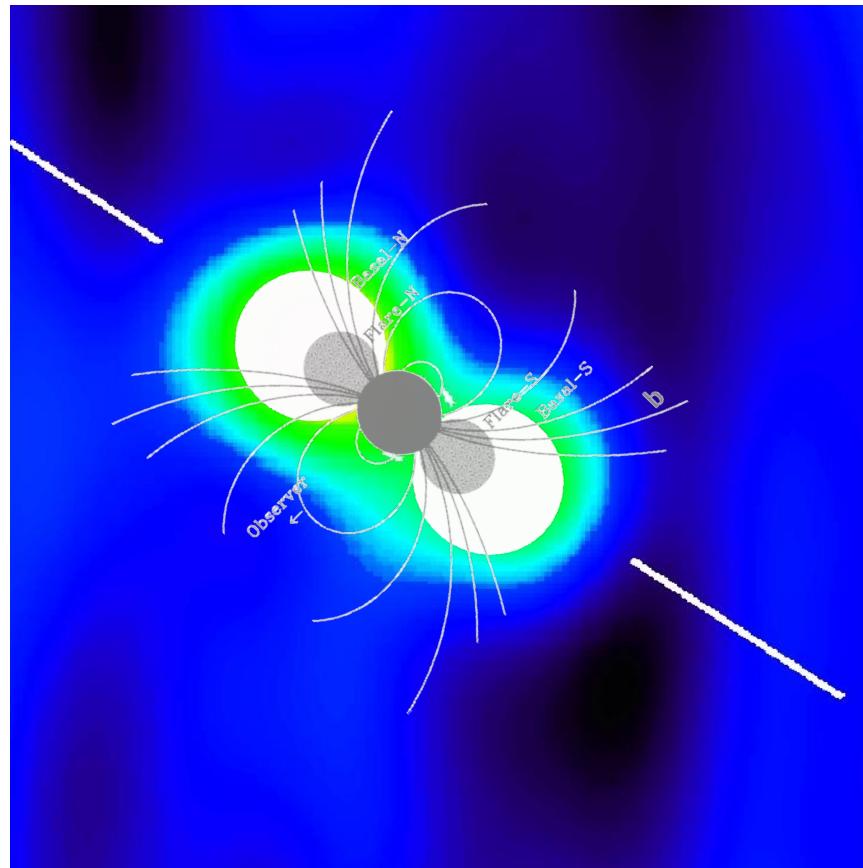
GI 65A



GI 65B

Spectral class	M5.5Ve	M6Ve
Mass	$0.1225 M_{\odot}$	$0.1195 M_{\odot}$
Radius	$0.165 R_{\odot}$	$0.159 R_{\odot}$
Rot. $v \sin i$	28.5 km/s	30.6 km/s
Rot. period	5.86 hr	5.45 hr
Metall. [Fe/H]	-0.03	-0.12
$\langle B_f \rangle$ Stokes I	5.2 kG	6.7 kG
B_{dip} strength V	0.3 kG complex, non-axisymmetric	1.3 kG axisymmetric dipole

