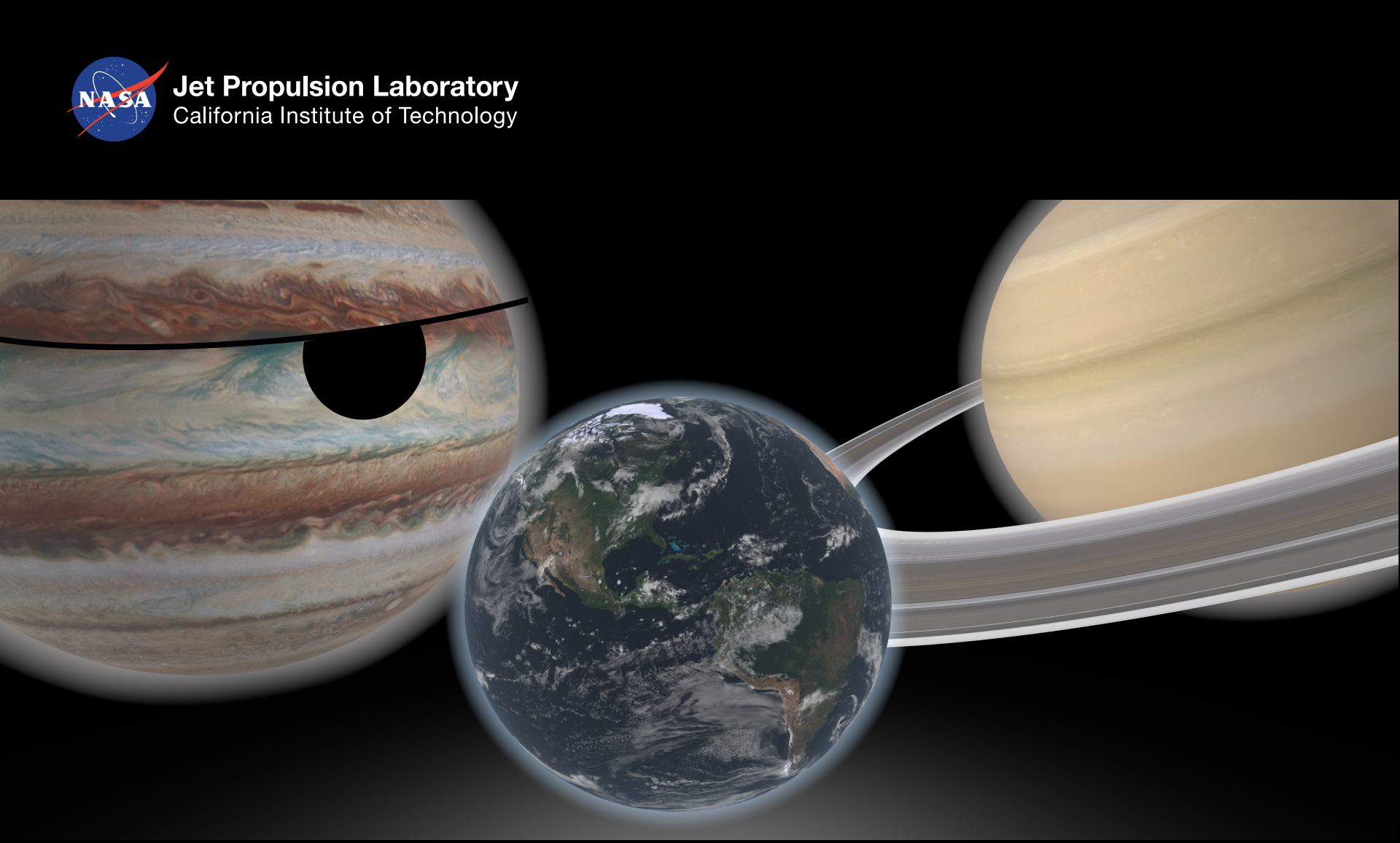


Giant planets: good neighbors for habitable worlds?

Siegfried Eggl (JPL/Caltech/UW)

GPs can be friendly on the one hand…

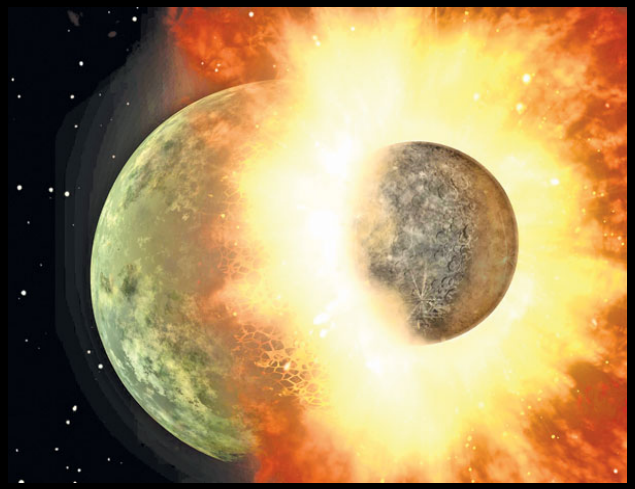
Image credits: ESO/Sphere 2018

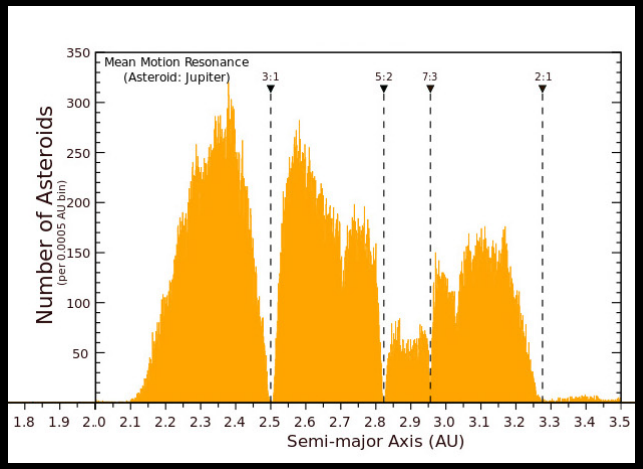
Image credits: ESO/Sebastian Deiries 2007

- Dynamical barriers
- Enhance disc collision probabilities
- Material transport/mixing
- Increase water transport

(Izidoro 2015, Stewart et al. 2009, Fogg & Nelson 2007)

… and bullies on the other hand.

