

Circumstellar Calcium around WD 1124-293: The Last Gasp of a Dying Planetary System

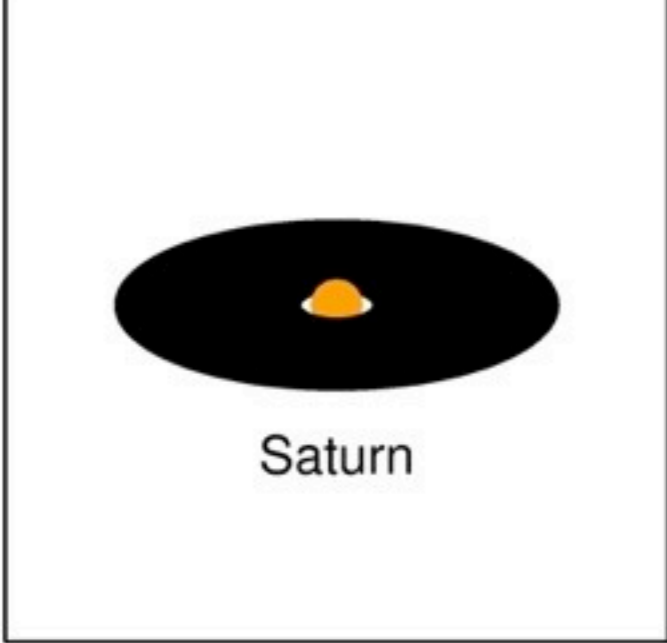


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We can learn just as much about planet formation in the last 12 Gyr of a planetary system's "life" as we can in the first Gyr...





Saturn



SDSS J1043+0855



SDSS J2209+1223



GALEX J1931+0117



PG 0843+517



WD 2115-560



SDSS J0845+2257



HE 2221-1630



EC-11507



PG 1541+651



SDSS J1228+1040



G 166-58



HS 0307+0746



WD 1116+026



GD 61



G29-38



GD 56



GD 16



HE 0106-3253



GD 362



GD 40



WD 1457-086



SDSS J1617+1620

1987

2005
*Spitzer (2003)

2006

2007

2008

2009
*WISE (2009)