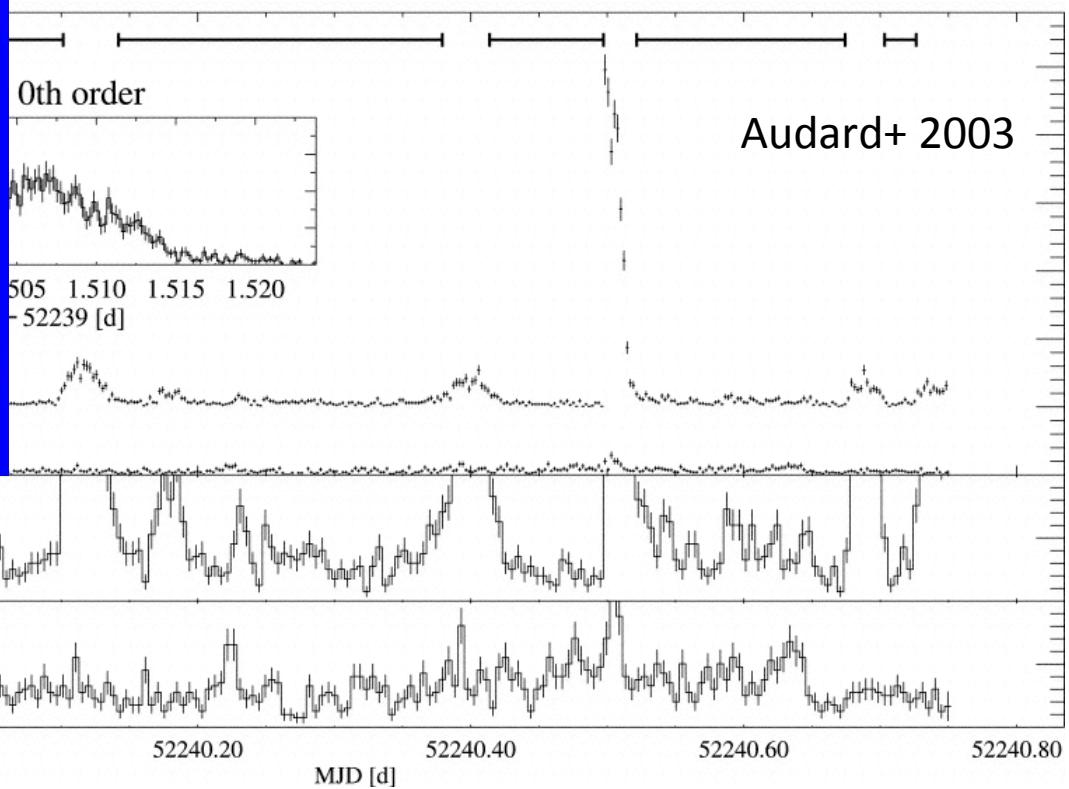
Kervella et al. 2016, Barnes et al. 2016, Kochukhov et al. 2017, Lynch et al. 2017



Benz+ 1998

Diversity of Stars

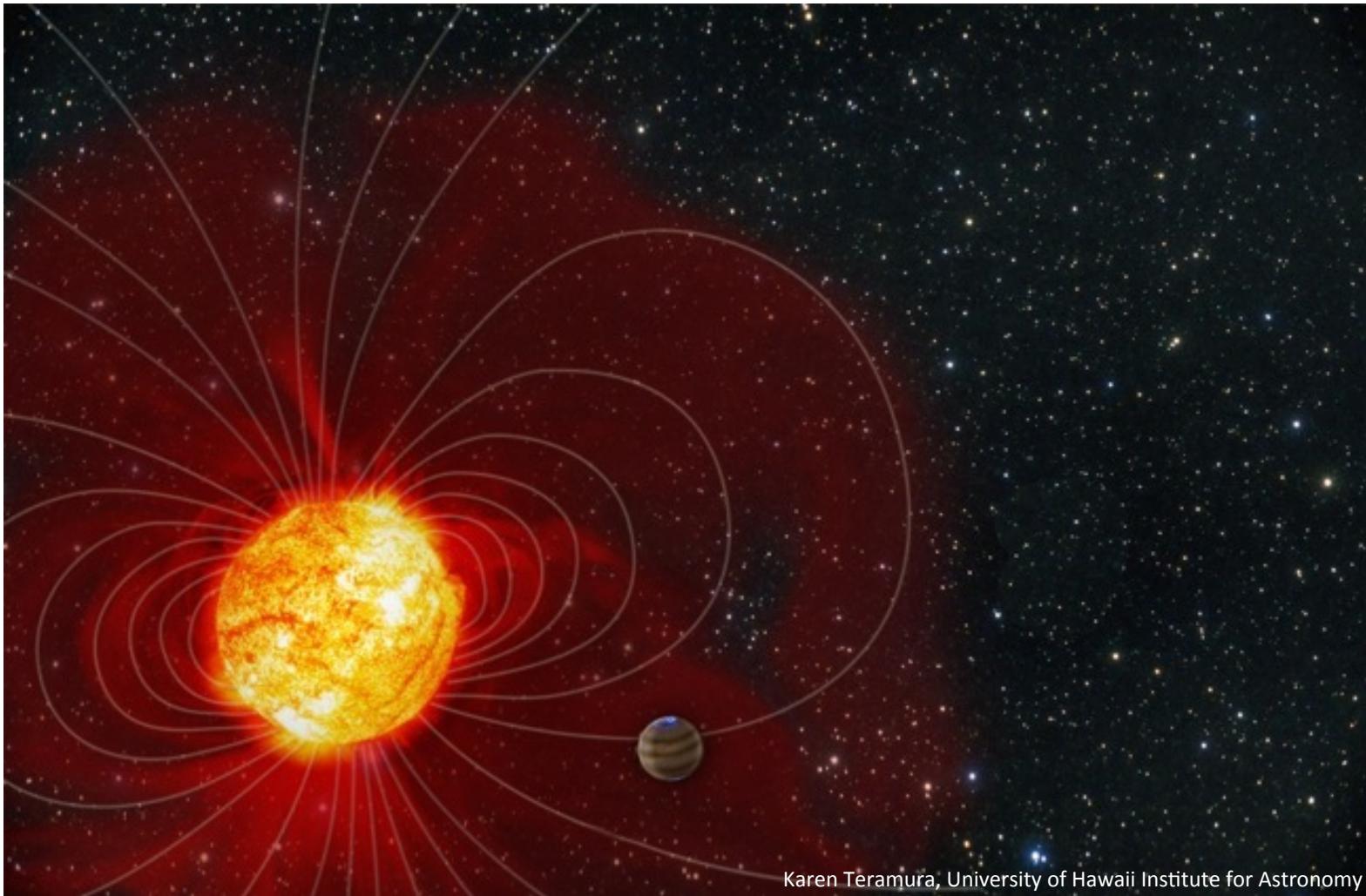
Important: Combining all information from all wavelengths