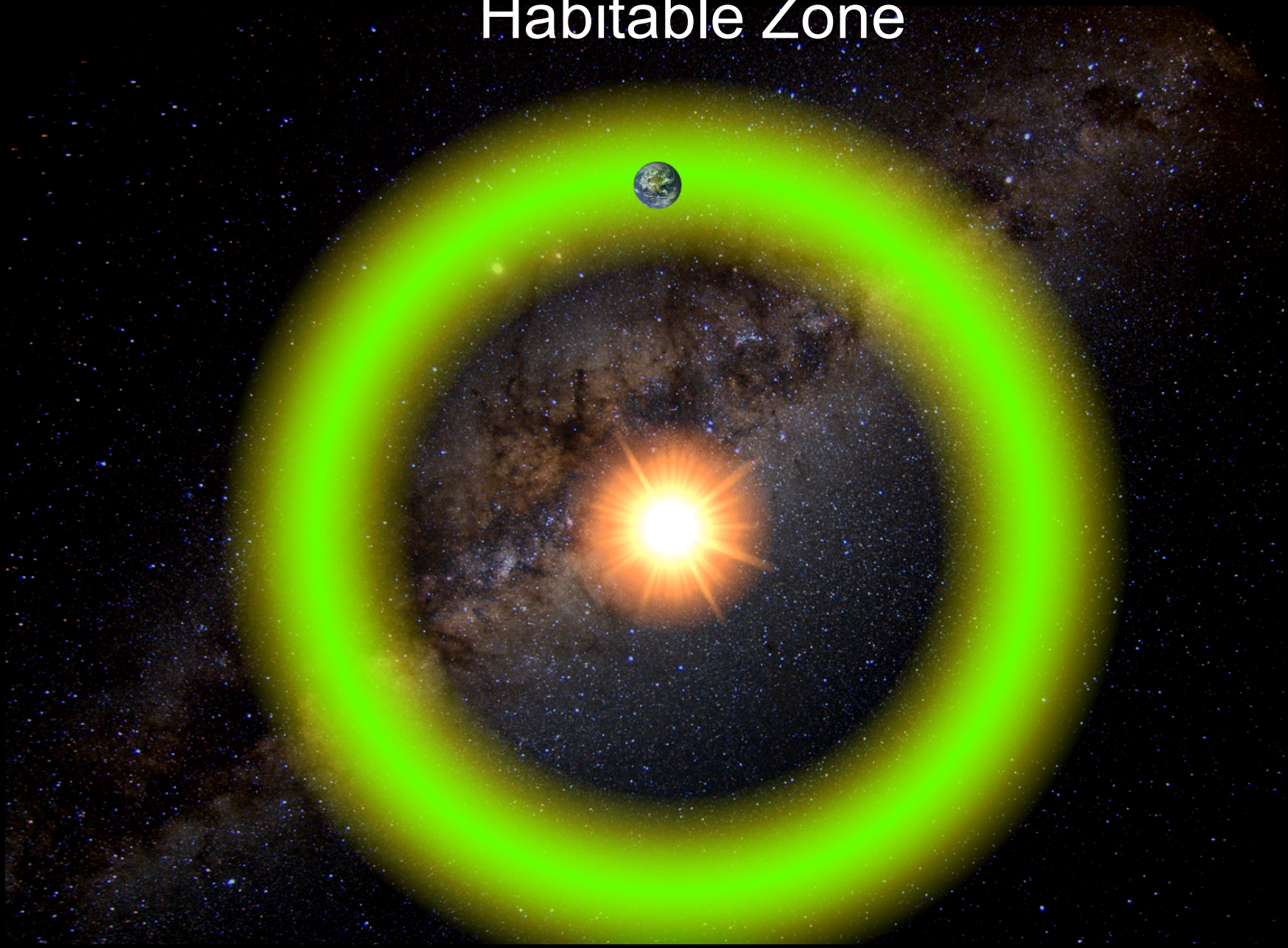




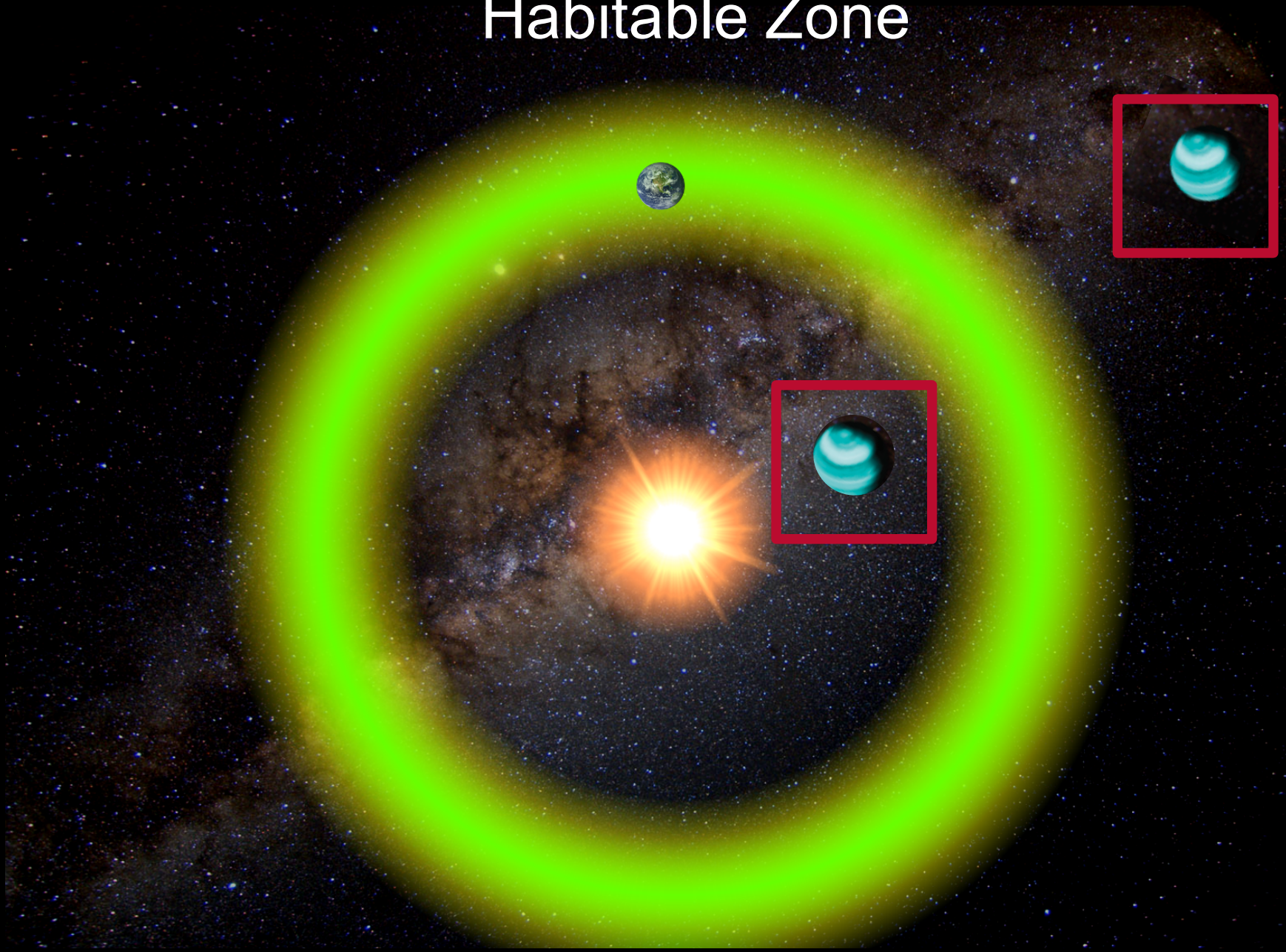
- Dynamical instability
- Potentially higher collision speeds in discs
- Migration (resonance sweeps)
- “Nice catastrophe”
- “Keep throwing rocks at ya”

(Tsiganis 2005, Morbidelli et al. 2005, Walsh et al. 2011, Nesvorny 2018, Kirkwood 1866)

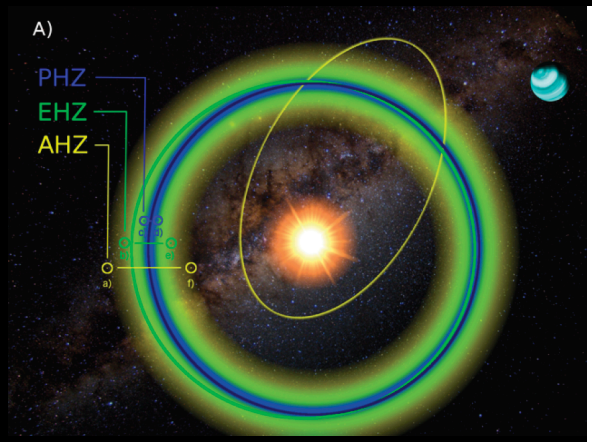
Habitable Zone



Habitable Zone

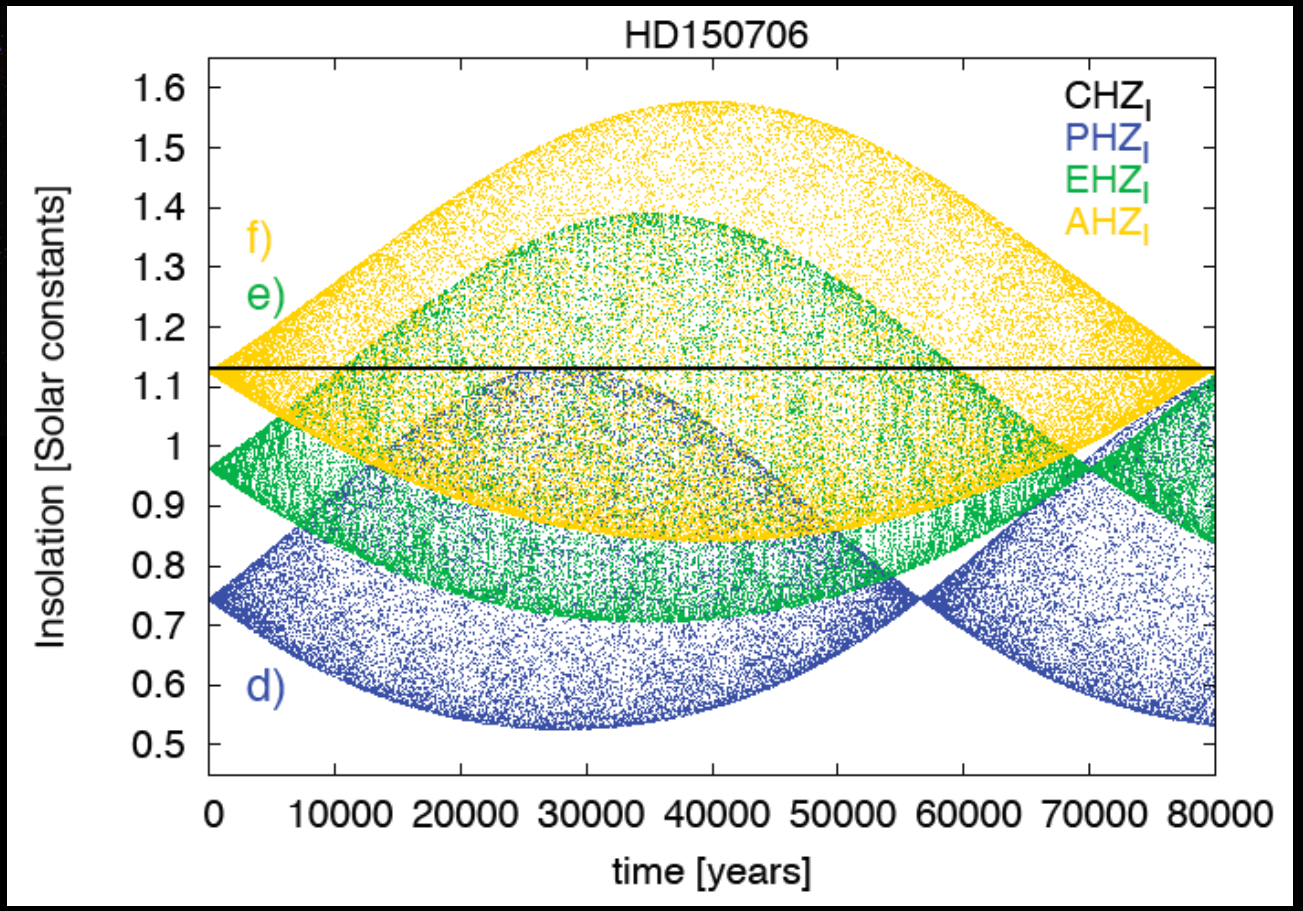


Orbital Dynamics and Insolation

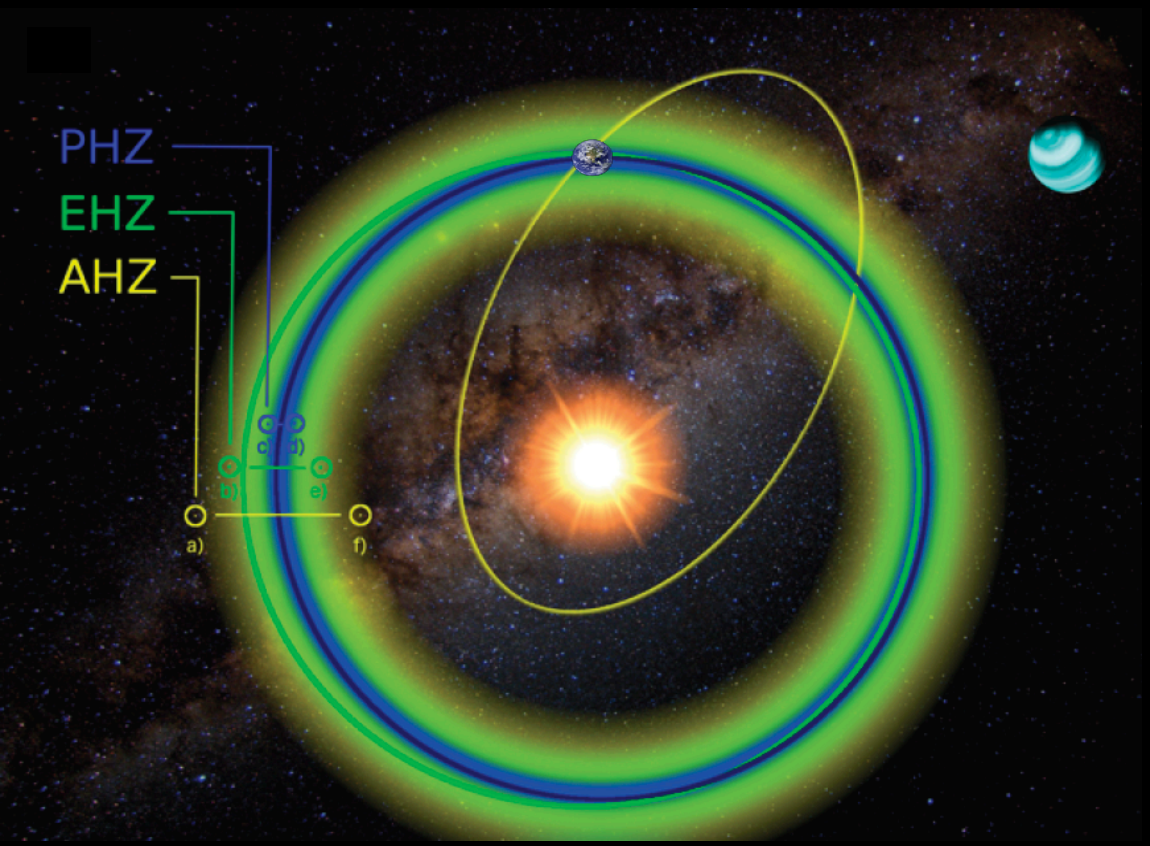


Analytic insolation solutions using high order secular perturbation theory.

