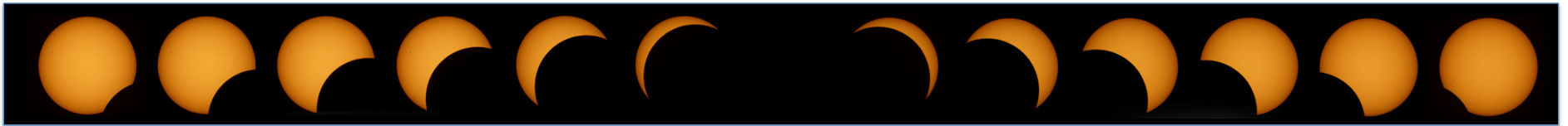


# How to Find Earths in the “Habitable zones” of cool white dwarfs with Transit Surveys



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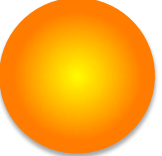
Agol, 2011, ApJL, 731, L31



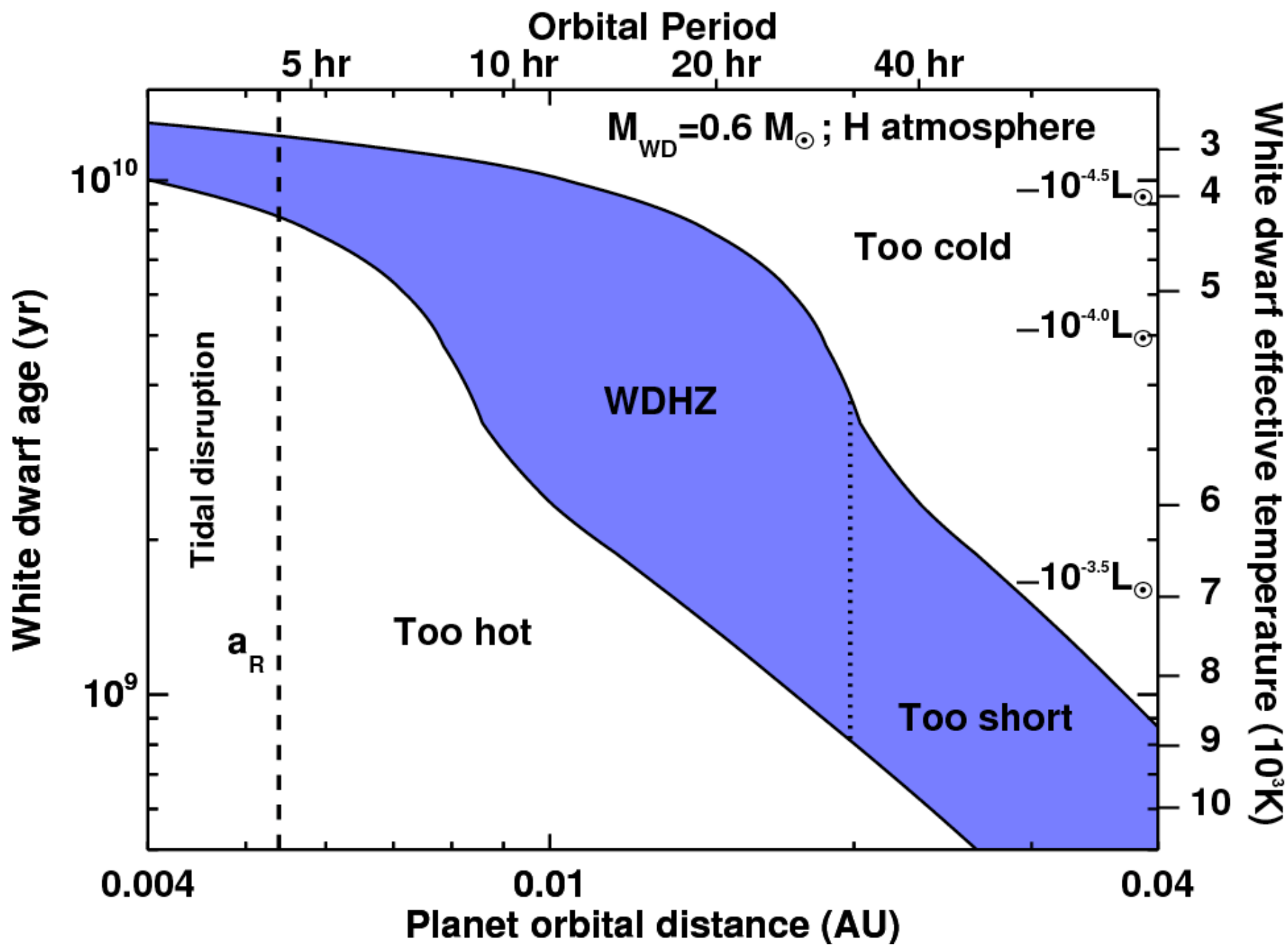
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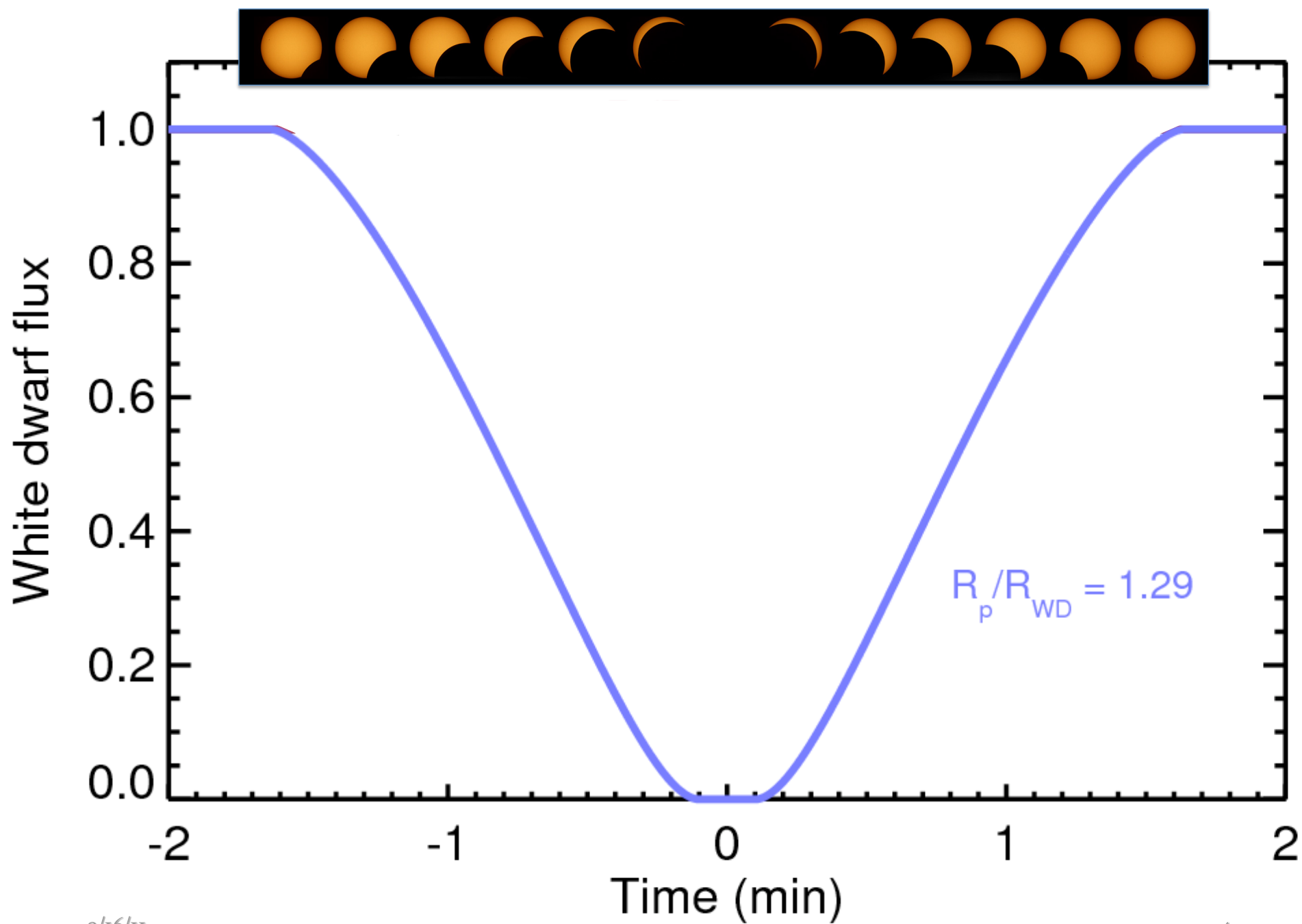