Consequences for space weather/planet interaction....

AND STELLAR SPIN-DOWN → feedback on stellar output and habitability

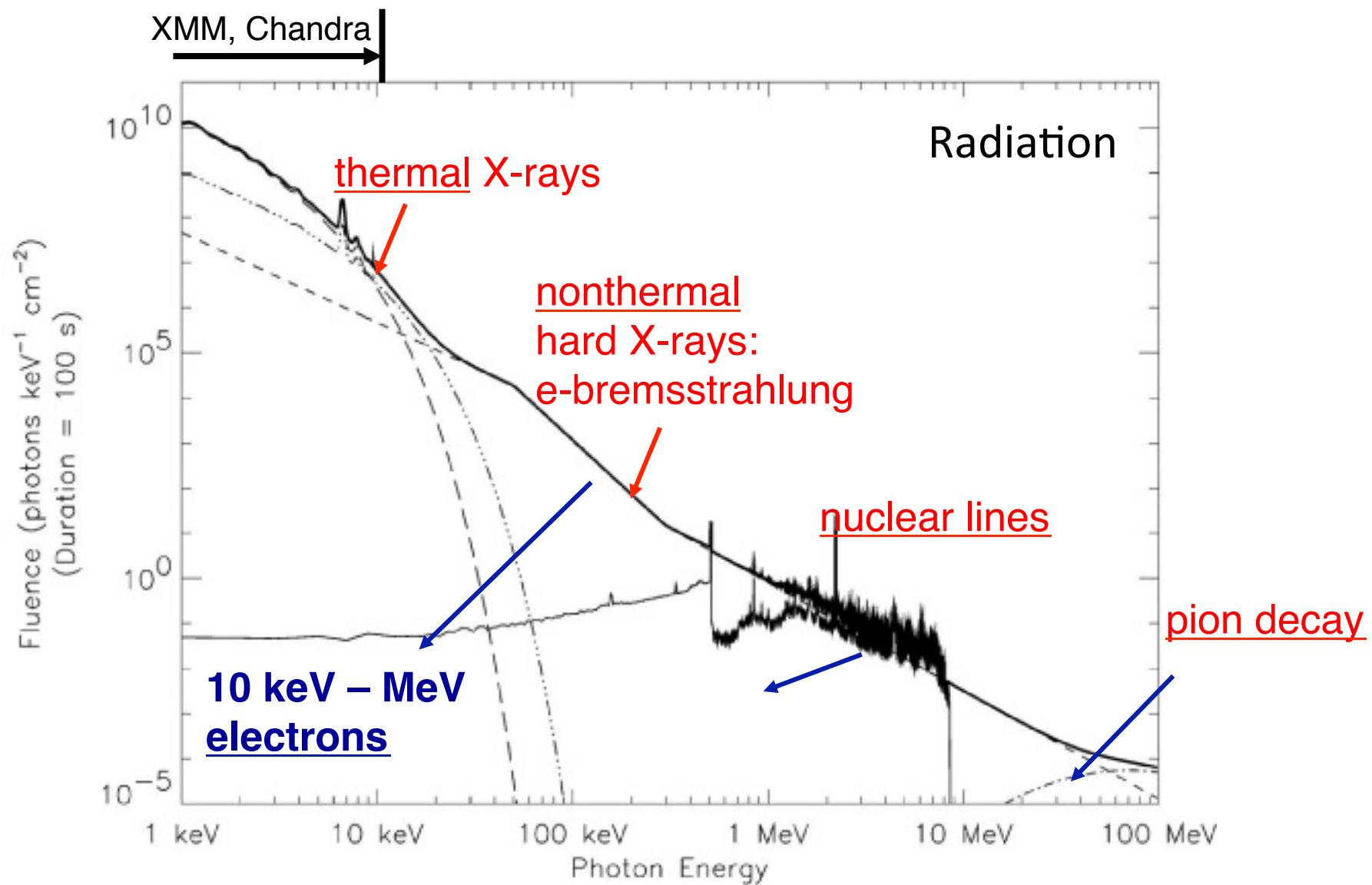
Who affects Whom?