2010

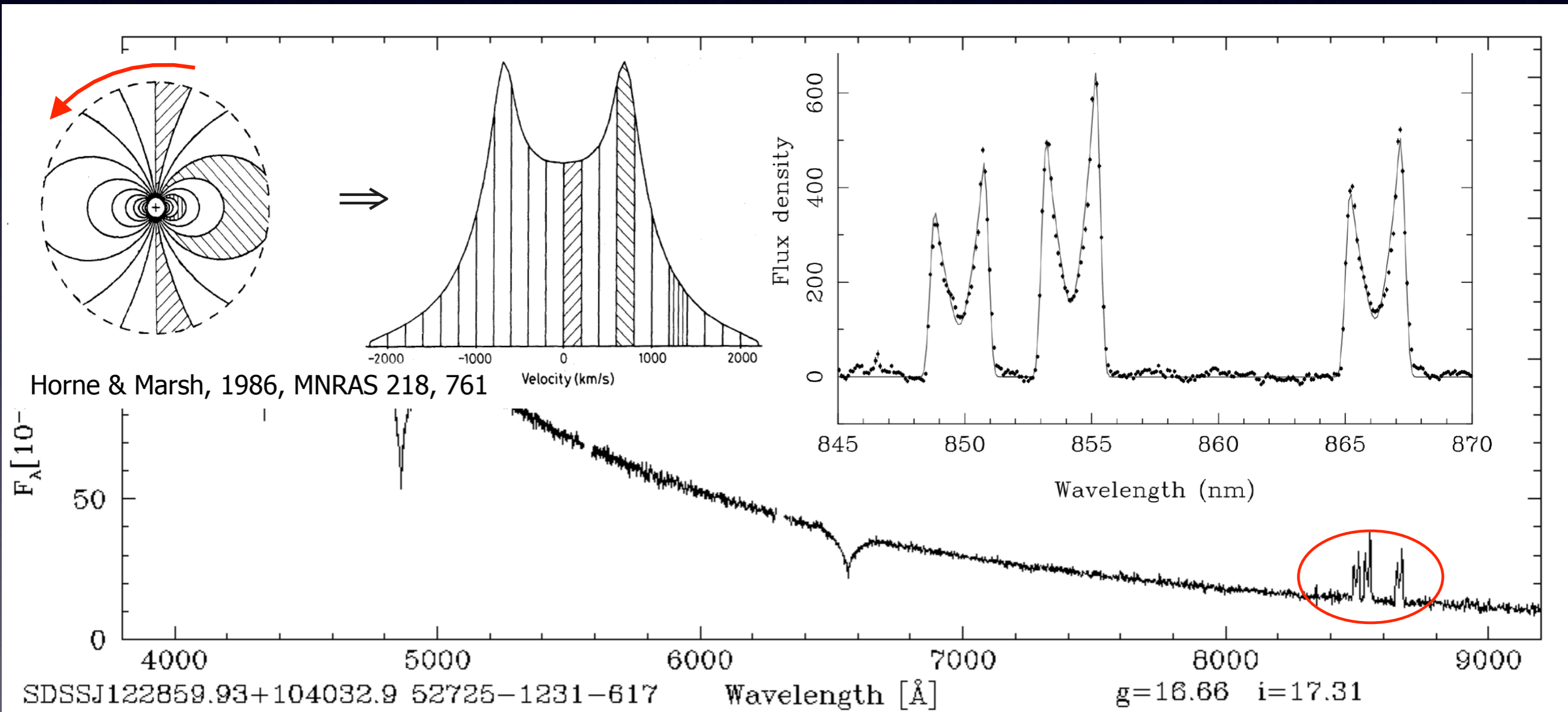
2011

Year of Discovery

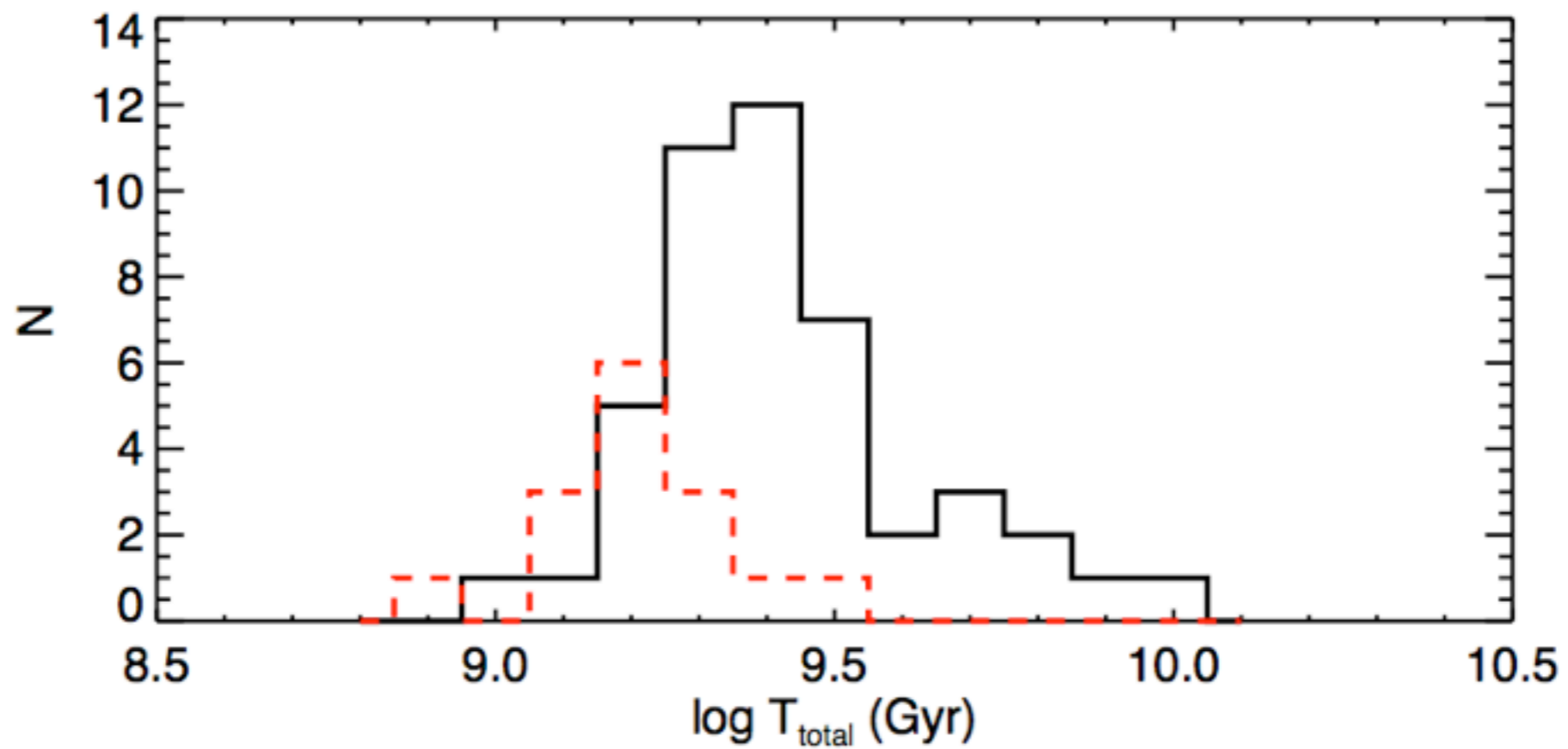
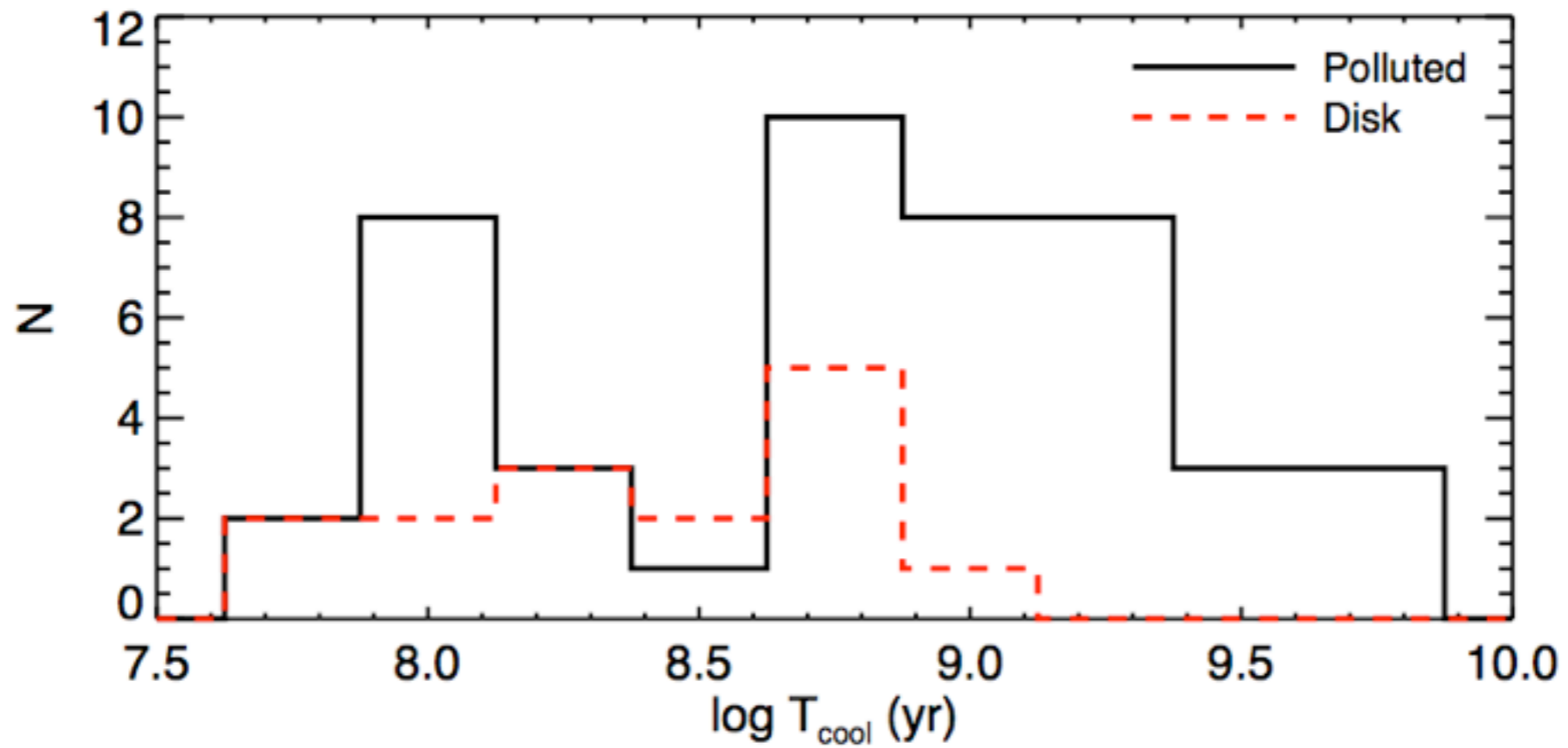
Dusty and Gaseous WDs

Dynamical constraints on the geometry: flat discs with an outer radius of $\sim 1R_{\odot}$
 \Rightarrow *within the tidal disruption radius of the WD*

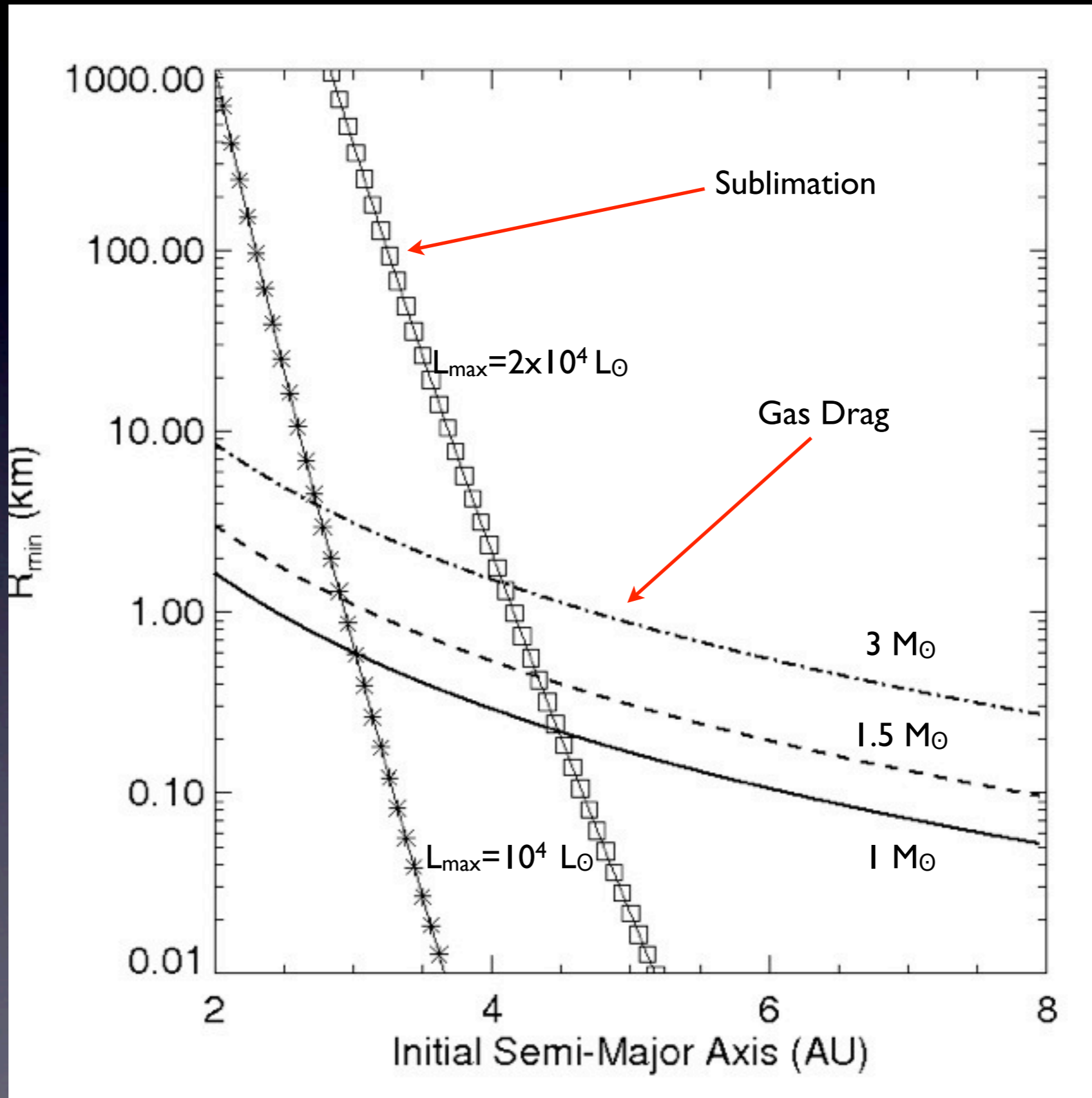
Gänsicke et al. 2006, *Science* 314, 1908; Gänsicke et al. 2007, *MNRAS* 380, L35; Gänsicke et al. 2008, *MNRAS* 391, L103; Melis et al. 2011ApJ 732, 90; Hartmann et al. 2011, *A&A* 530, 7; Gänsicke et al. 2011, *Science* 314, 1908; Gänsicke 2011, AIPC 1331, 211