# Four Coincidences:

1. White dwarfs are similar in size to Earth:  
2. WD have temperatures near that of the Sun:  
$$L \approx 10^{-4} L_{\odot} \quad \& \quad R \approx 10^{-2} R_{\odot} \quad \Rightarrow \quad T \approx T_{\odot}$$

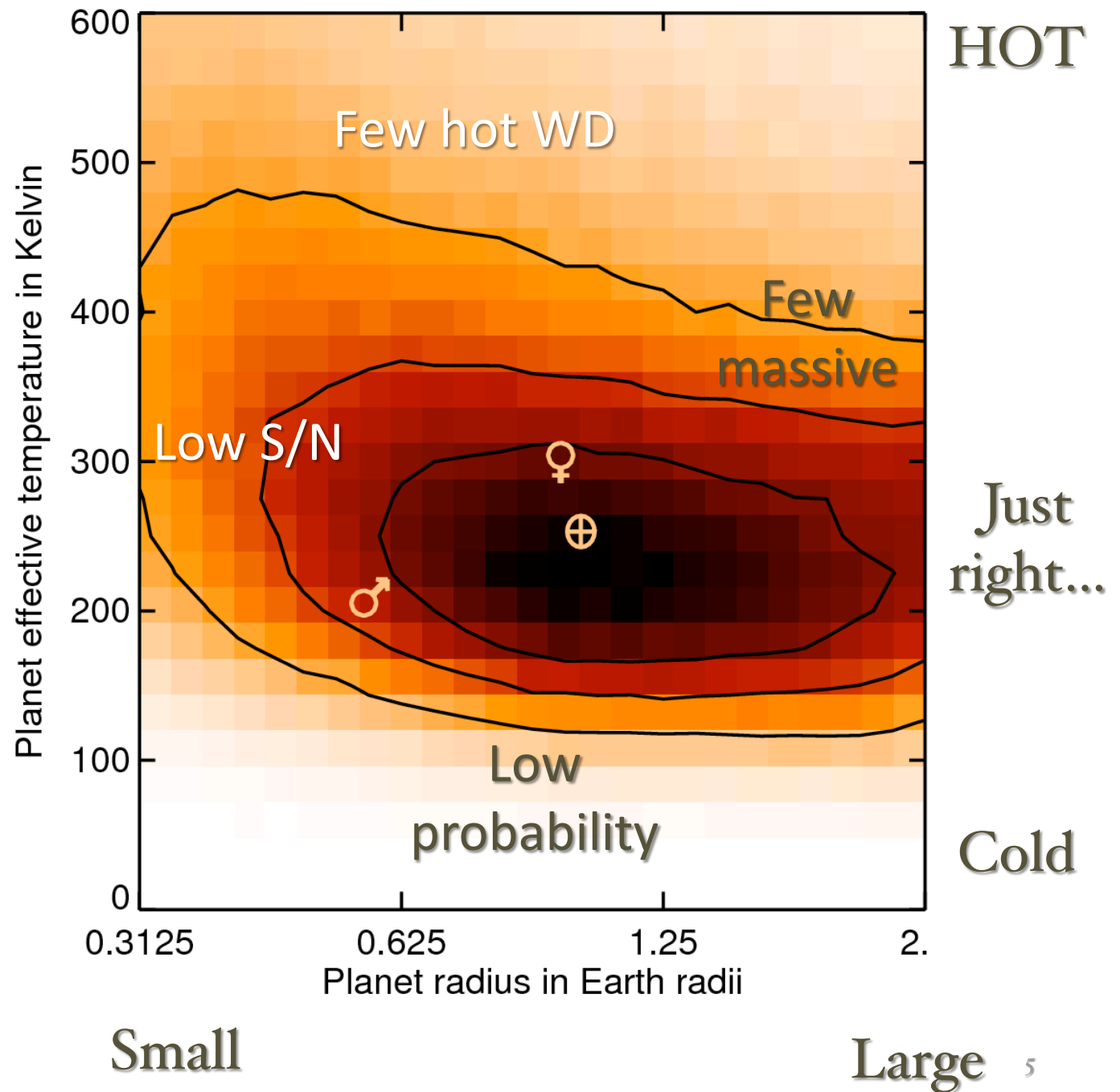
(‘orange lilliputians’?)
3. White dwarf ‘habitable zone’  $\approx 0.01$  AU is twice the Roche limit  $\approx 0.005$  AU (for Earth density)
4. A planet spends maximum time in WDHZ of 8 Gyr at 0.01 AU