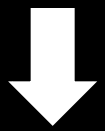
Georgakarakos et al. (2018)



Habitable Zones in perturbed systems?

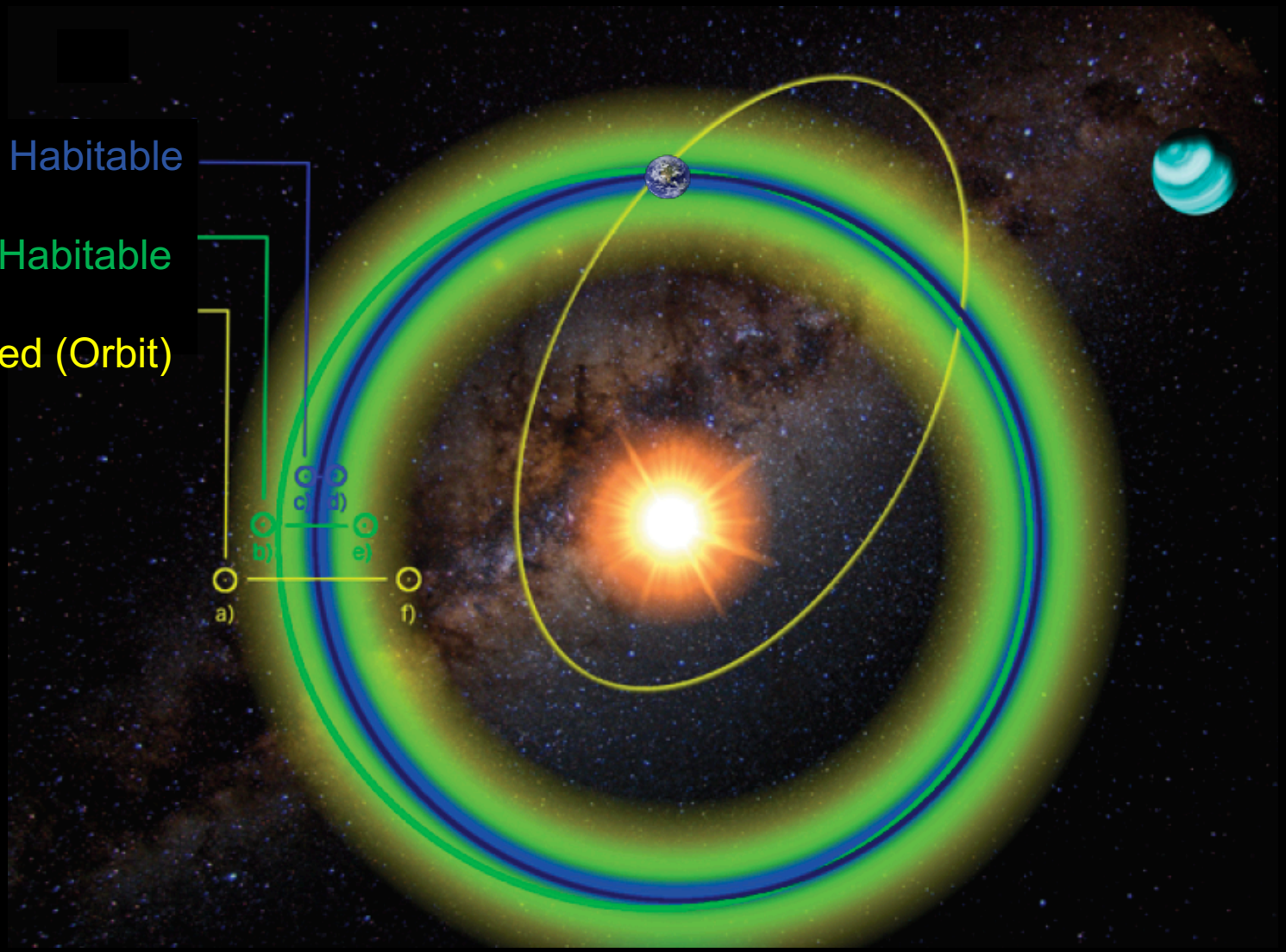


- Orbital eccentricity
- Obliquity
- Spin period
- Atmospheric Composition
- Surface Gravity

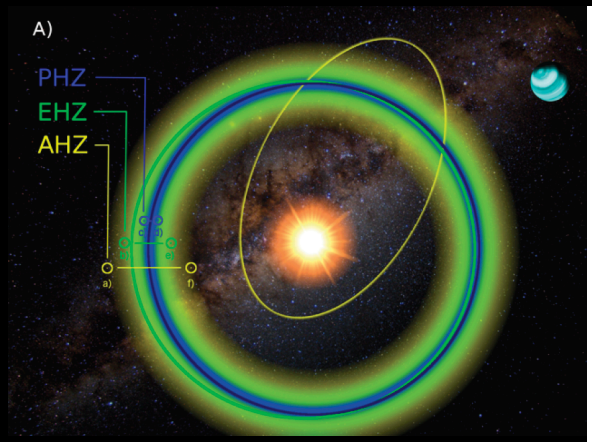


Climate Inertia

Dynamically Informed Habitable Zones

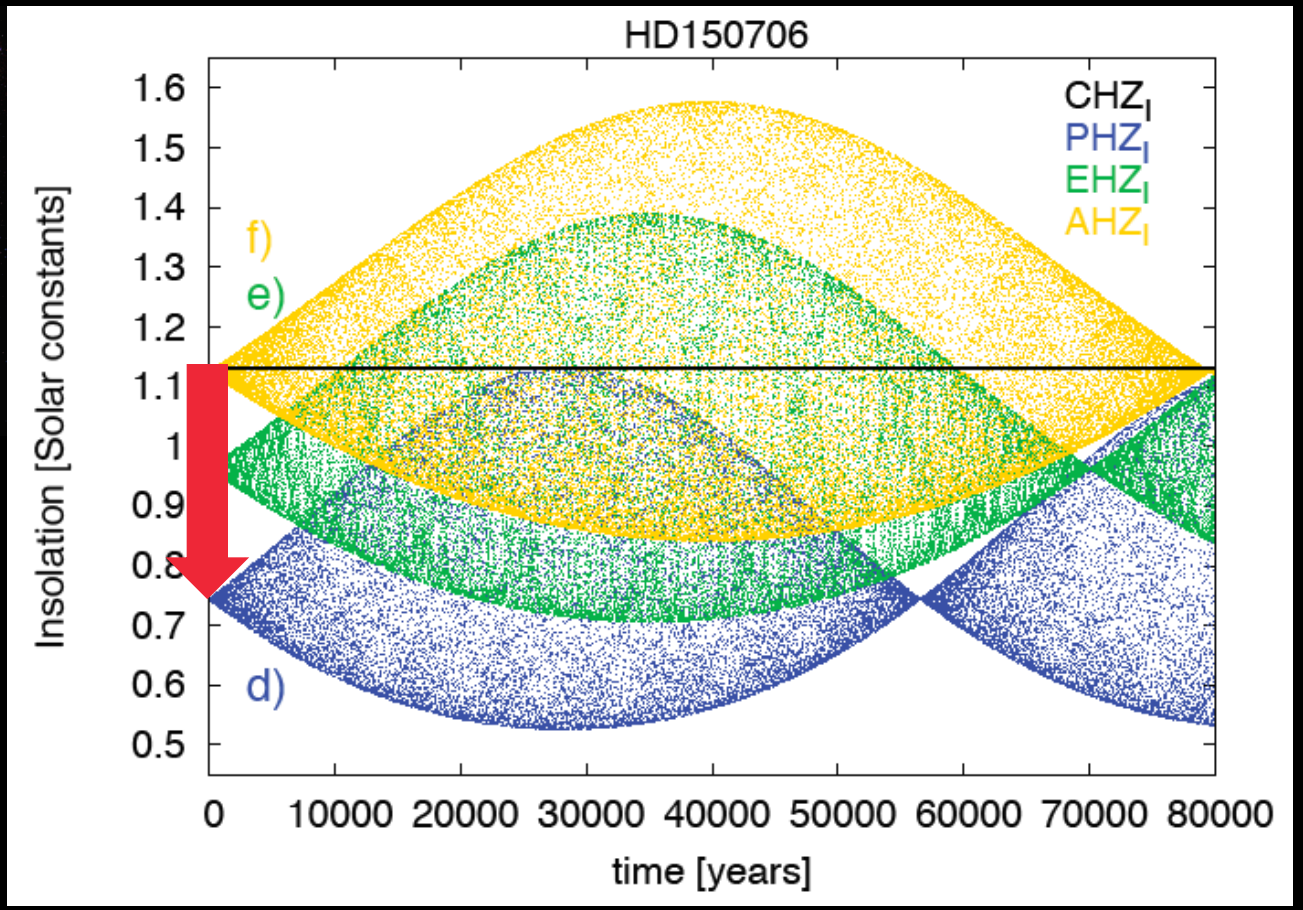


Orbital Dynamics and Insolation

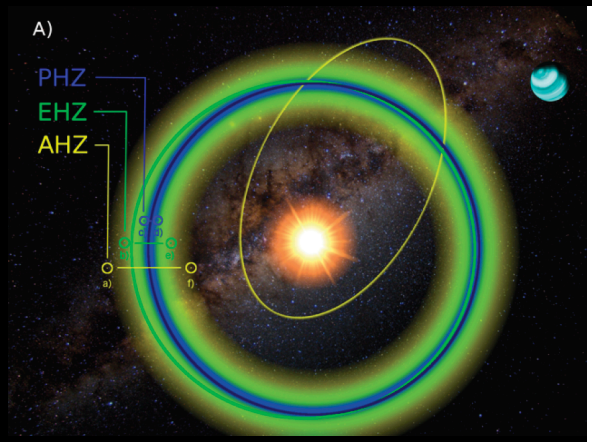


Analytic insolation solutions using high order secular perturbation theory.