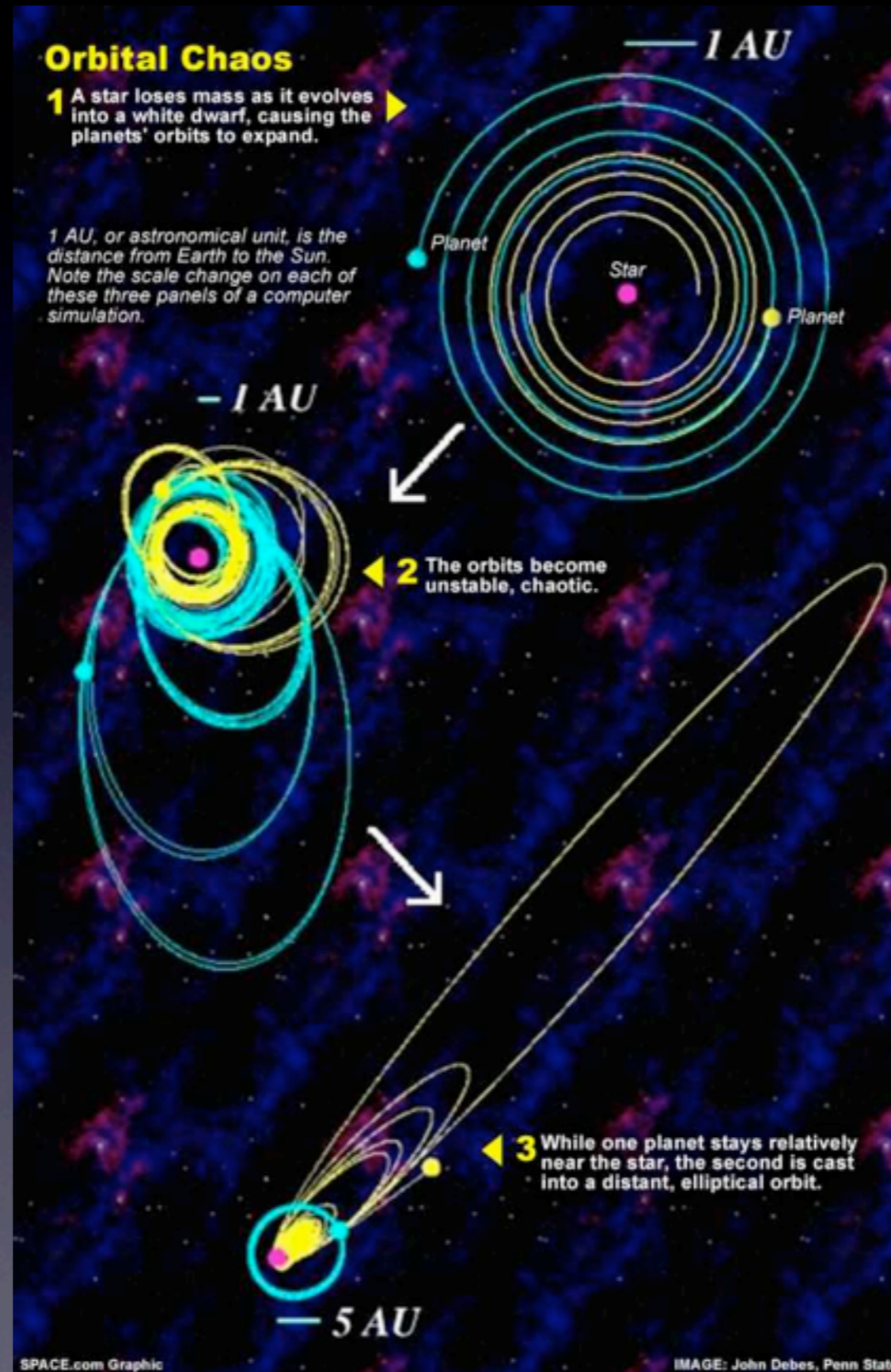
Slide from B. Gänsicke



Survival of Planetesimals



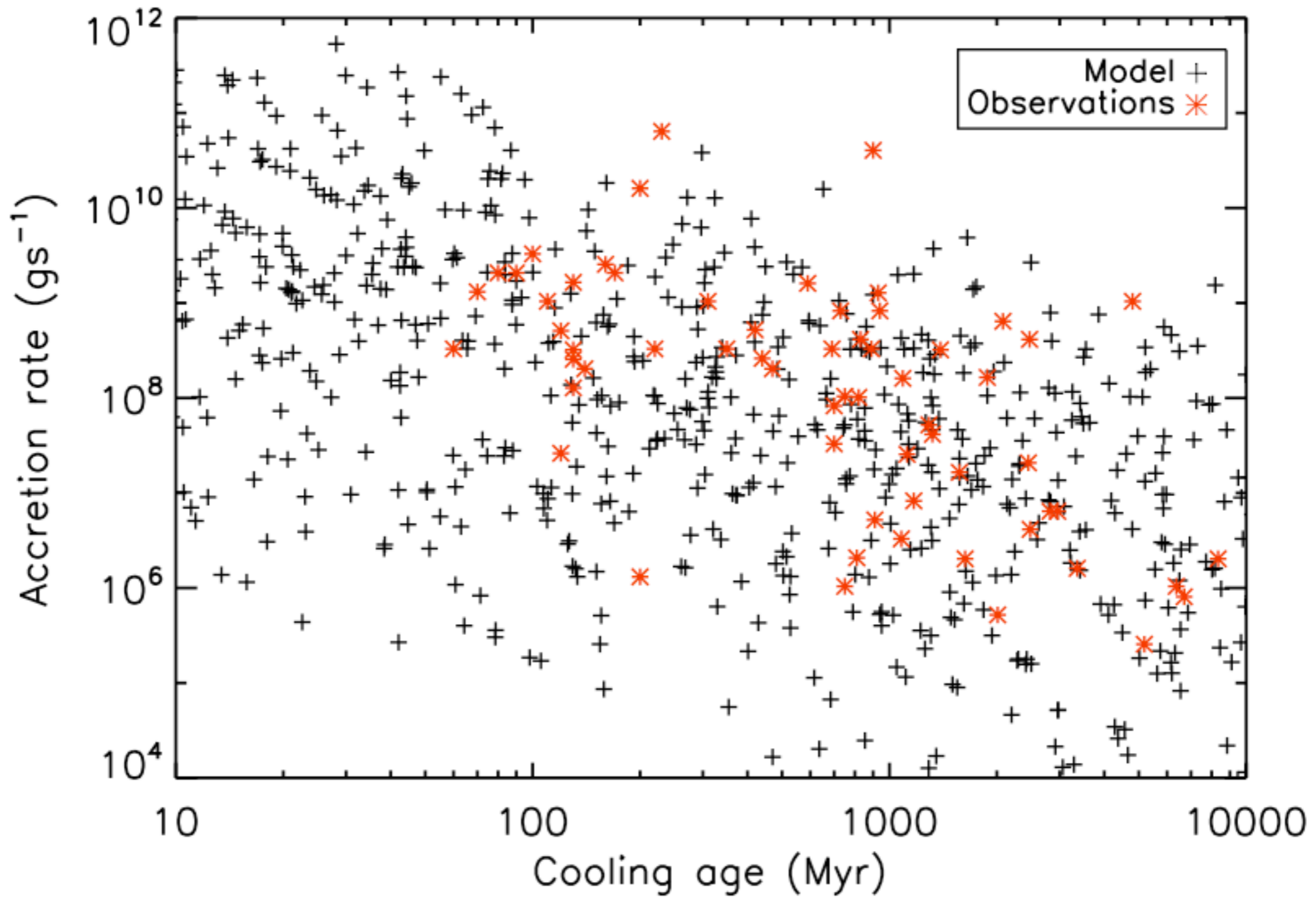
How do you get asteroids in?



