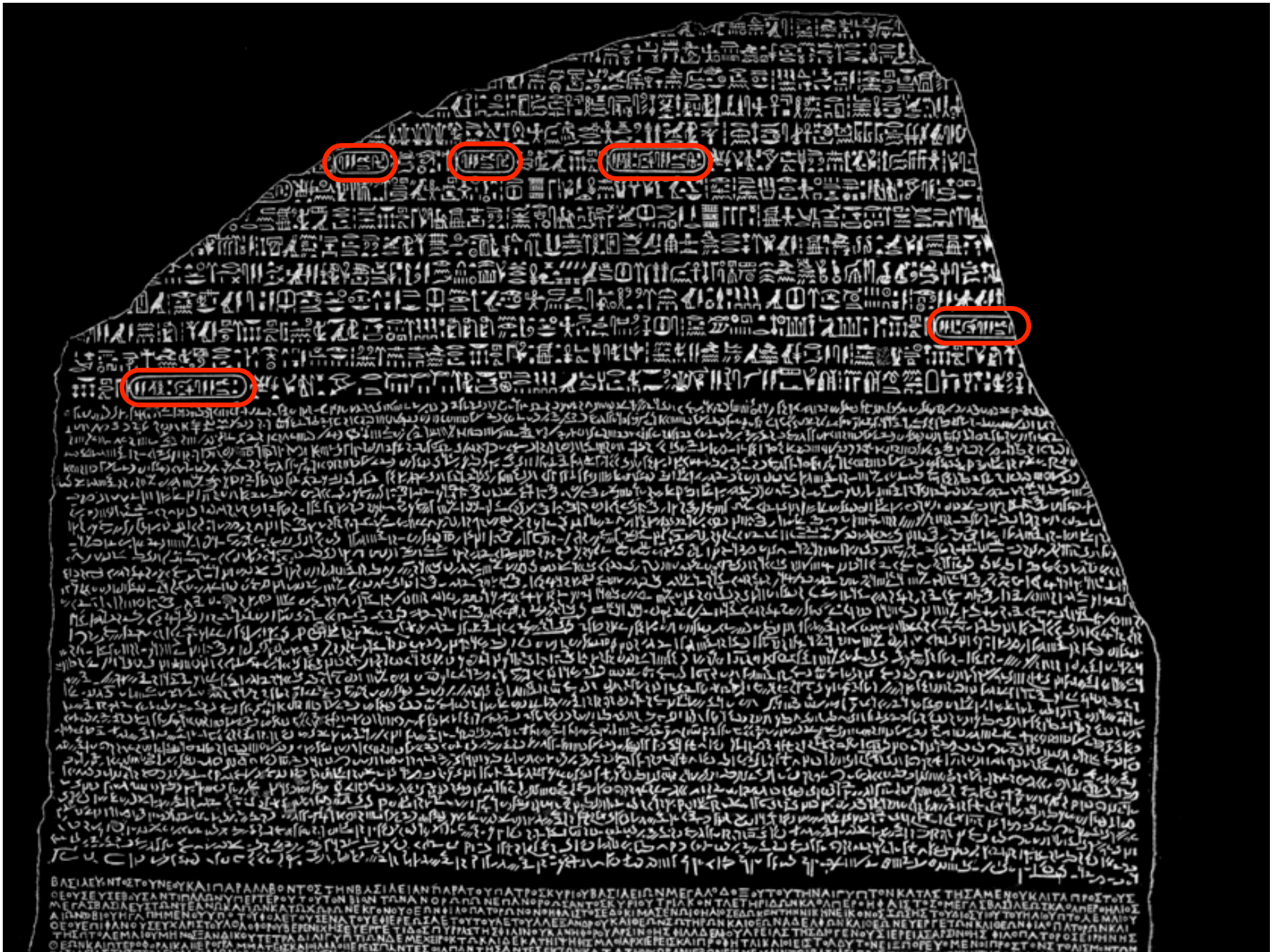


# “Exoplanetology” with transiting planets

Frédéric Pont

Geneva Observatory



ΕΙΣ ΤΗΝ

ΕΙΣ ΤΗΝ

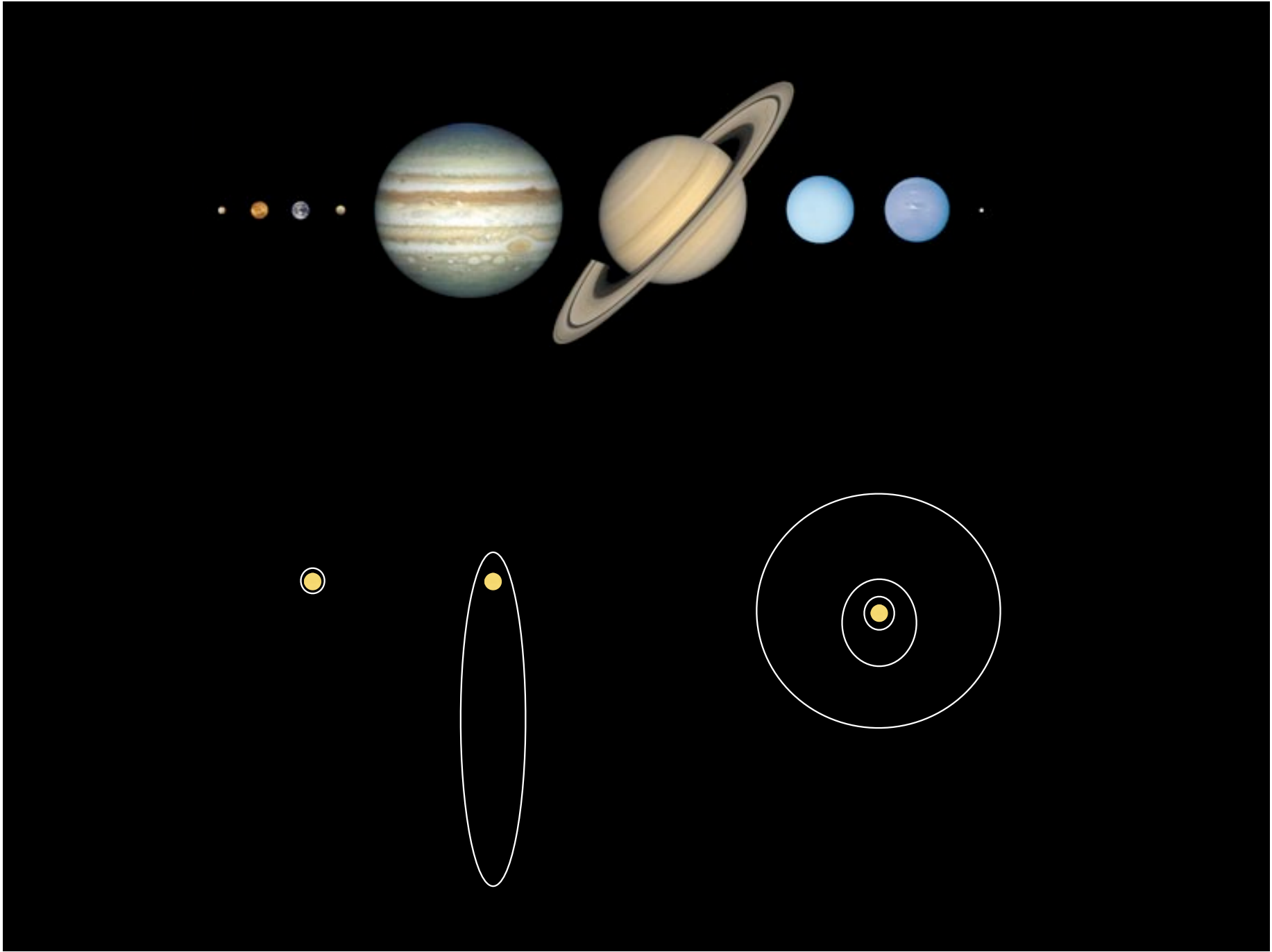