Georgakarakos et al. (2018)

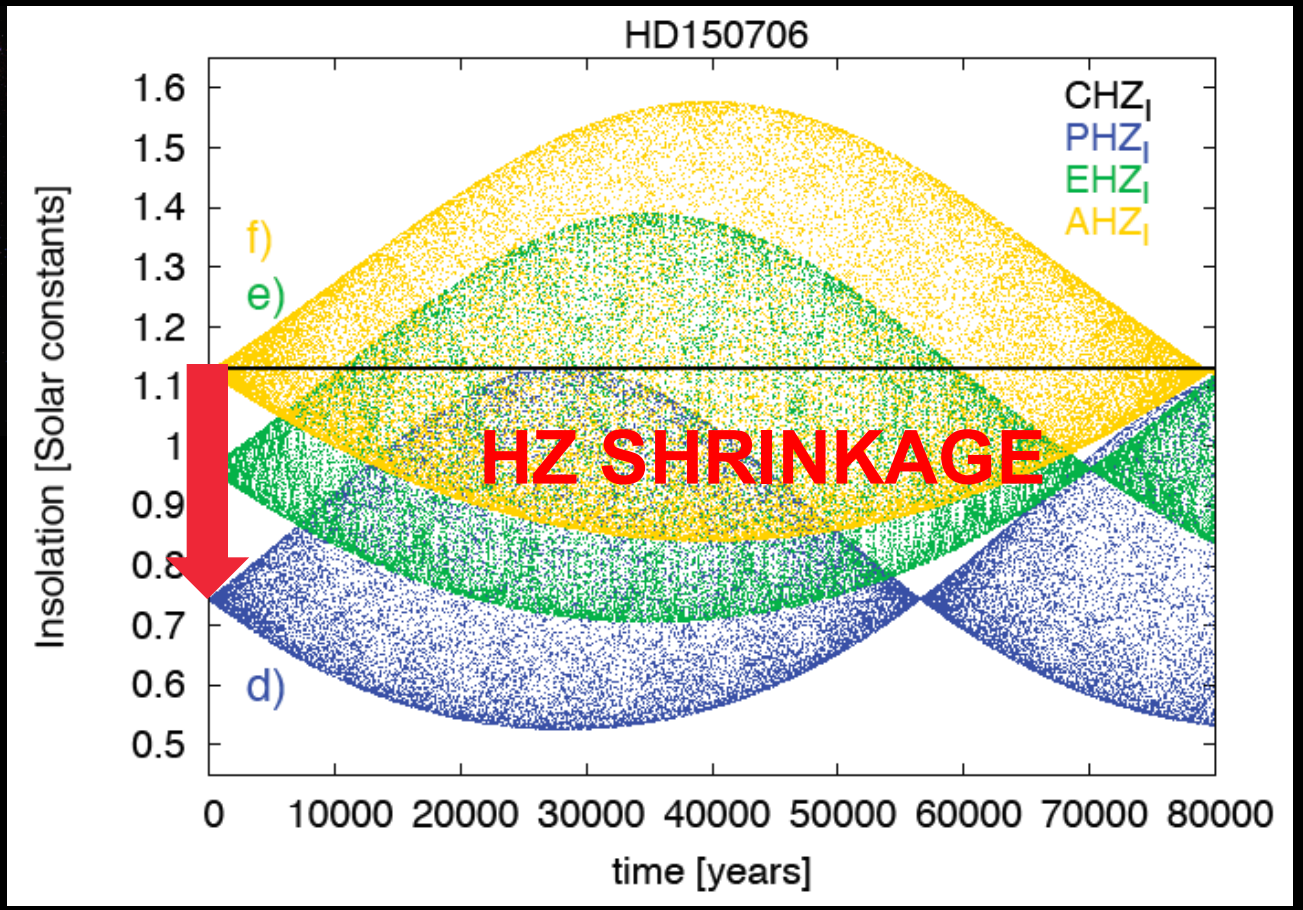


Orbital Dynamics and Insolation

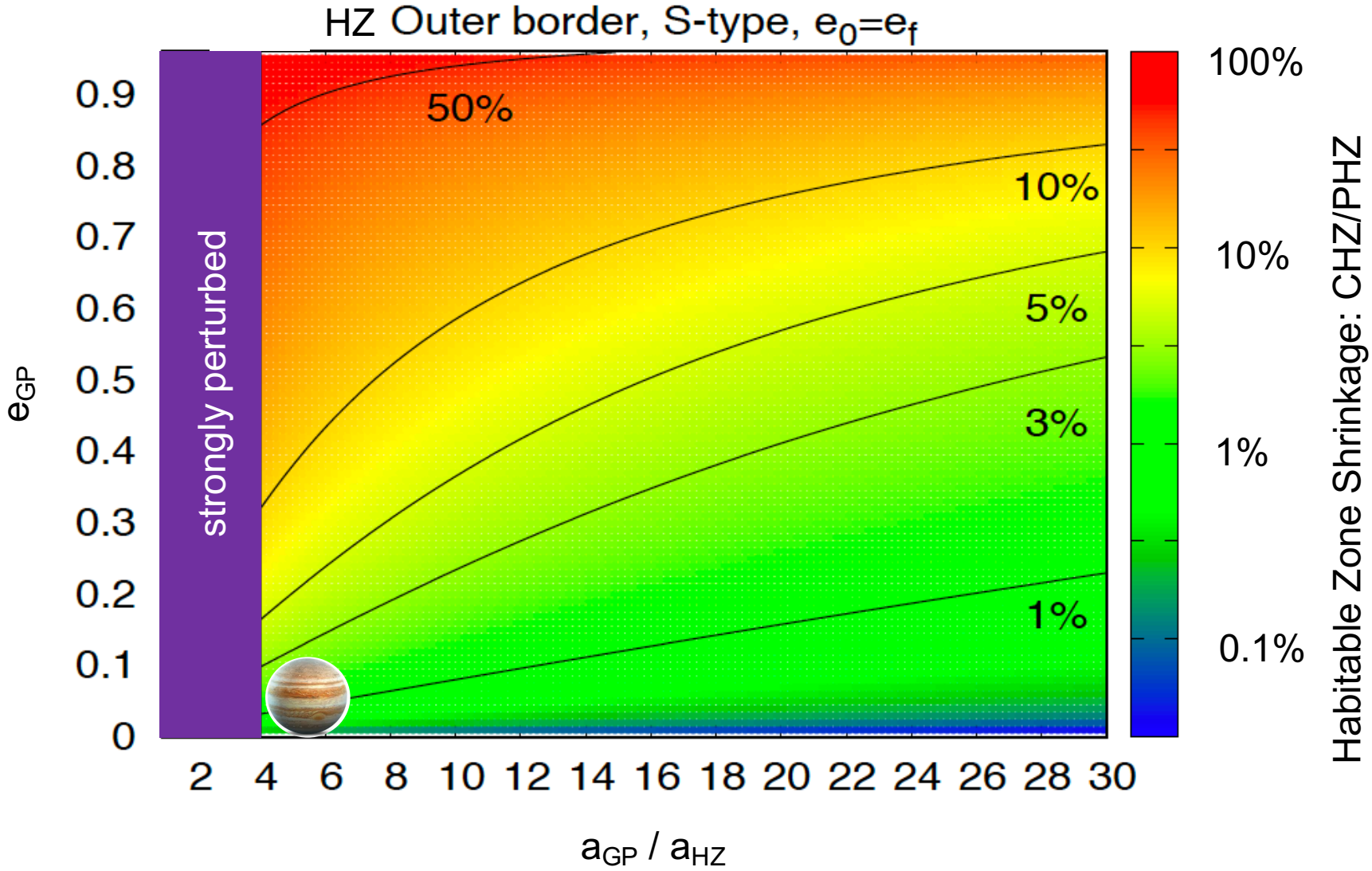


Analytic insolation solutions using high order secular perturbation theory.

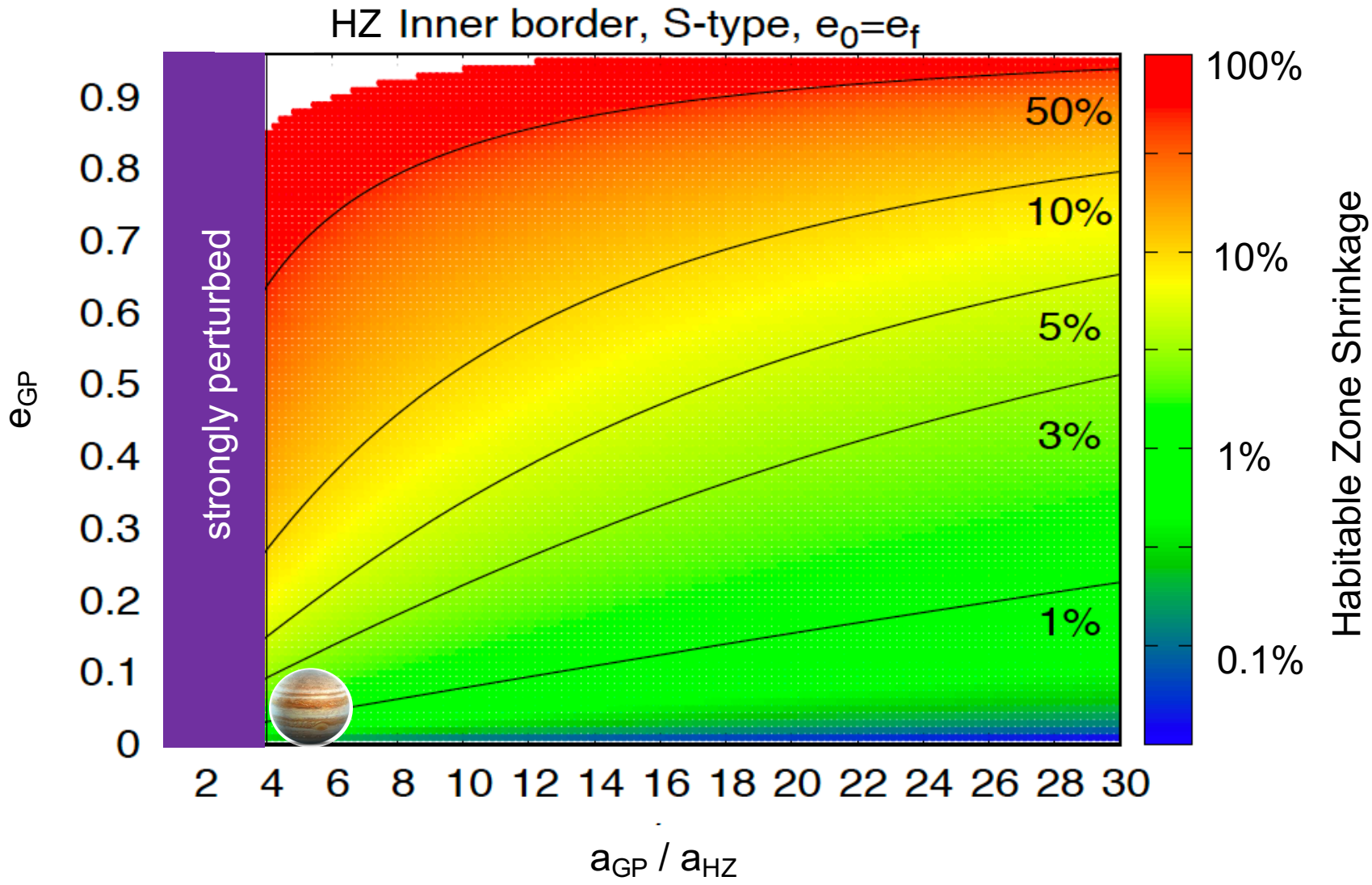
Georgakarakos et al. (2018)