Unstable Planets

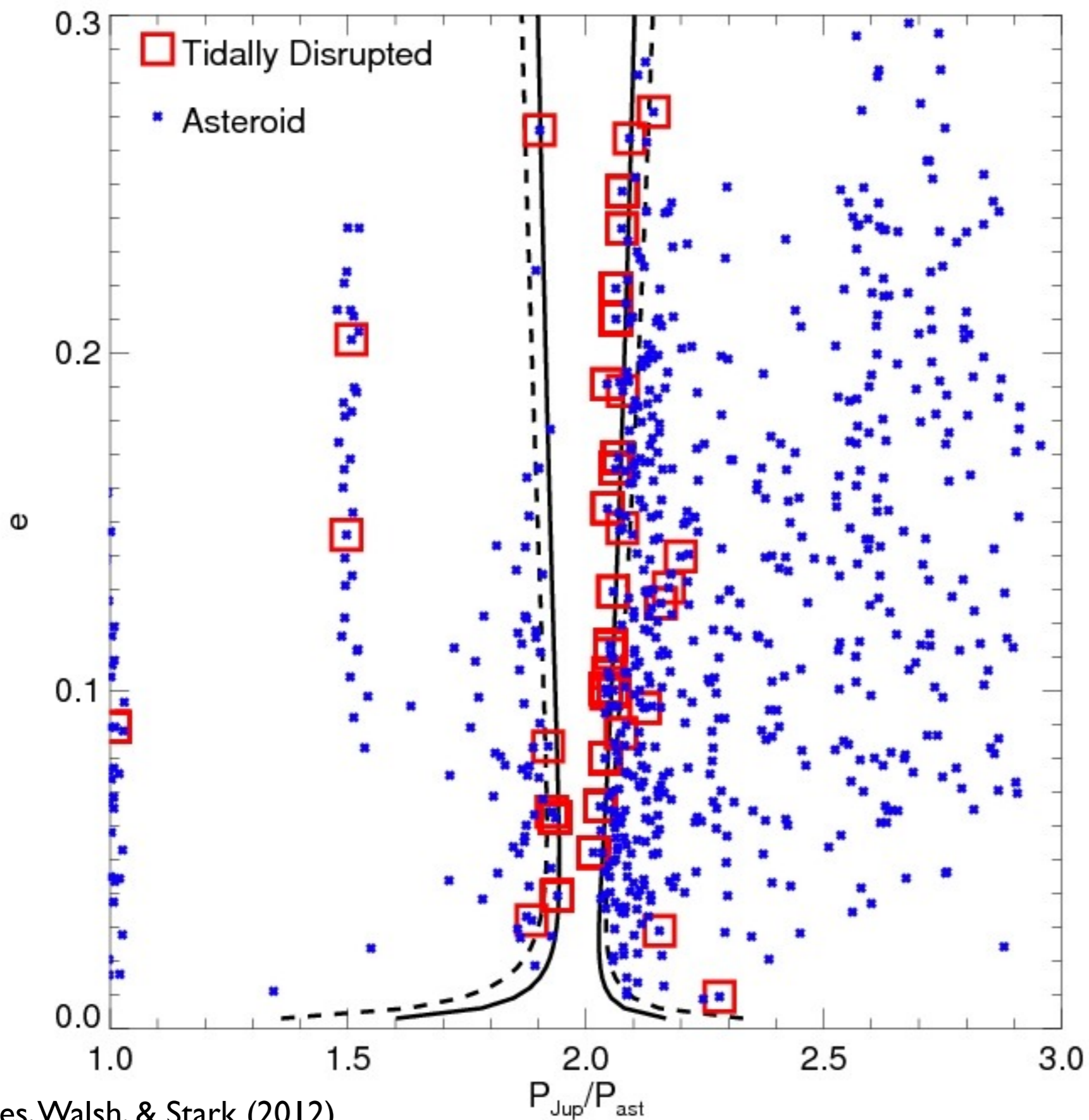
Debes & Sigurdsson (2002)

Exterior Resonances



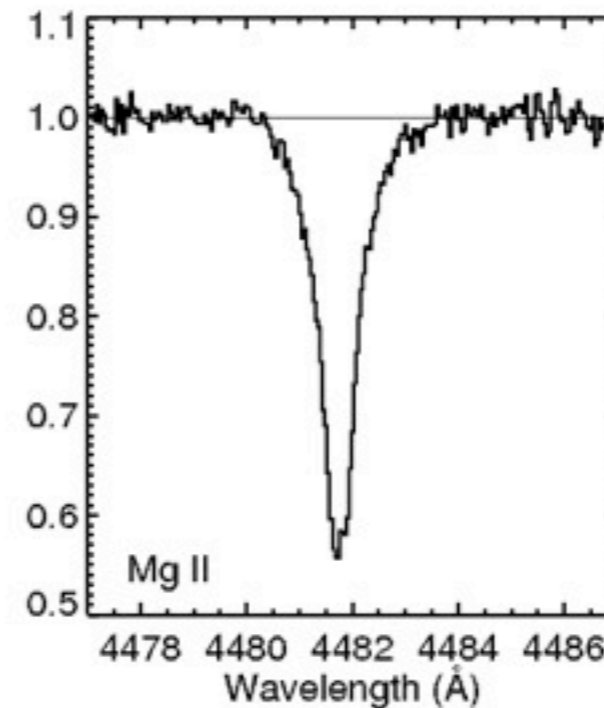
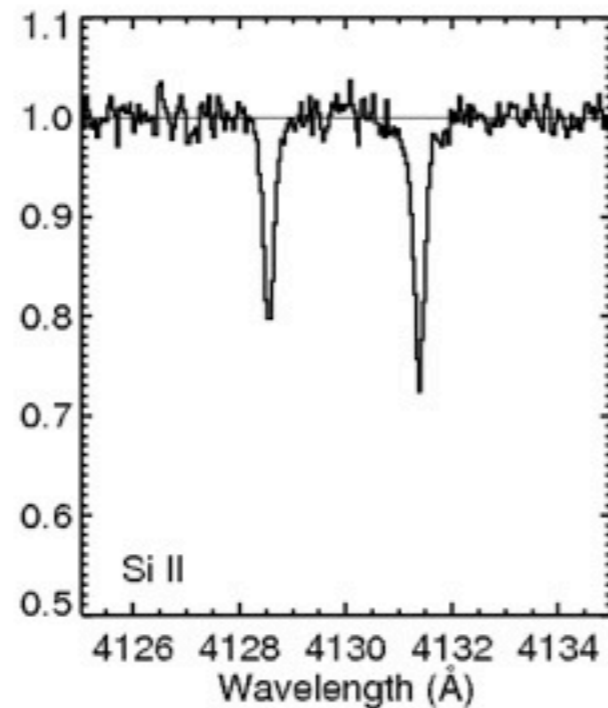
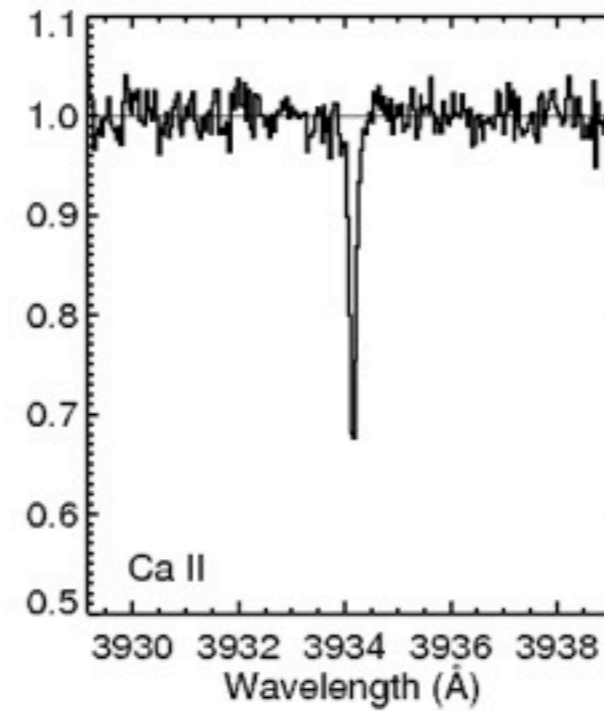
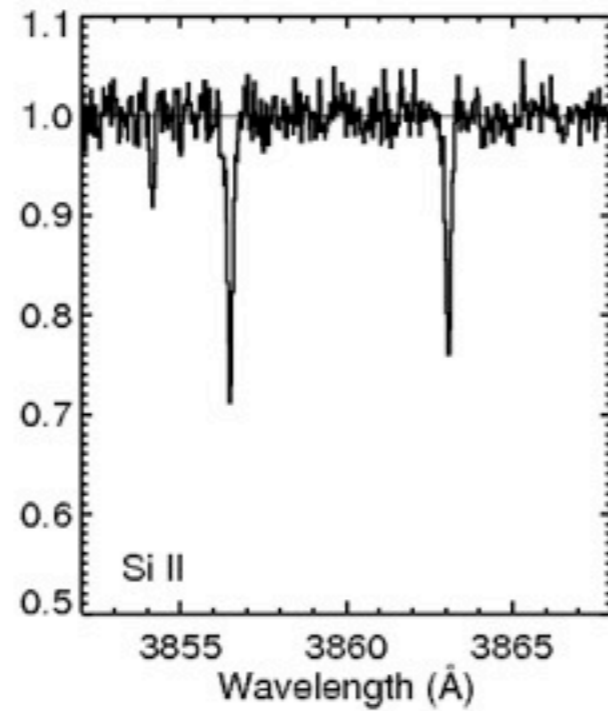
Bonsor et al., (2011)