ΕΙΣ ΤΗΝ

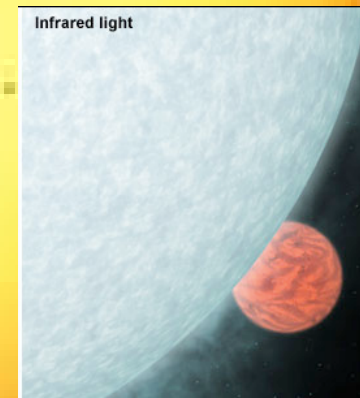
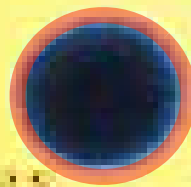
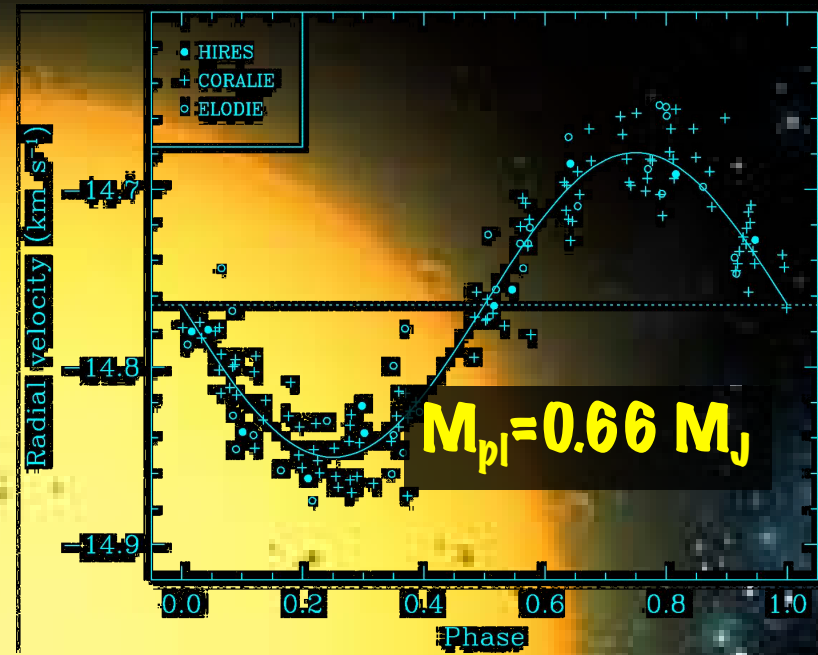
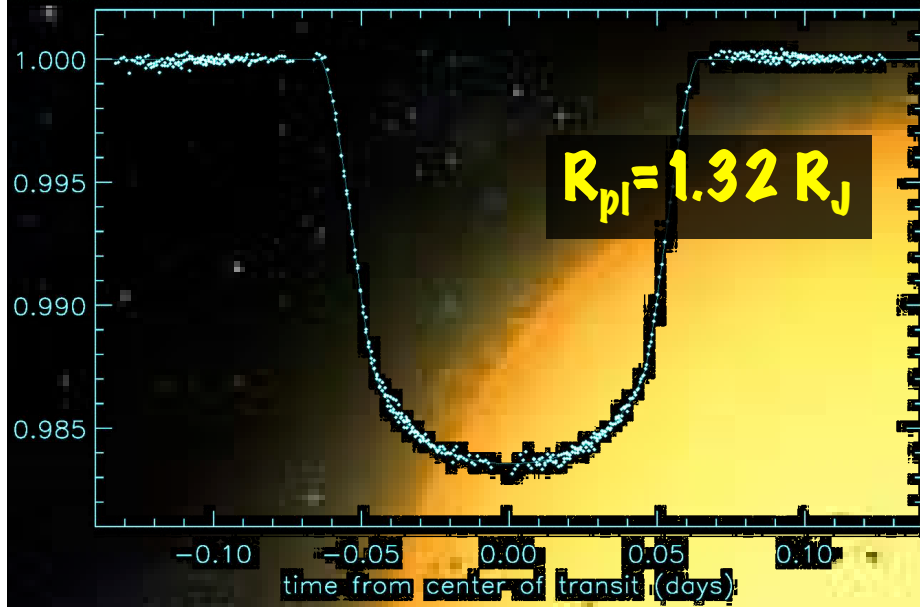
ΕΙΣ ΤΗΝ

ΕΙΣ ΤΗΝ

Fragment of an ancient papyrus scroll containing Greek text. The text is written in a cursive hand and is partially obscured by the fragment's shape. The circled words are 'ΕΙΣ ΤΗΝ'.