Karen Teramura, University of Hawaii Institute for Astronomy

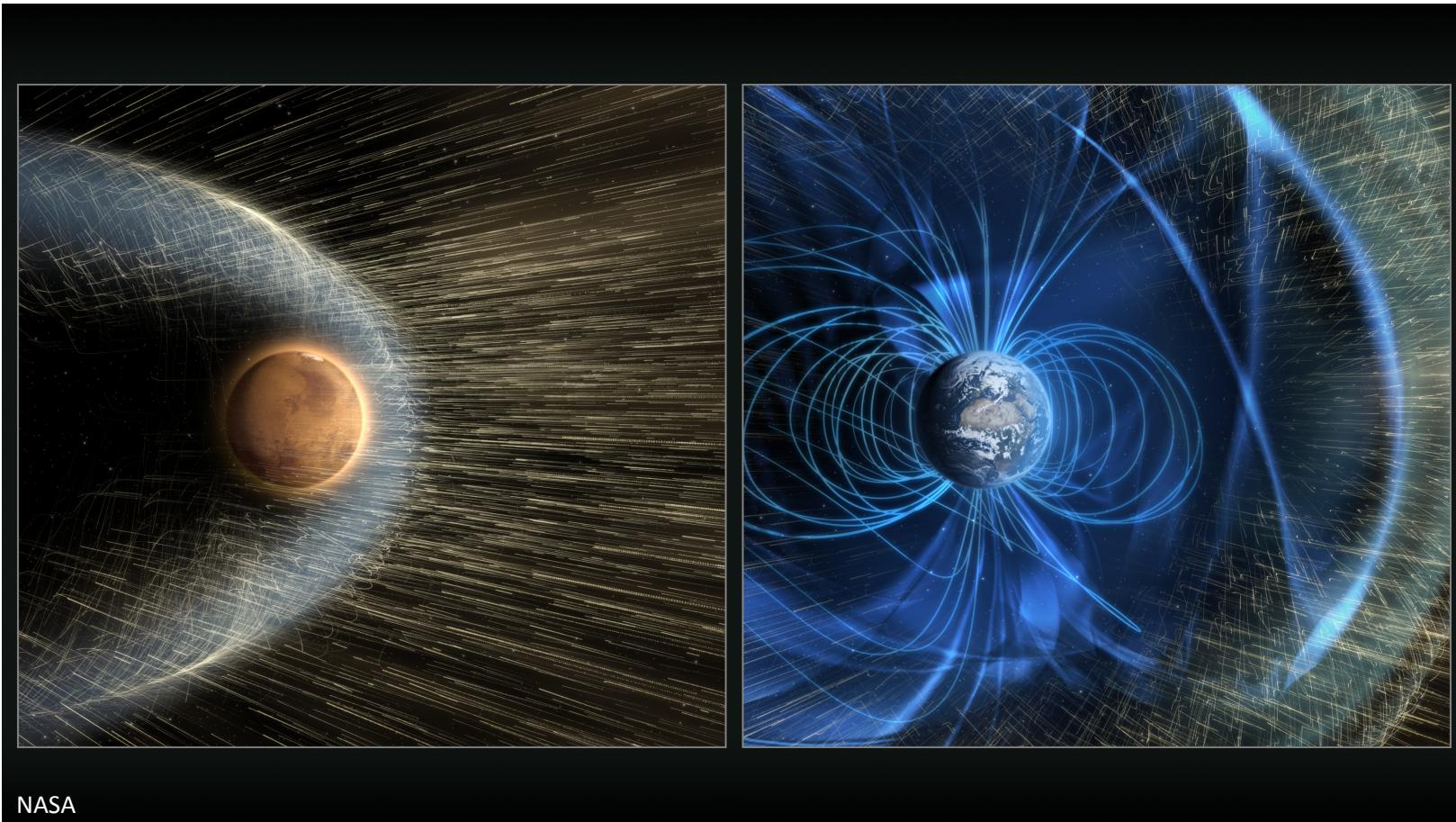
tidal, magnetic, particles, radiation? Feedback loops?
Exchange of flows, energy, particles along connecting B?