Interior Resonances



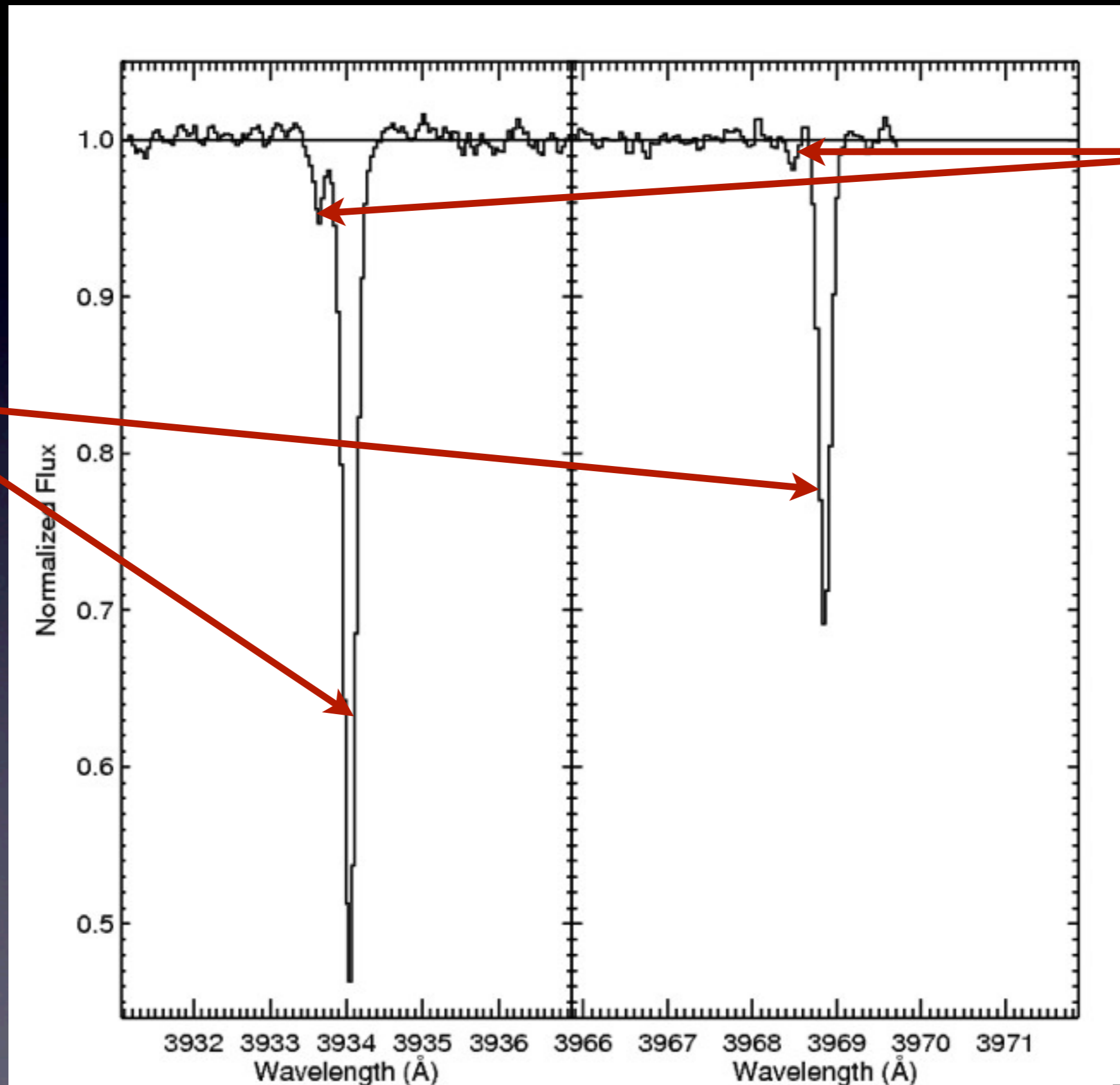
Debes, Walsh, & Stark (2012)

Optical Spectra of WDs



Debes et al. (2011)

Asteroids around polluted WDs?