Simulated  
distribution  
of detected  
planet  
temperature  
& radius from  
ground-based  
survey:

20,000 WD  
to 100 pc w/  
1 meter  
telescopes



# Pro-Am White dwarf Monitoring

<http://brucegary.net/WDE>

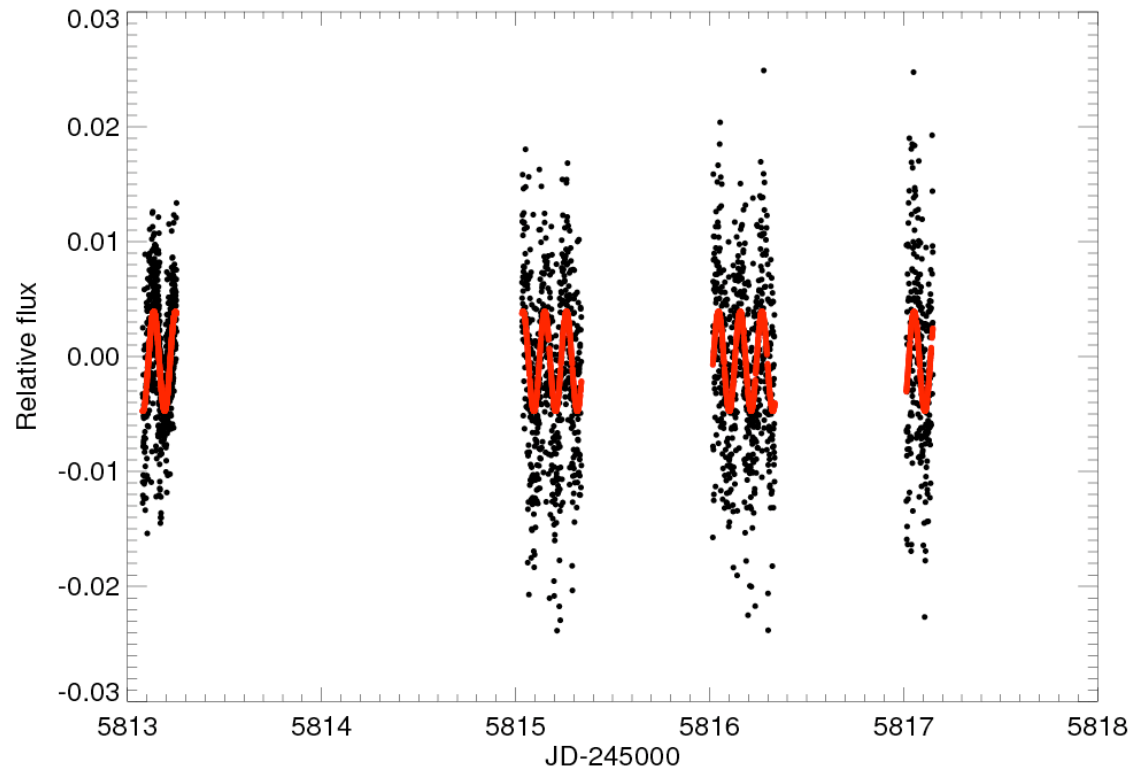
Sep 2011: Bruce Gary, Howard Relles, EA  
+23 observers;  $\approx 30$  WD so far



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9/16/11



ESS-II

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# Conclusions

- White dwarfs have a potentially ‘habitable’ zone from  $\approx .005$ -.02 AU lasting few+ Gyr
- If planets could (re)-form close to white dwarfs, “easy” to detect via transit ( $p \approx 1\%$ )
- Ground-based robotic surveys could find these planets, and next generation ground/space telescopes could characterize them; (LSST may reach small  $\eta_{\oplus} < 0.05\%$ )
- Would have some properties similar to Earth