The Full High-Energy Picture?



Lin+ 2002

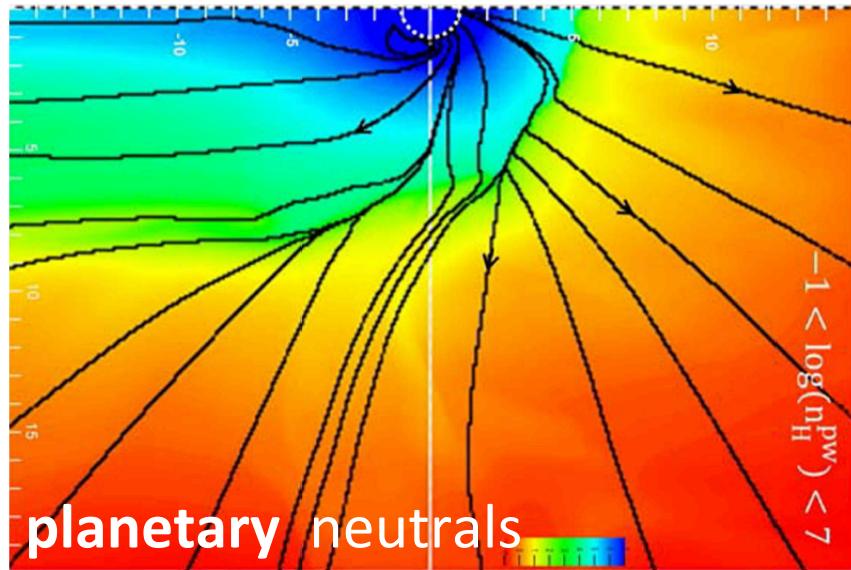
Magnetospheres: Shields or Funnels?



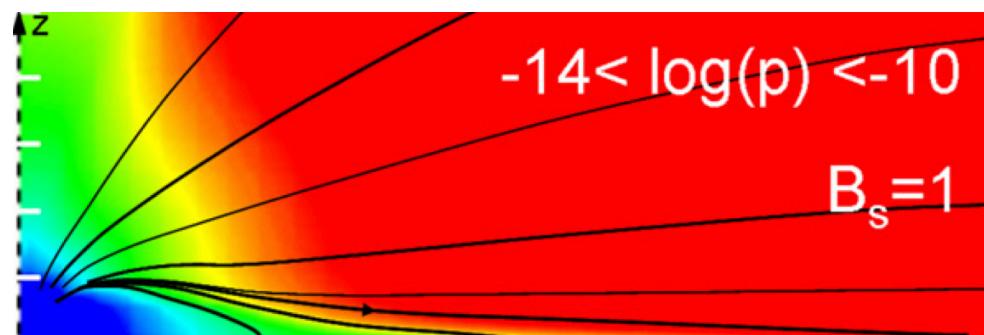
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it probably depends! Type of atmosphere,
strength of magnetosphere, strength of stellar wind,....