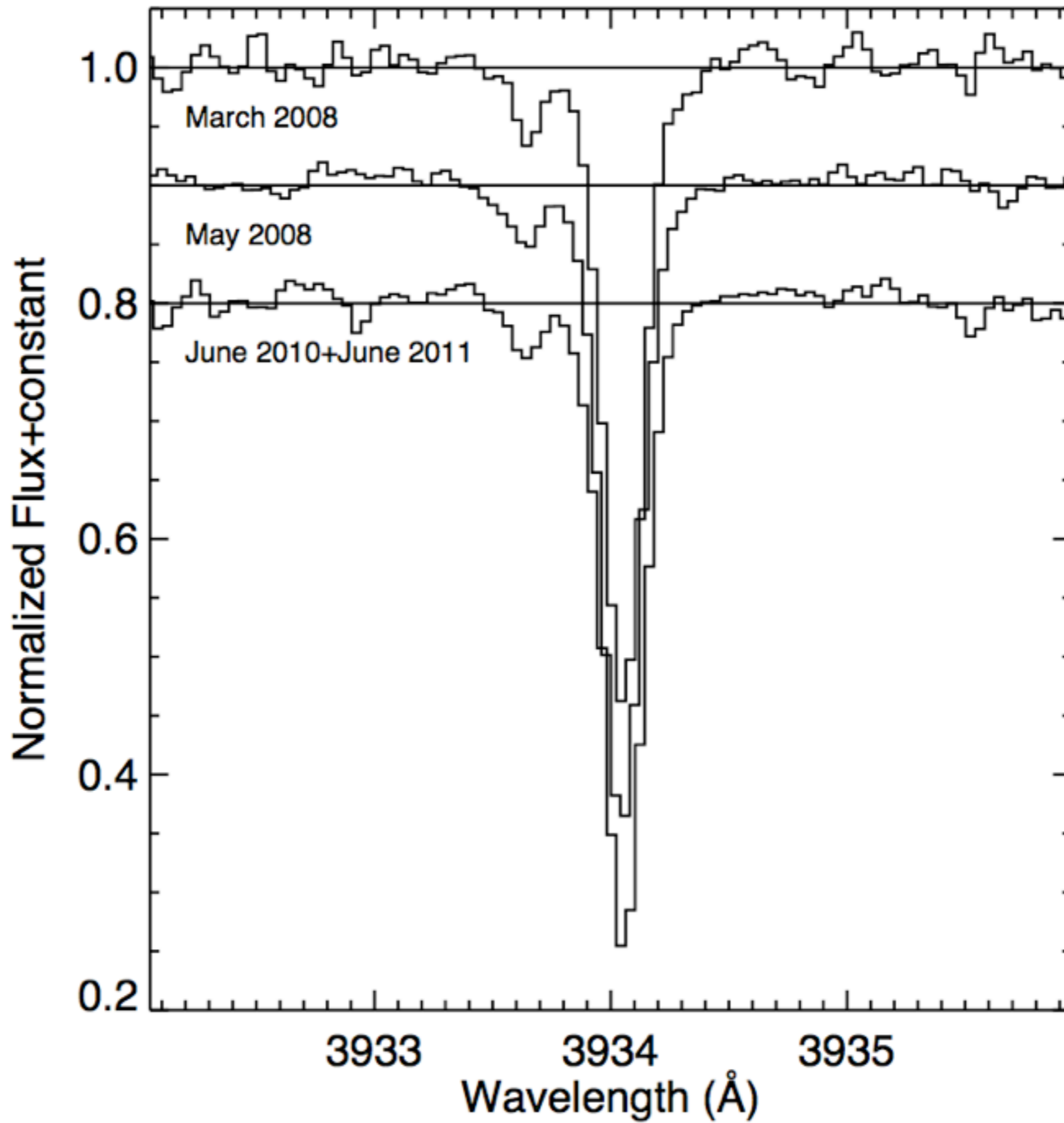


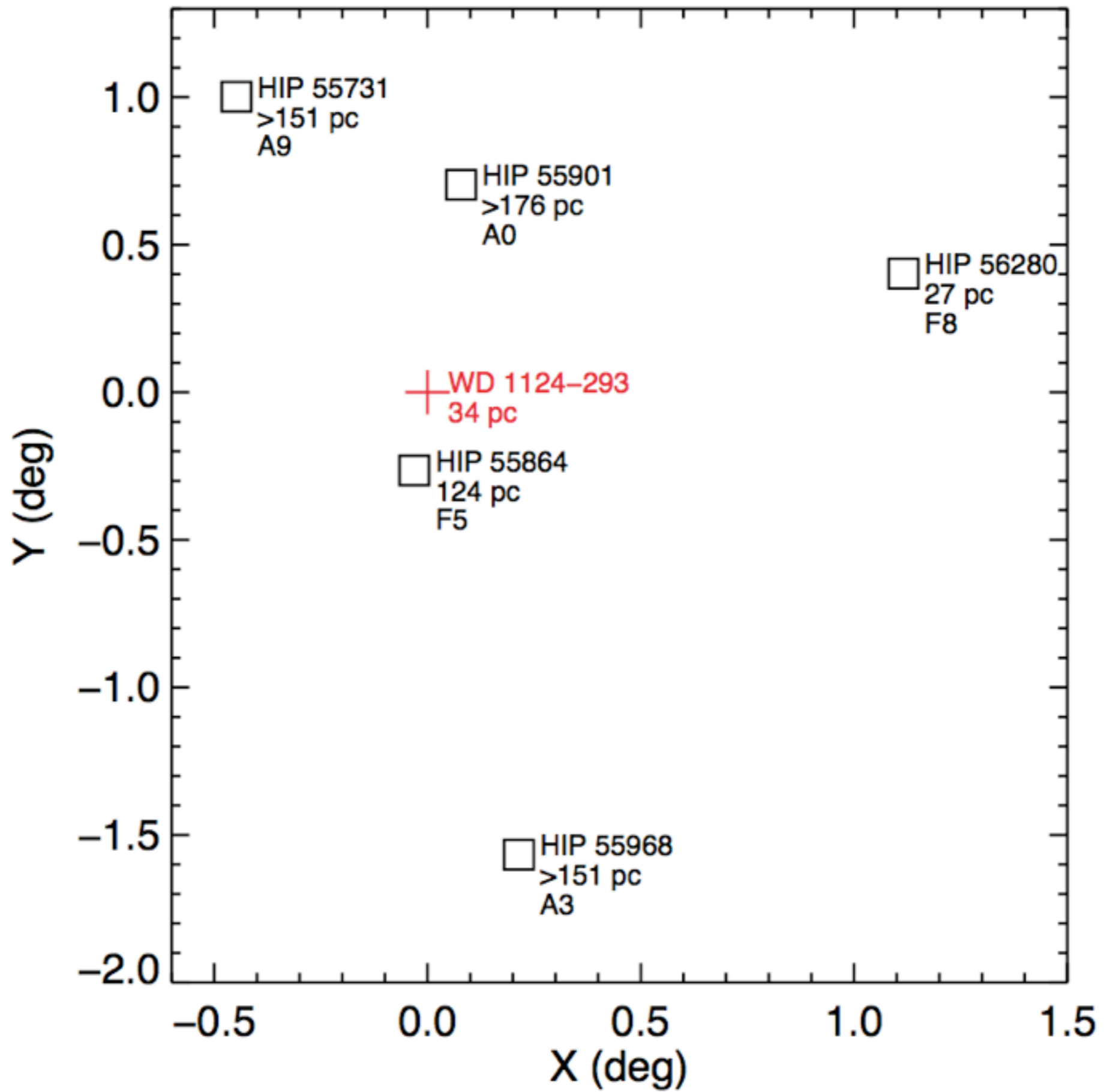
circumstellar
Ca

photospheric
Ca

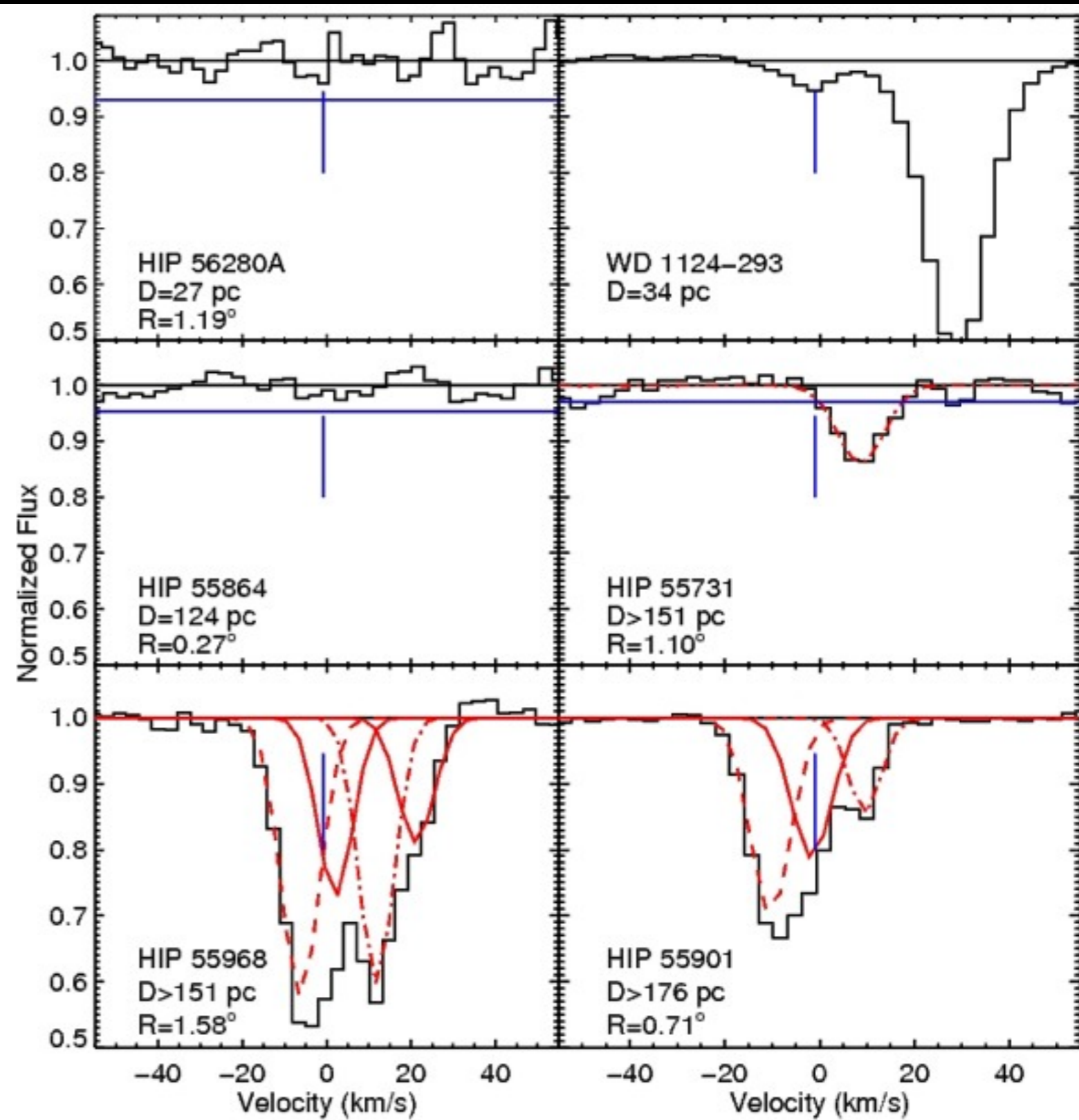
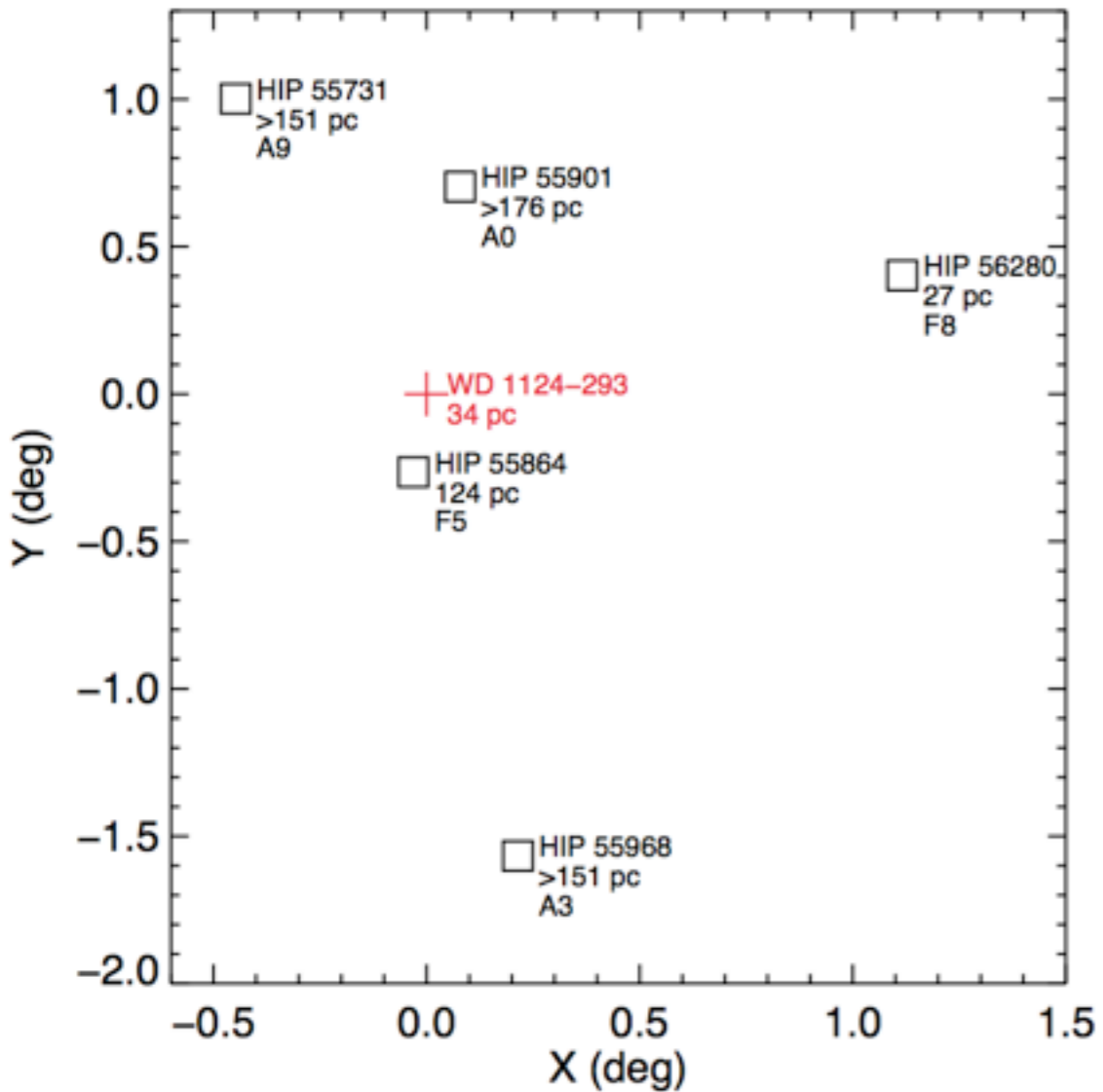
WD 1124-293
T_{eff}=9400
M=0.66 M_{sun}
T_{settle}: 194 yr