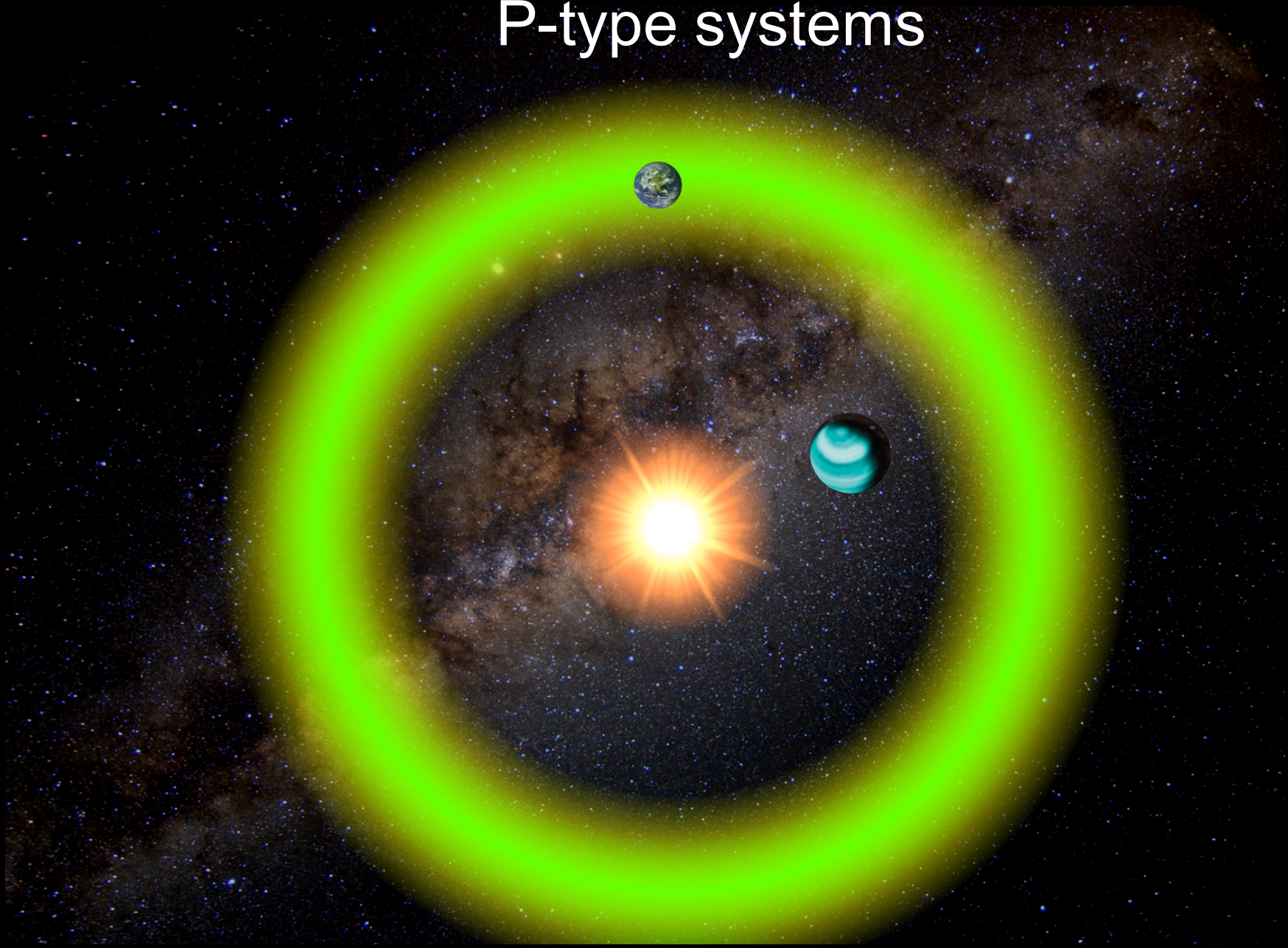
S-type system (e.g. Sun - Earth - Jupiter)