Planetary Wind Processed by Stellar Wind and Radiation: Magnetic Fields Matter!

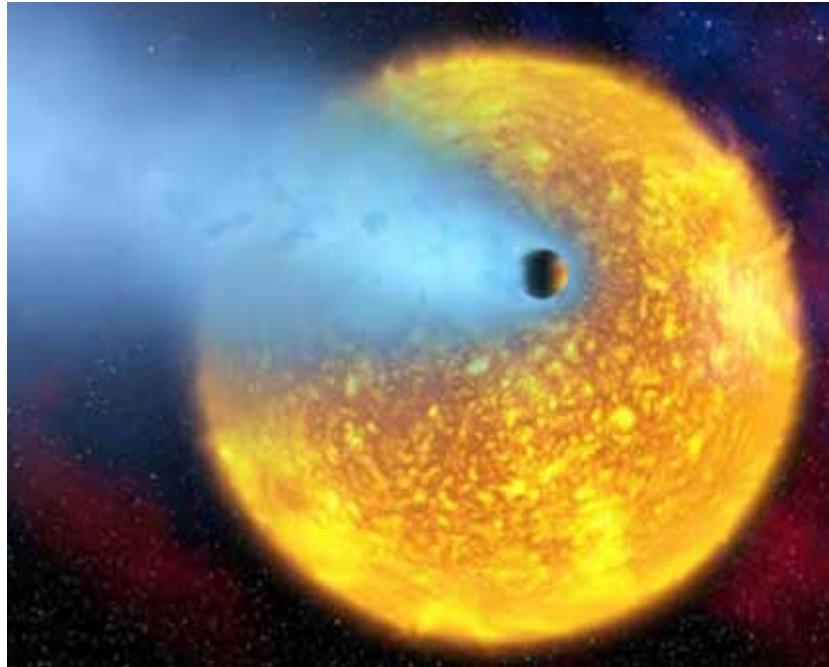


non-magnetic
Shaikhislamov+ 2016

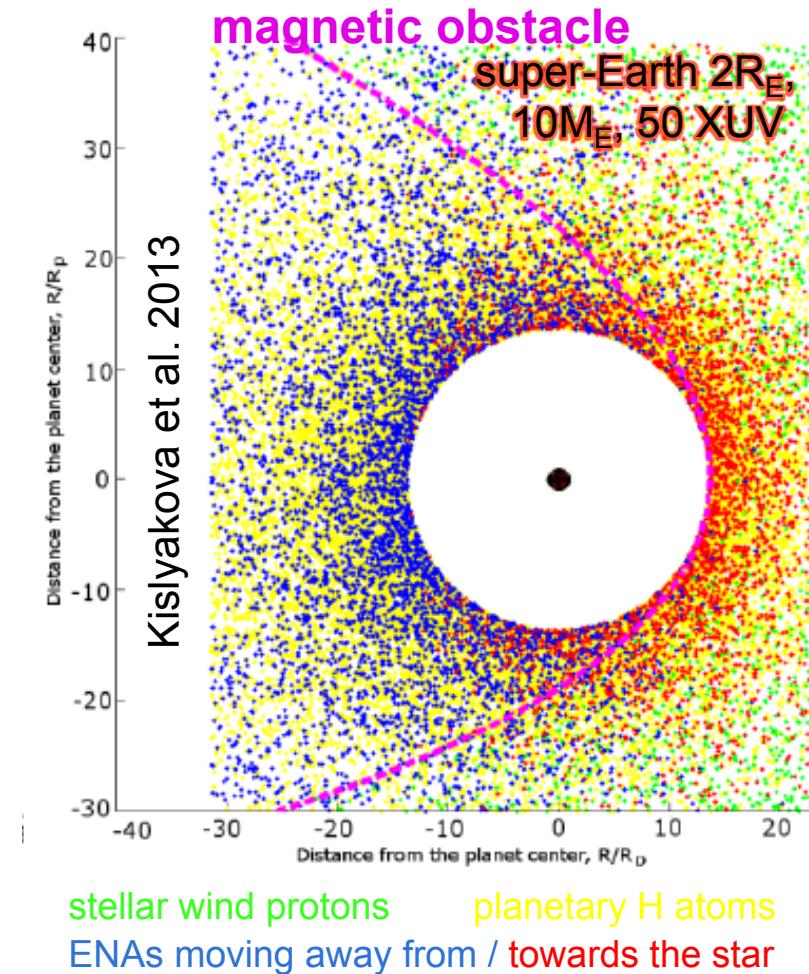


magnetospheric
Khodachenko+ 2015

What Atmospheric Erosion?