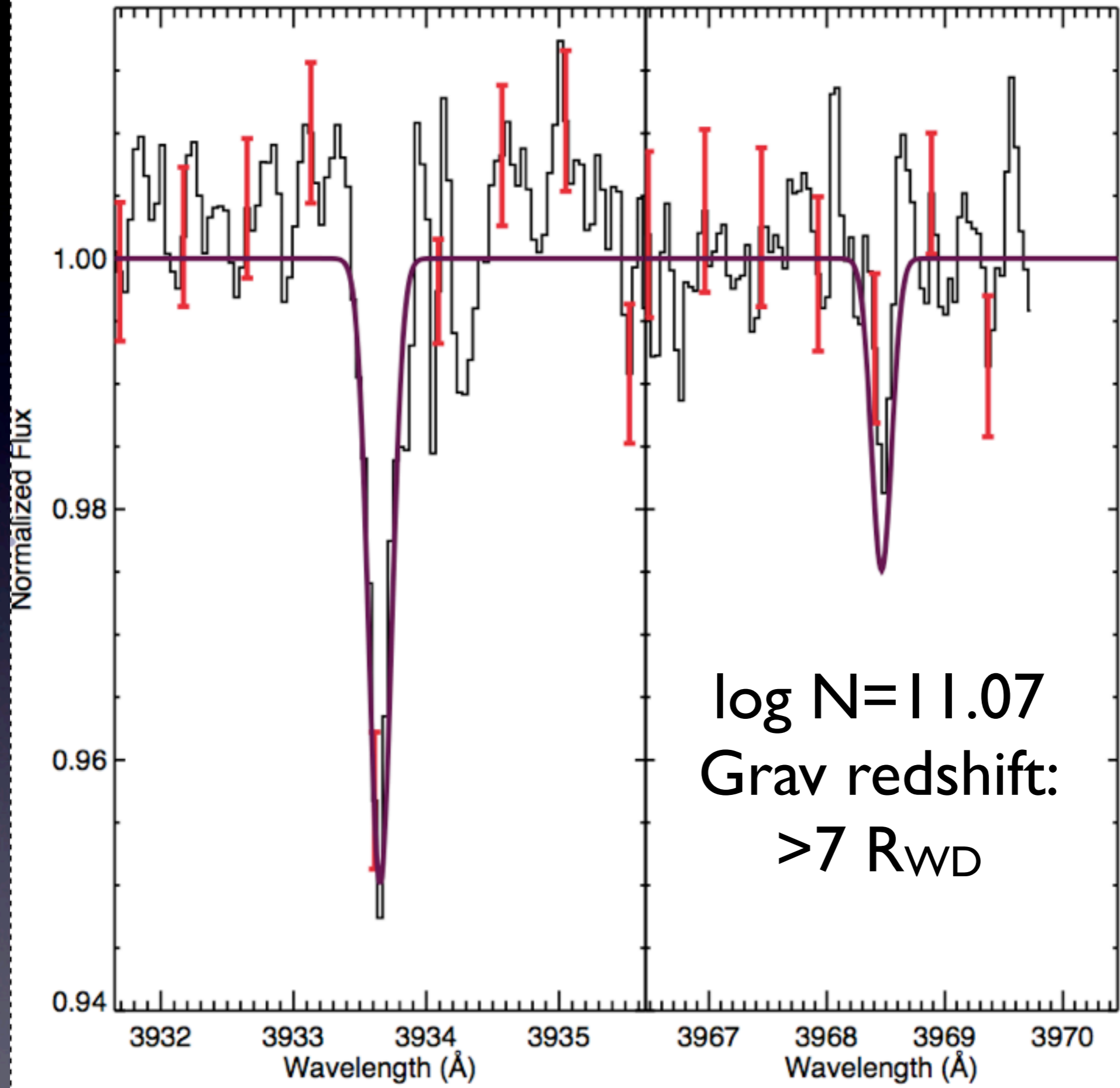
Debes et al. (2012)