ΒΑΣΙΛΕΥΣ ΝΤΕ ΤΟΥ ΝΕΟΥ ΚΑΙ ΠΑΡΑΛΛΟΝ ΤΟΣ ΤΗΝ ΒΑΣΙΛΕΙΑΝ ΠΑΡΑ ΤΟΥ ΑΤΡΟΣ ΚΥΡΙΑ ΒΑΣΙΛΕΙΑ ΝΜΕΓΑΛΑ Δ ΕΥ ΤΟΥ ΤΗΝ ΑΙΟΥ ΤΟΝ ΚΑΤΑΣ ΤΗΣ ΑΜΕΝΟΥ ΚΑΙ ΤΑ ΠΡΟΣ ΤΟΥΣ  
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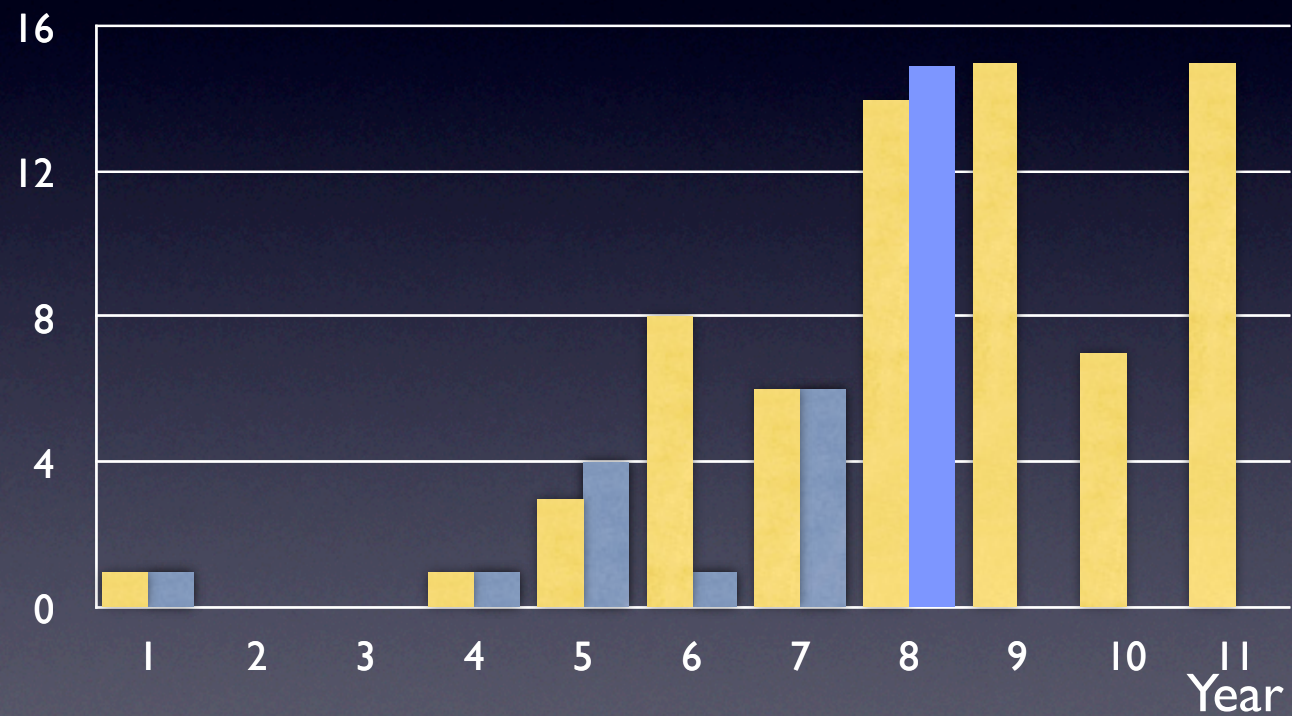