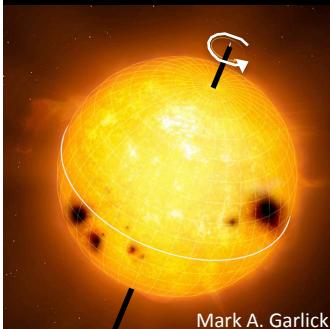
NASA, European Space Agency, Alfred Vidal-Madjar (Institut d'Astrophysique de Paris, CNRS)



boundary conditions, simultaneous operation, additional factors (dust/clouds/hazes? chemistry? lower atmospheres? magnetospheres/ionospheres?). Many non-thermal mechanisms.

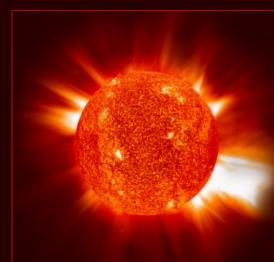
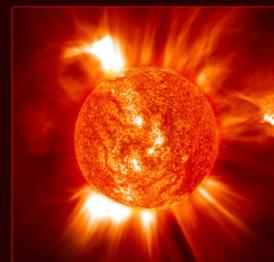
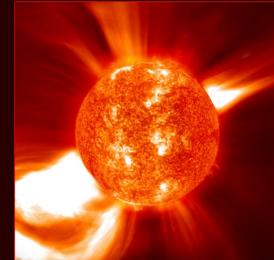
To understand a planet and its habitability, the entire evolution of the stellar/planetary environment must be known!