Ruling out the intervening ISM





Gas at $<60 R_{WD}$

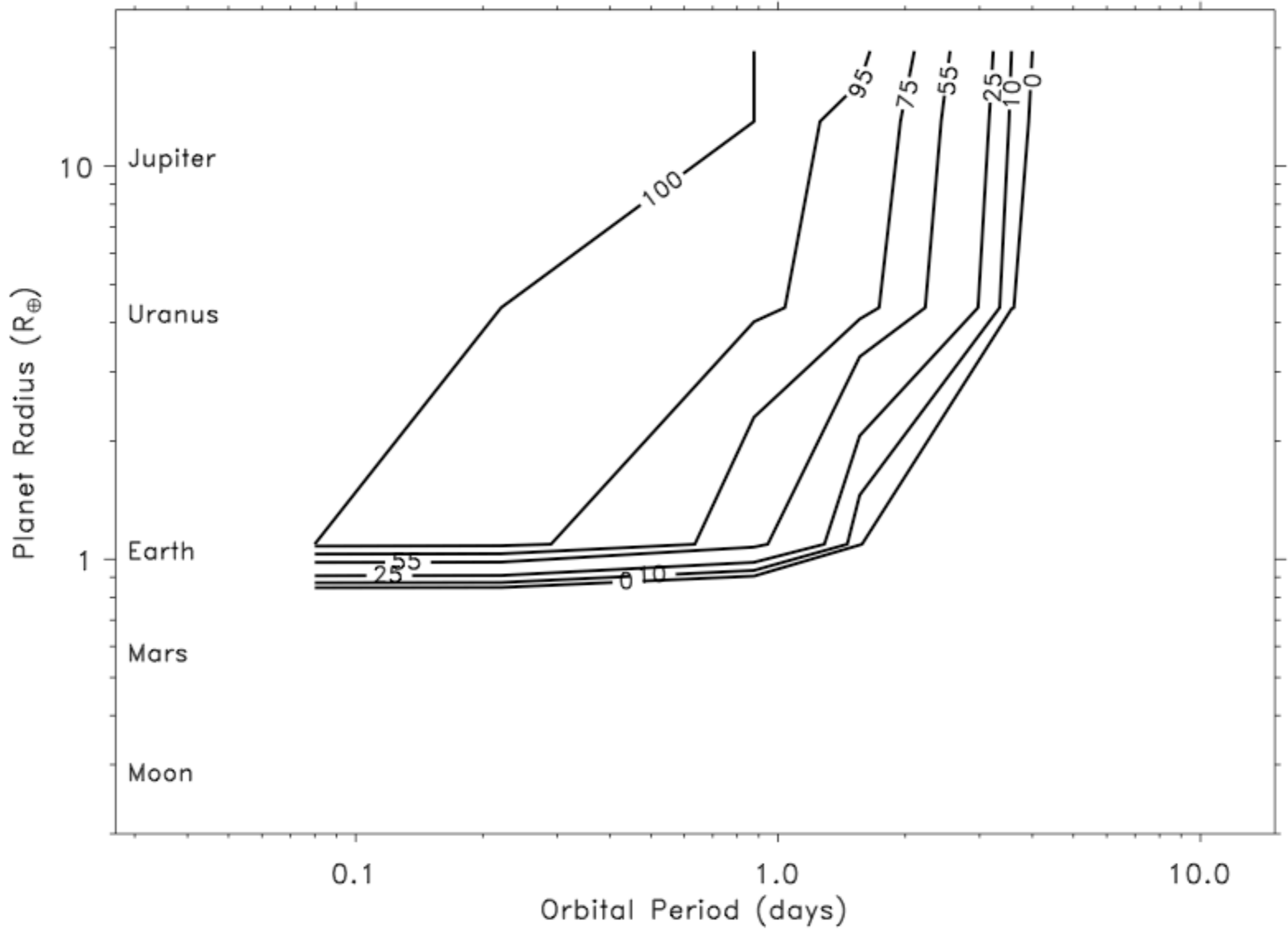


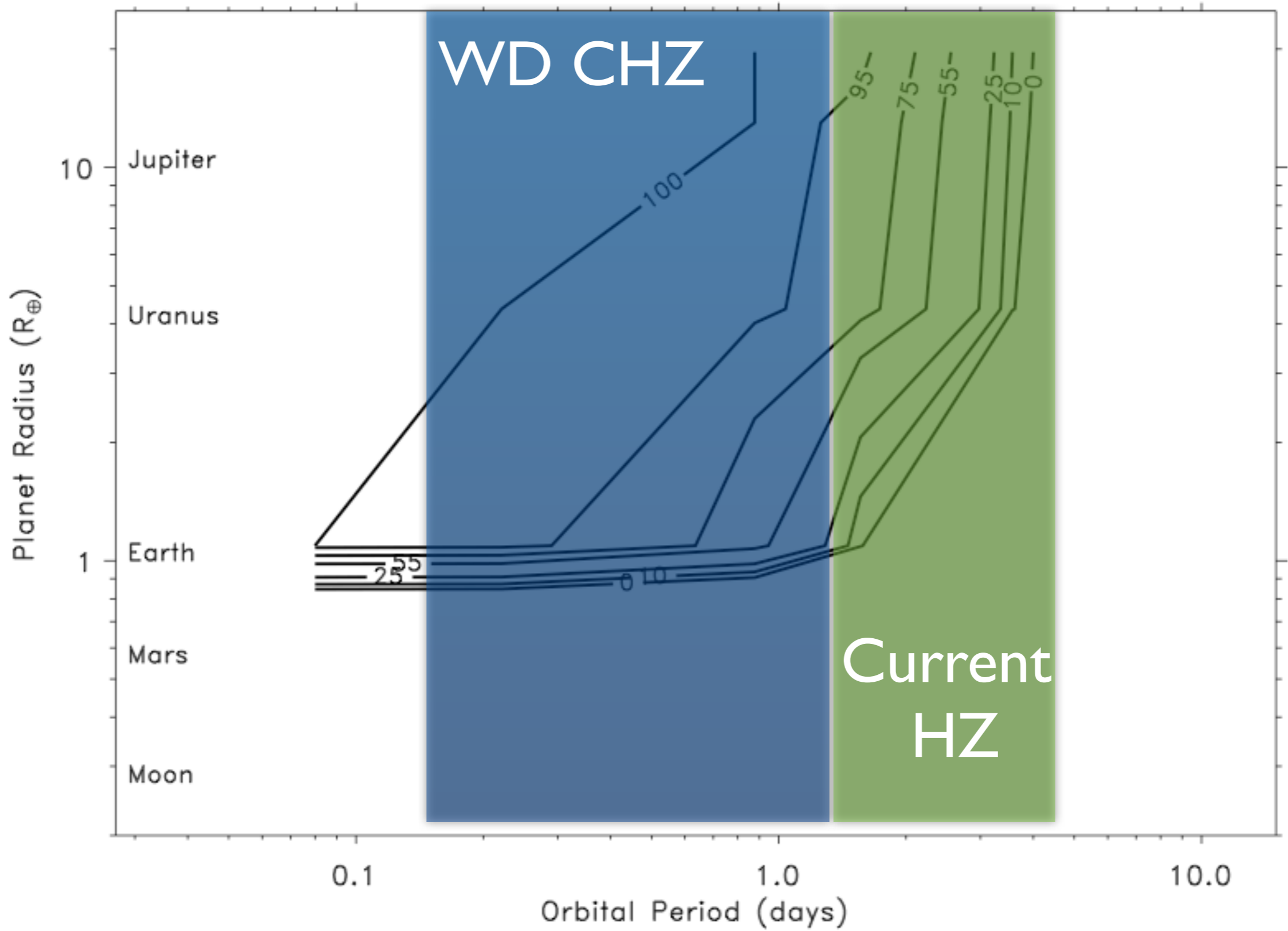
FWHM = 16 km/s

$R_{\text{gas}} = 54 R_{WD}$

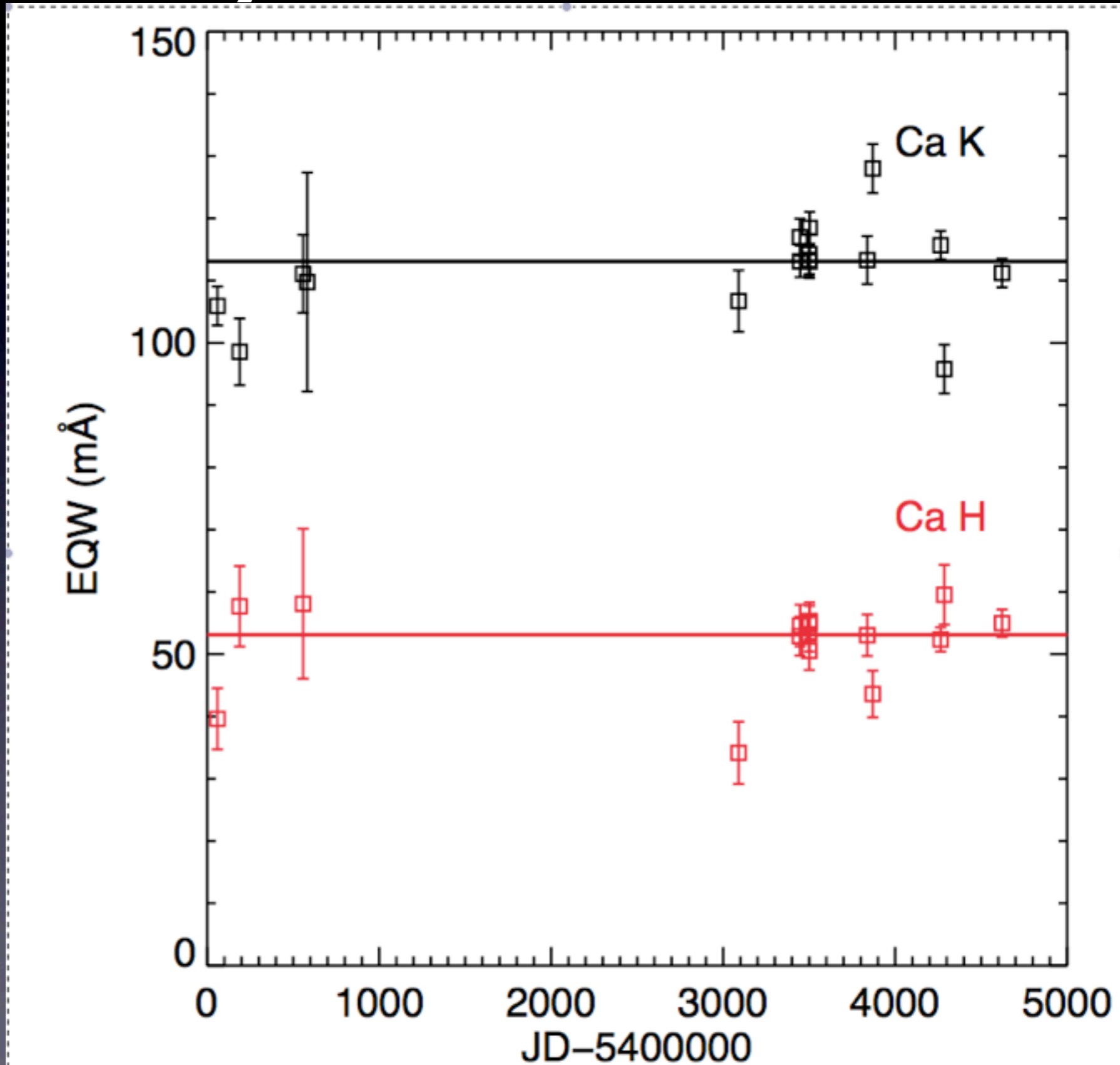
$R_{\text{sublimation}} = 43 R_{WD}$







Steady State Accretion



Summary

- WDs show evidence of planetary systems through dust, gas, and photospheric pollution
- WD I 124-293 is the first example of a cool WD with circumstellar gas absorption, thanks to high S/N optical MIKE spectroscopy
- The gas resides in a similar location to dusty WDs, suggesting that almost all WD photospheric pollution is due to the accretion of large and small asteroids/comets