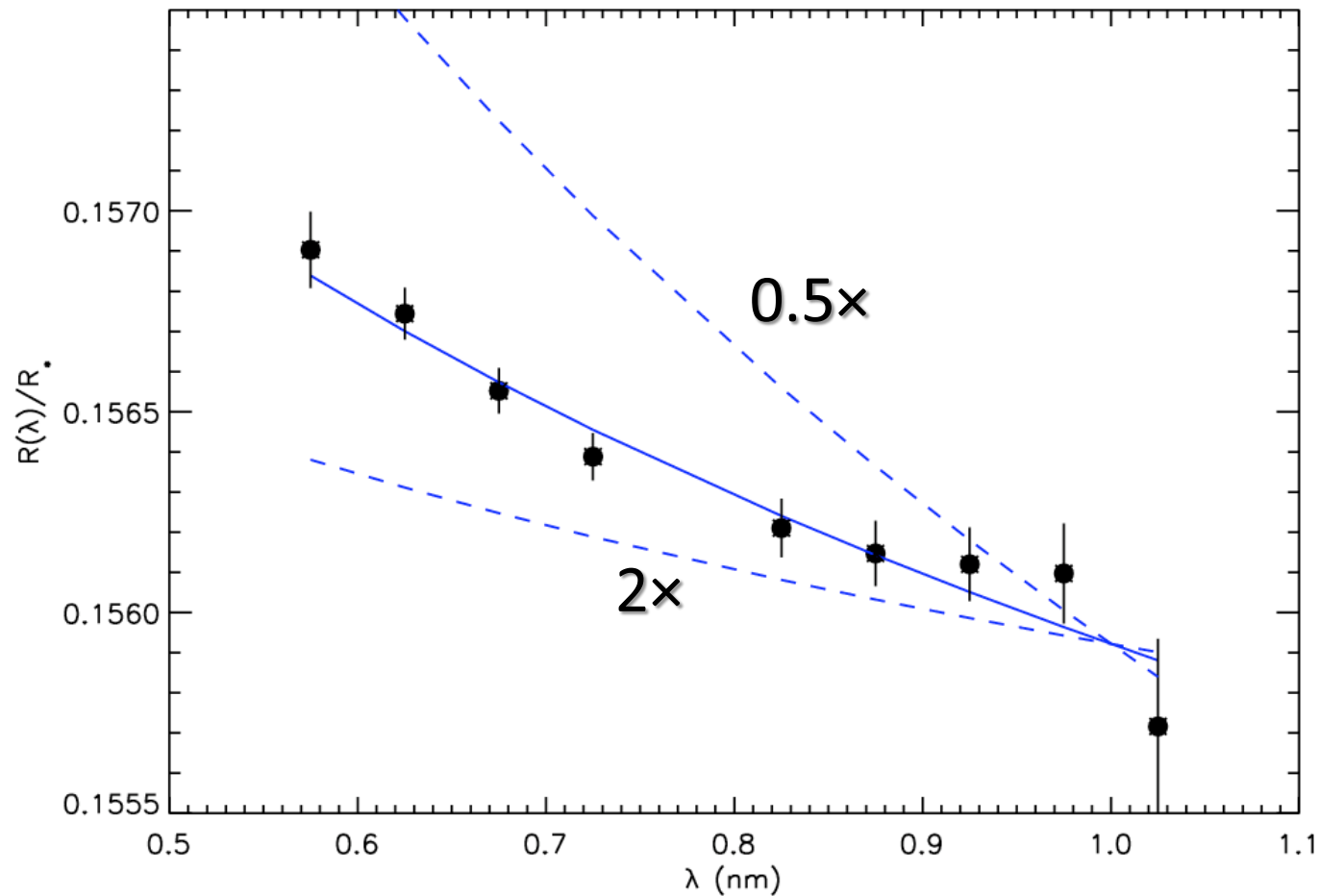


# Why look for habitable planets orbiting white dwarfs?

“When we are exploring the universe and looking for evidence of life, either we may look for things that are probable but hard to detect or we may look for things that are improbable but easy to detect. In deciding what to look for, detectability is at least as useful a criterion as probability.... To have the best chance of success, we should keep our eyes open for all possibilities.”

-Freeman Dyson, the Atlantic Monthly, Nov. 1997

# HD 189733 mass from Rayleigh scattering



$$R \approx R_0 + 8H/R_p \ln(\lambda/\lambda_0) \longrightarrow M = 1.1 \pm 0.1 M_J$$