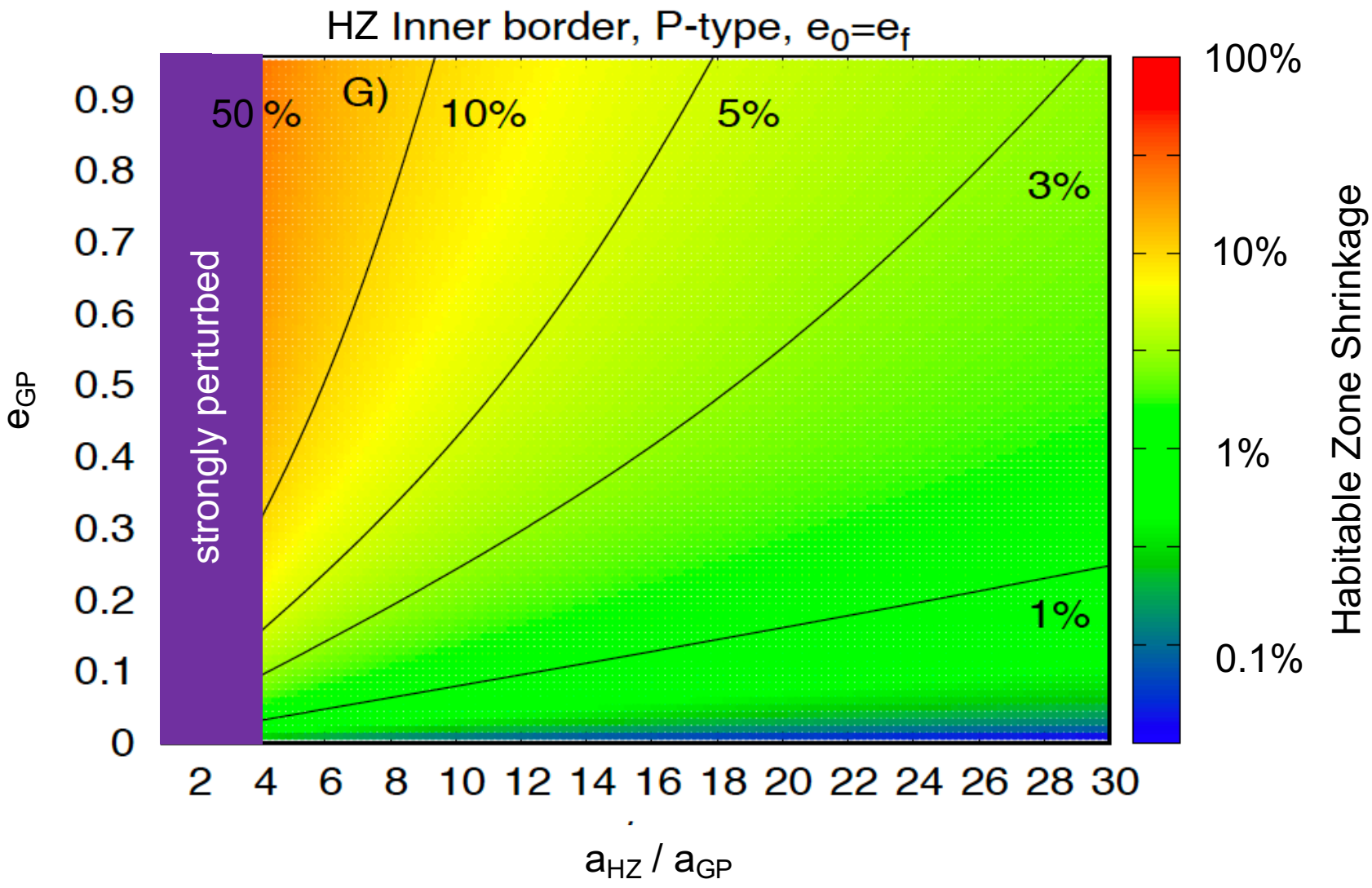
S-type system



P-type systems



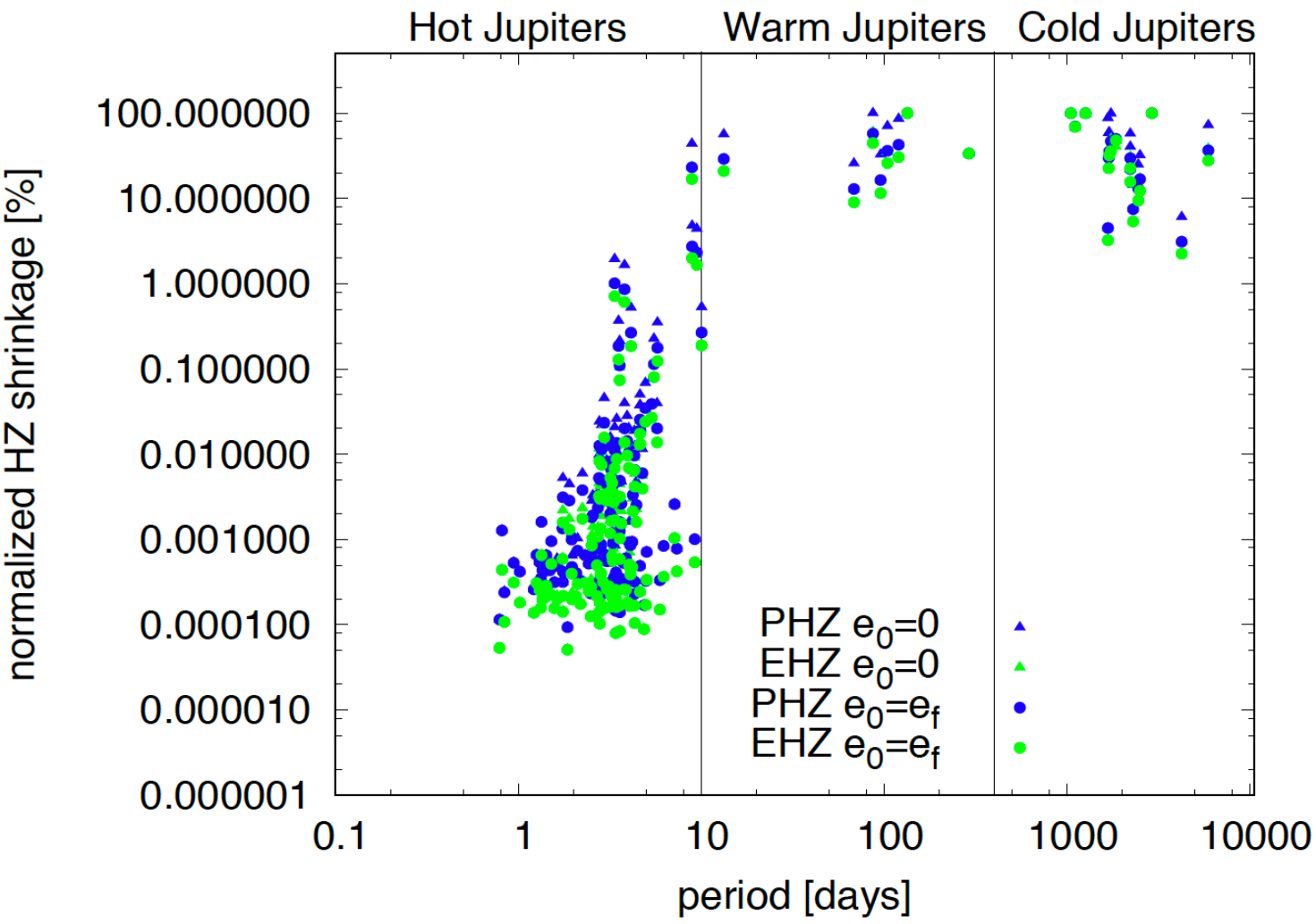
P-type systems (e.g. Sun - Hot Jupiter - Earth)



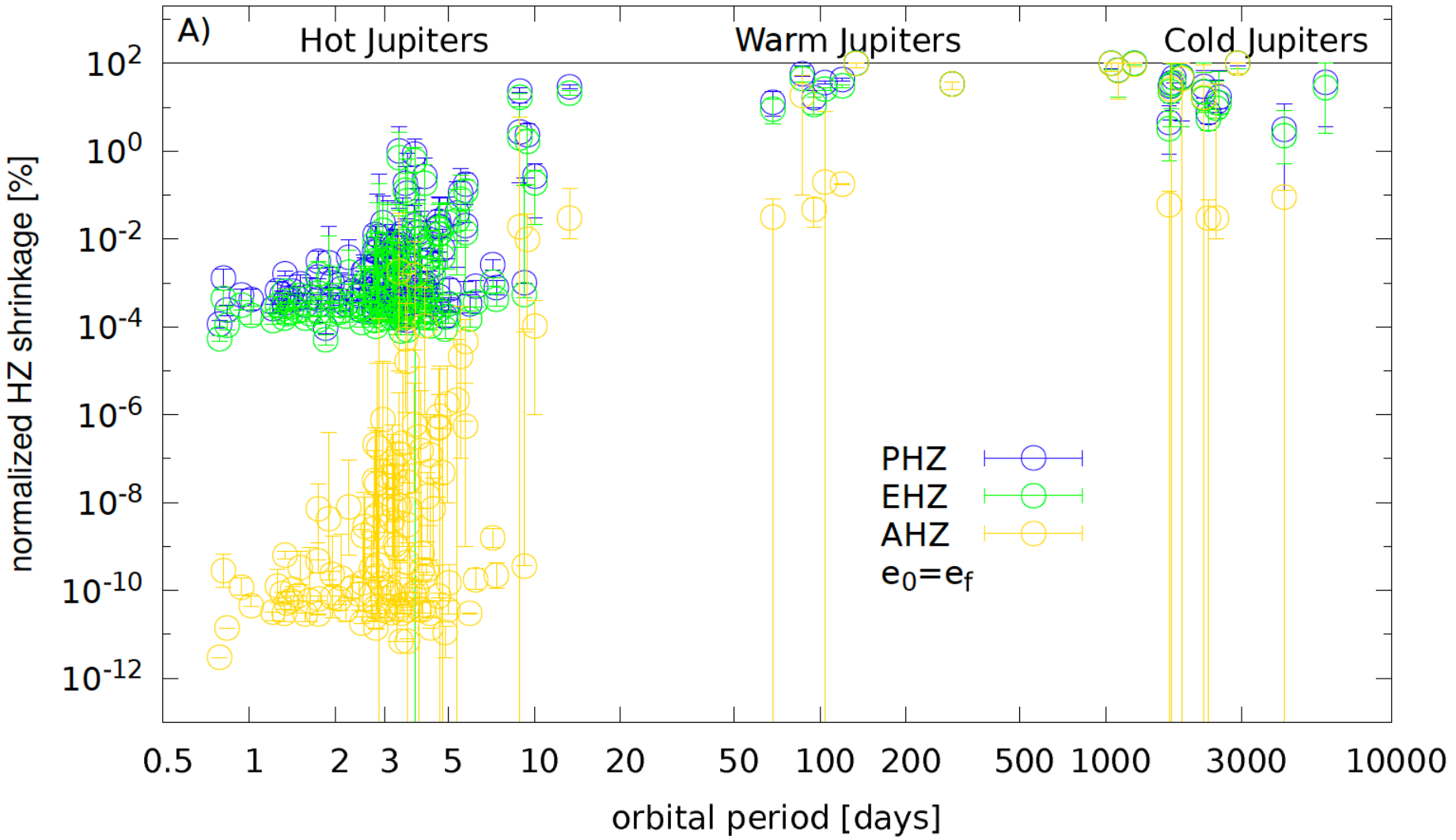
Are Giant Planets Good Neighbors?

Application to 147 “single GP systems” with “reliable” parameters.

Are Giant Planets Good Neighbors?



Are Giant Planets Good Neighbors?

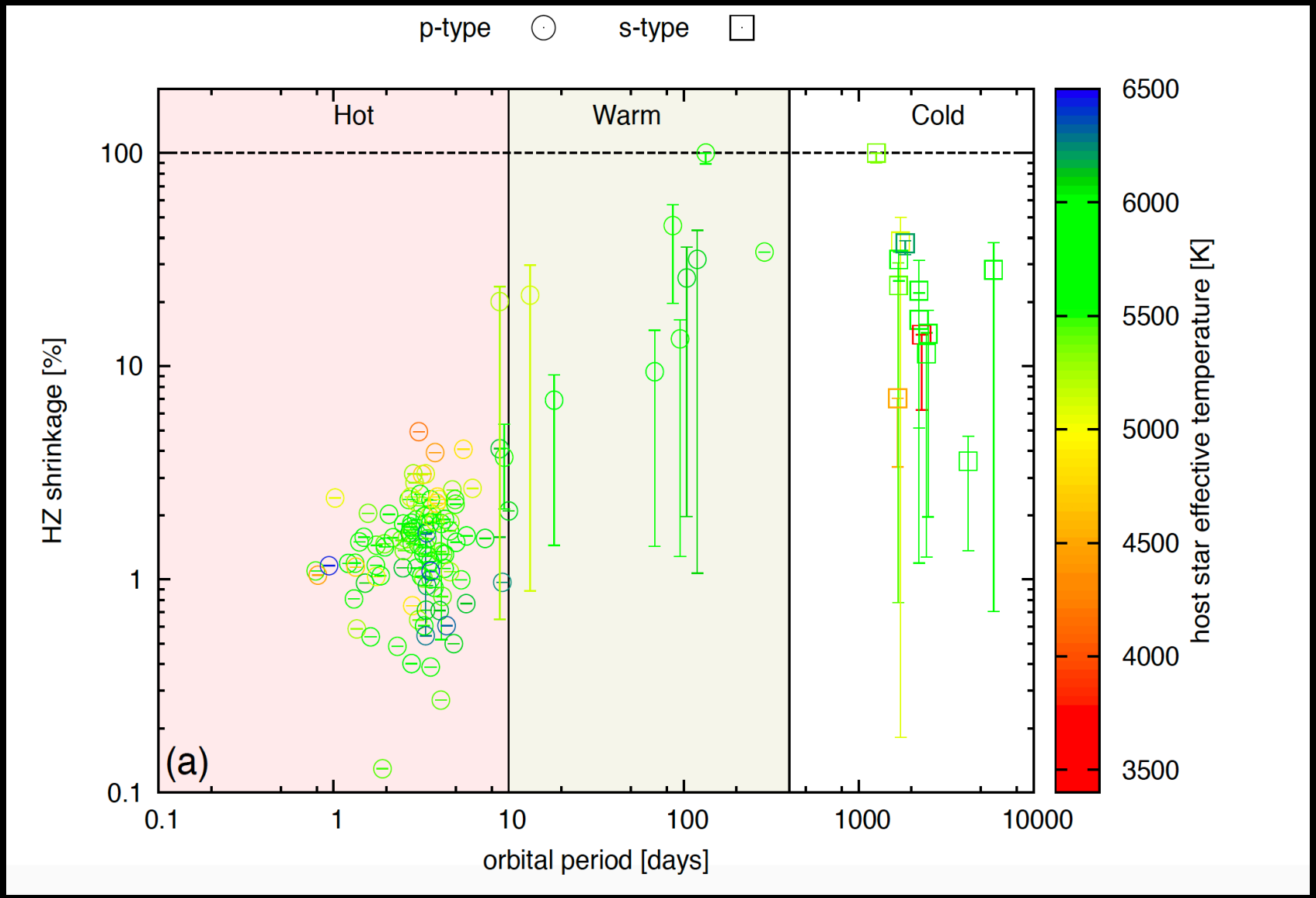


Are Giant Planets Good Neighbors?