stellar



Mark A. Garlick

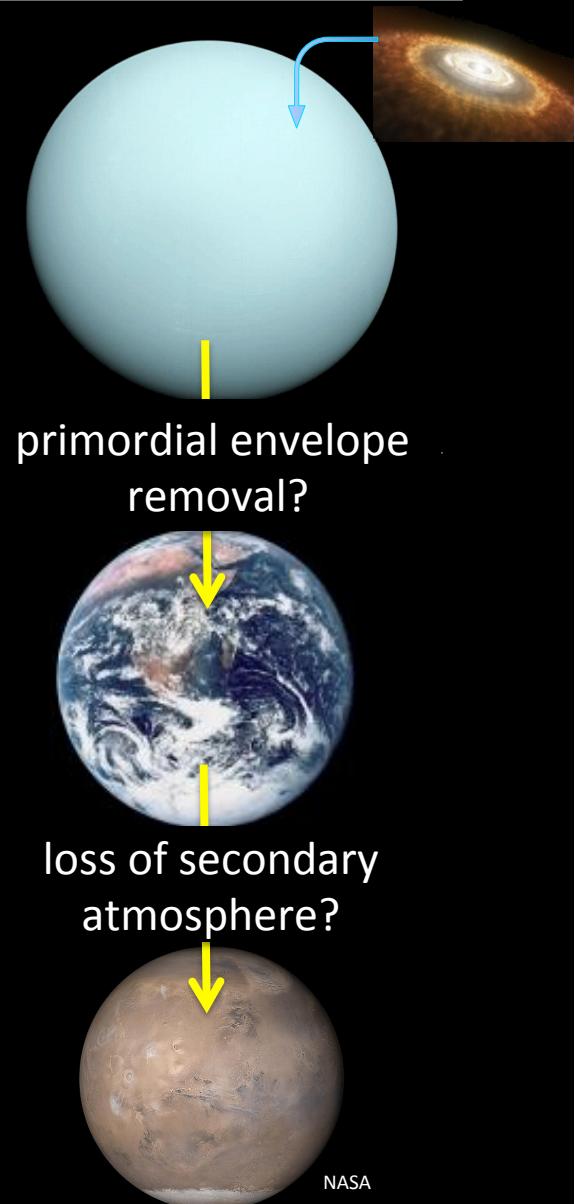
rotation



WallpapersWide.com

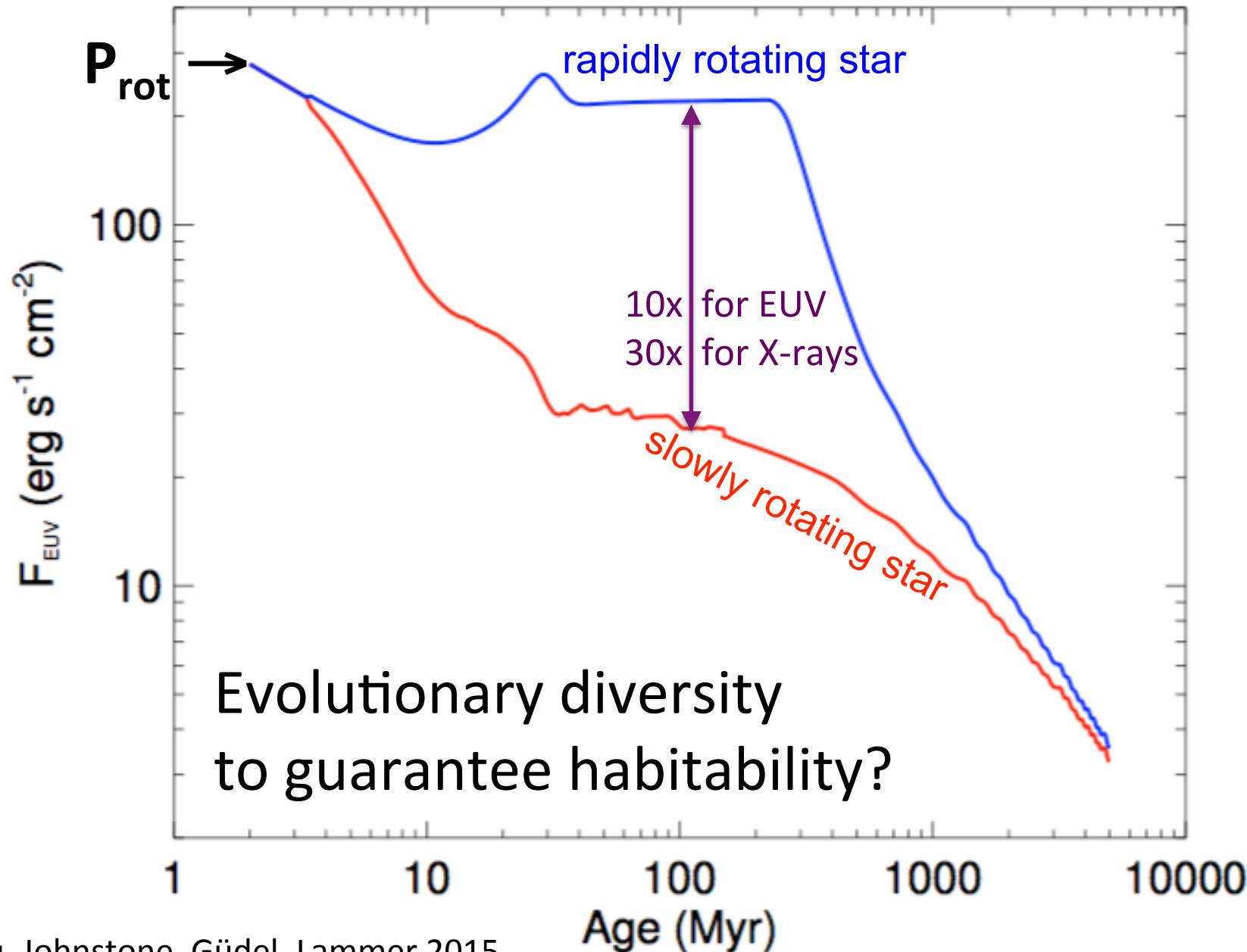
activity output

time



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Against Simplification – Nature Takes Freedom



Nature keeps **parameter space** and **evolutionary options wide open**, allowing it to accommodate many habitable planets in an extremely complex interplay of environmental factors such as radiation, winds, magnetic fields, particles, and planetary structure.



END