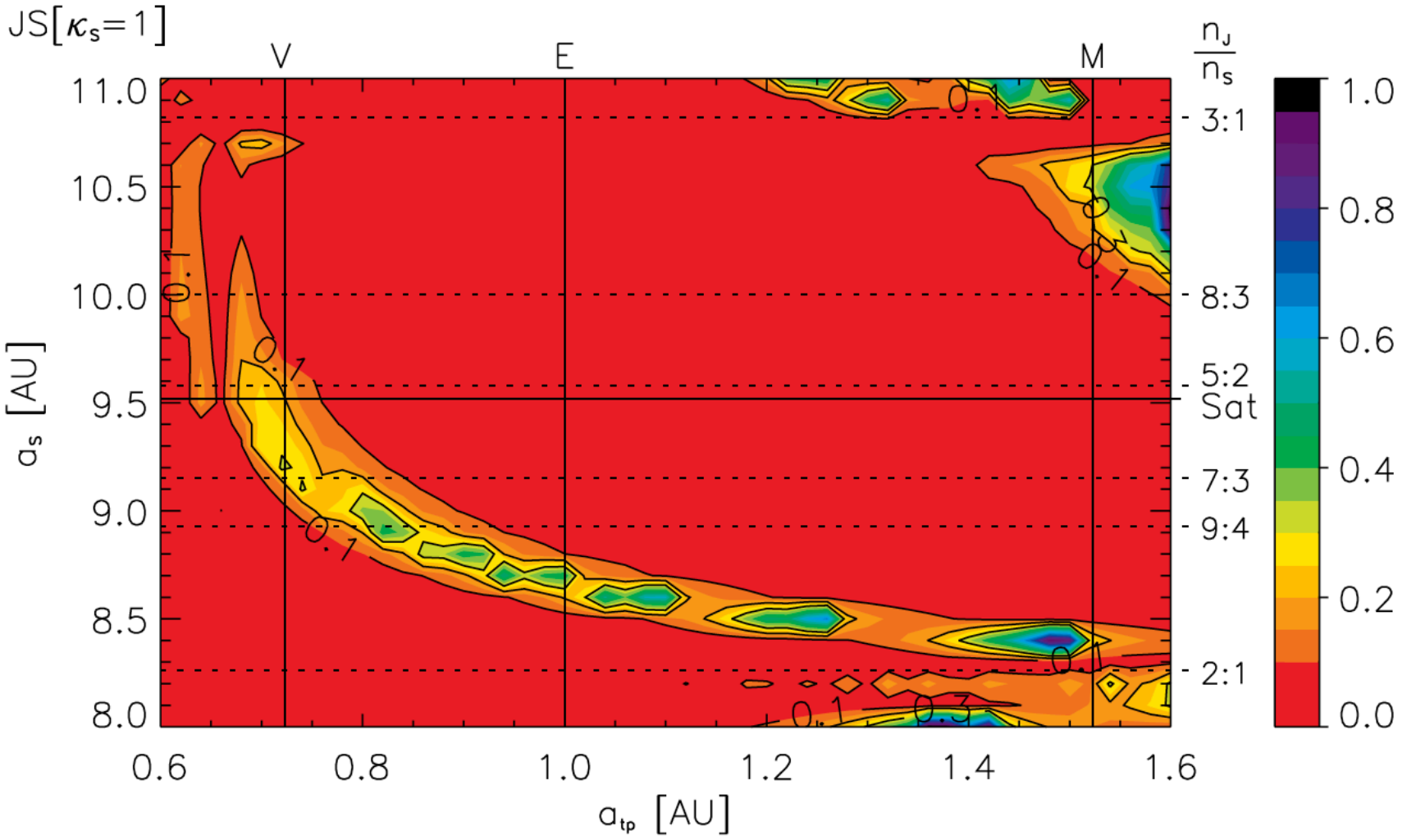
Table 1. Candidates for follow-up observations.

Name
BD-114672, CoRoT-12, CoRoT-13, CoRoT-14, CoRoT-16, CoRoT-18, CoRoT-2,CoRoT-25, CoRoT-27, CoRoT-29, CoRoT-4, CoRoT-5, CoRoT-6, CoRoT-8,HAT-P-12, HAT-P-18, HAT-P-19, HAT-P-21, HAT-P-22, HAT-P-23, HAT-P-25, HAT-P-27, HAT-P-28, HAT-P-29, HAT-P-3, HAT-P-36, HAT-P-37, HAT-P-38, HAT-P-43, HAT-P-5, HAT-P-51, HAT-P-52, HAT-P-53, HAT-P-54, HAT-P-55, HATS-1, HATS-10, HATS-13, HATS-14, HATS-15, HATS-16, HATS-18, HATS-2, HATS-25, HATS-28, HATS-29, HATS-30, HATS-32, HATS-33, HATS-34, HATS-4, HATS-5, HATS-8, HD13931, HD63454, K2-29, K2-30, K2-31, Kepler-15, Kepler-17, Kepler-41, Kepler-423, Kepler-425, Kepler-426, Kepler-428, Kepler-63, Kepler-74, Kepler-77, Qatar-1, Qatar-2, TrES-3, WASP-101, WASP-104, WASP-117, WASP-119, WASP-123, WASP-124, WASP-126, WASP-129, WASP-132, WASP-135, WASP-139, WASP-140, WASP-157, WASP-16, WASP-18, WASP-19, WASP-21, WASP-23, WASP-25, WASP-26, WASP-28, WASP-29, WASP-31, WASP-32, WASP-34, WASP-35, WASP-37, WASP-39, WASP-43, WASP-44, WASP-49, WASP-5, WASP-50, WASP-52, WASP-56, WASP-58, WASP-6, WASP-60, WASP-62, WASP-64, WASP-65, WASP-67, WASP-69, WASP-75, WASP-80, WASP-83, WASP-89, WASP-95, WASP-96, WASP-97, WTS-1, WTS-2, XO-5
Comments
BD-114672 and HD13931 are the only S-type systems
BD-114672, CoRoT-6, HAT-P-54, HD13931, Kepler-63 and WASP-89 have a maximum PHZ shrinkage of $\sim 10\%$
The rest of the systems have a maximum PHZ shrinkage less than 1%

Are Giant Planets Good Neighbors?

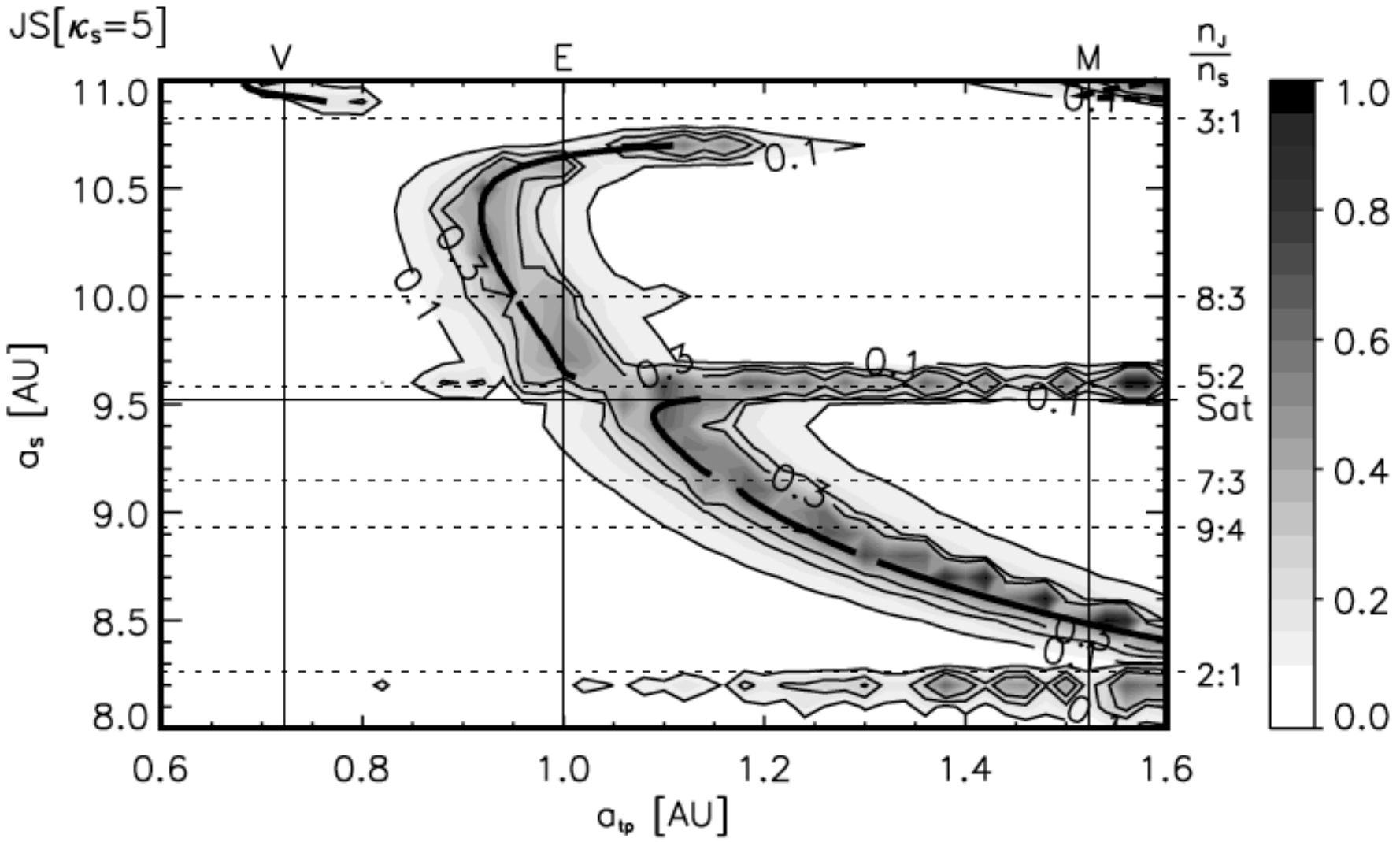


More than one GP?



Pilat-Lohinger et al. (2008)

More than one GP?



Pilat-Lohinger et al. (2008)

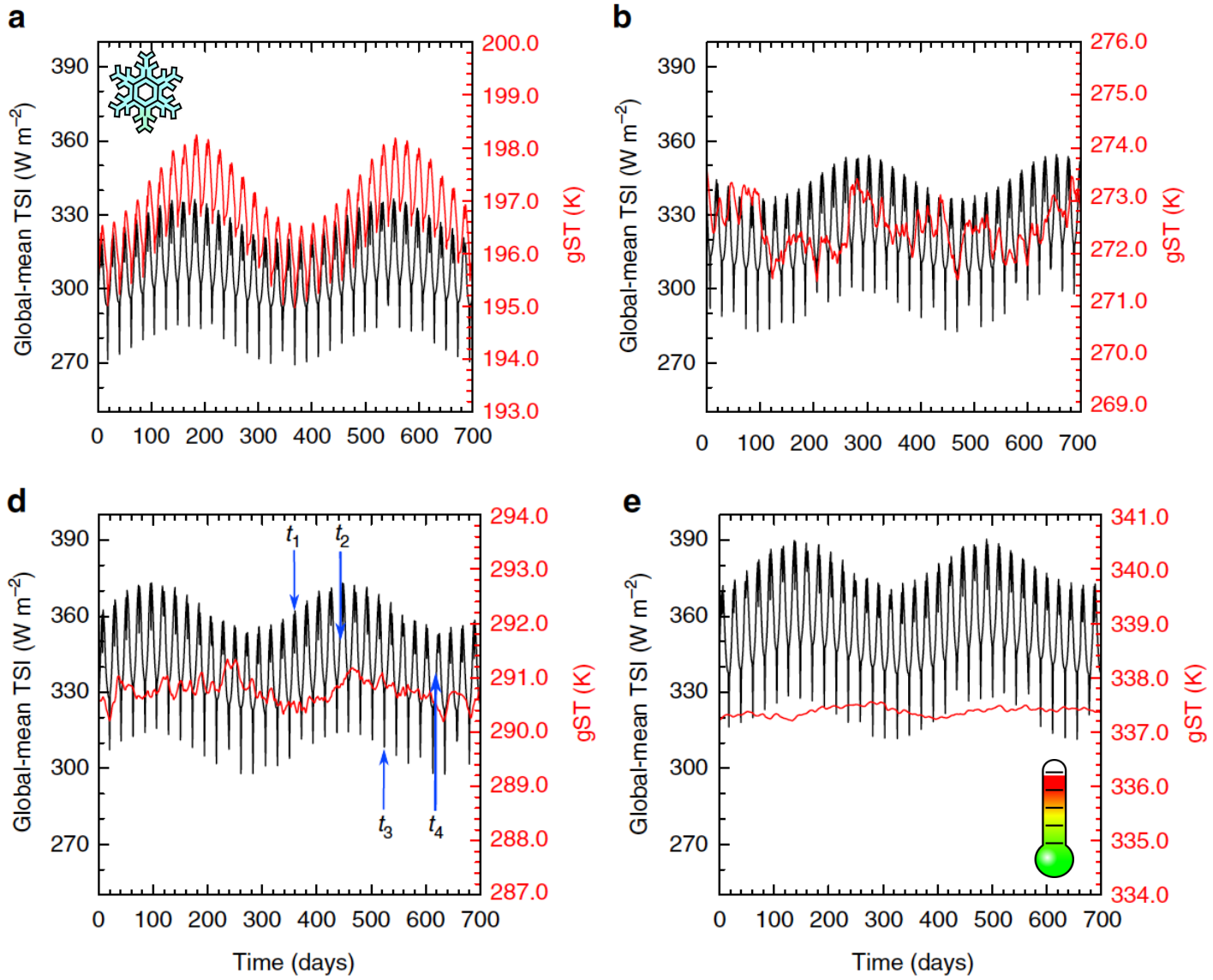
Conclusions:

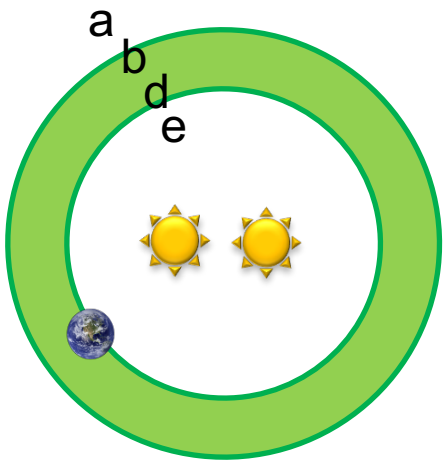
Are Giant Planets Good Neighbors?

Formation: GPs can be both friends and bullies

Habitable Zone shrinkage: Hot Jupiters: not quite as bad

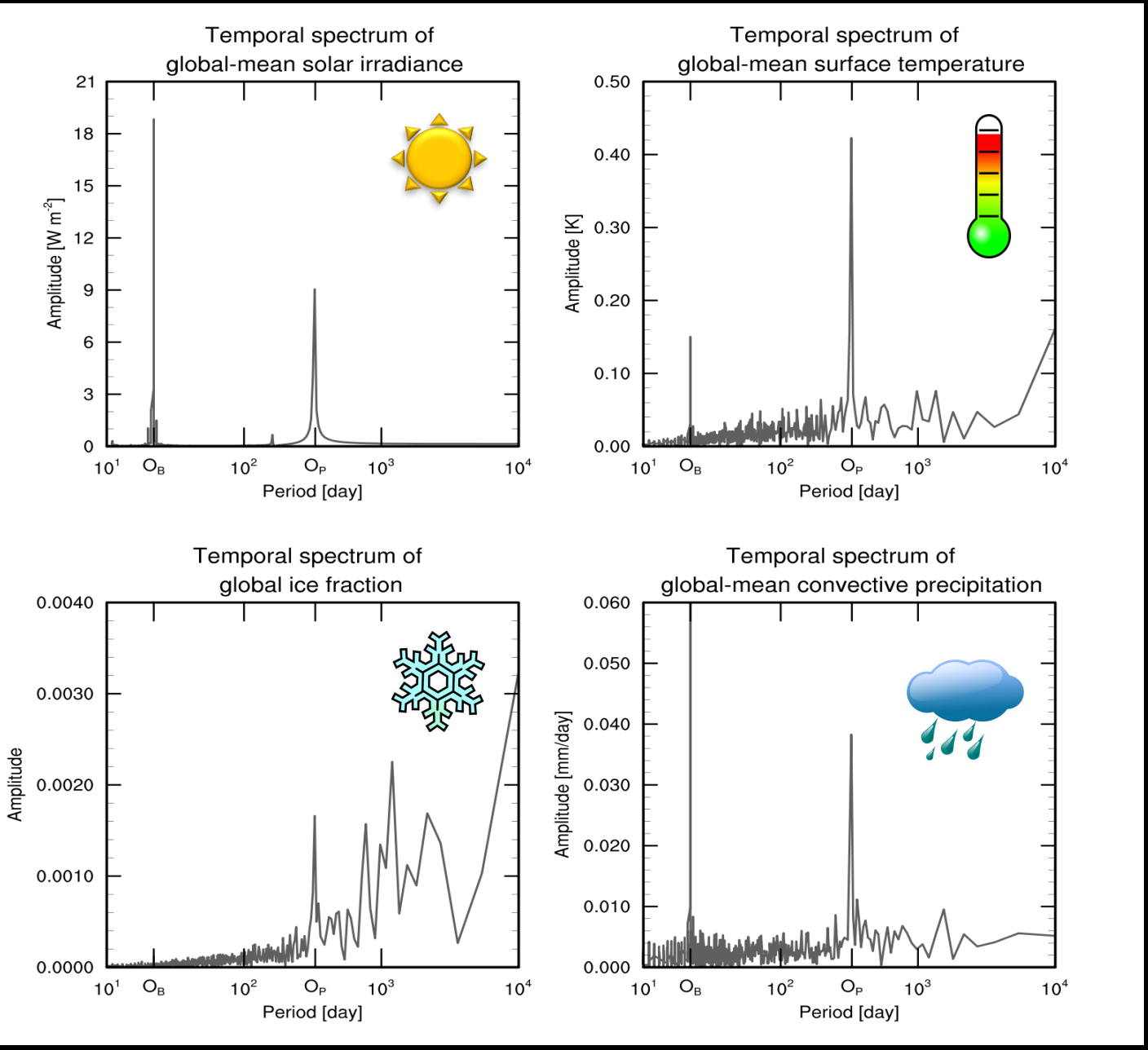
Multiple systems: resonances vs eccentricity dampening





Kepler-35 like system

Popp & Eggl (2017)

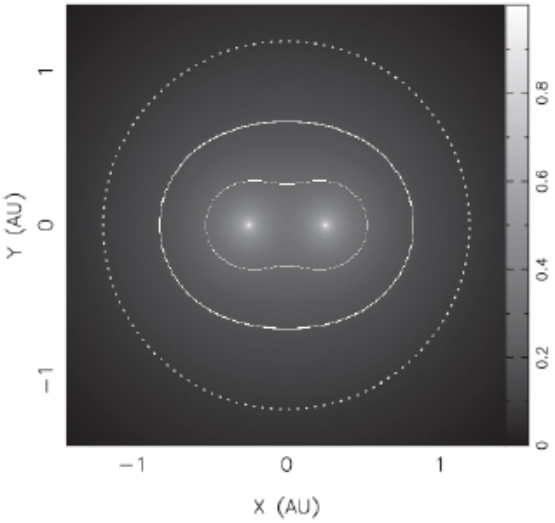


Kepler-35
like system

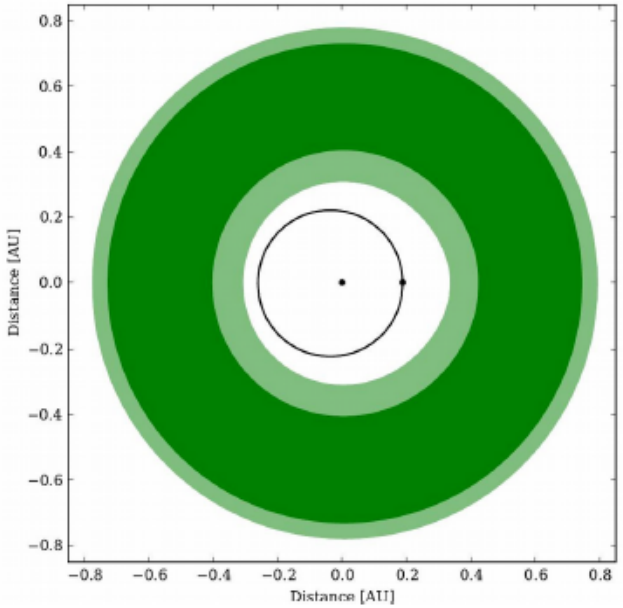
Earth @ 1.1 au

Popp & Eggl (2017)

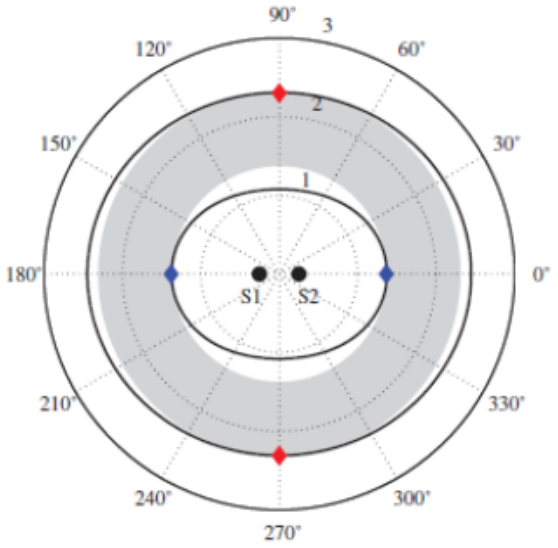
A smarter approach…



Kane & Hinkel (2013)



Müller & Haghighipour (2014)



Cuntz (2014)

Jet Propulsion Laboratory
California Institute of Technology

jpl.nasa.gov