HD 209458

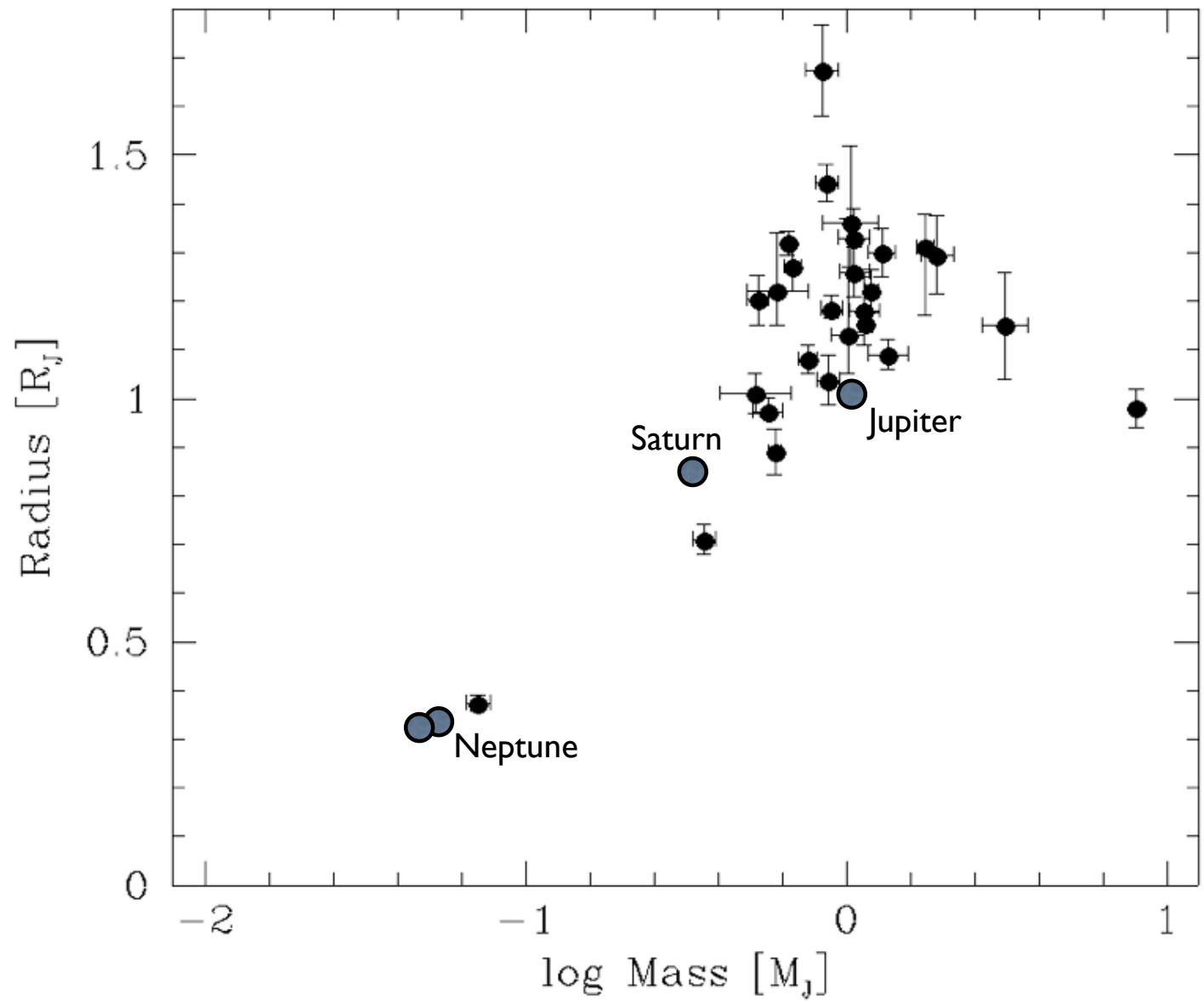
	<i>Planet</i>			<i>Orbit</i>		
	Mpl [M <sub>J</sub> ]	Rpl [R <sub>J</sub> ]	P [days]	Ttr [JD-2450000]	i [°]	a [AU]
<i>OGLE-TR-10</i>	0.61 (0.13)	1.122 (+0.12-0.07)	3.101278 ( _4)	3890.678 ( _1)	87.2-90	0.04162 (0.00
<i>OGLE-TR-56</i>	1.29 (0.12)	1.30 (0.05)	1.211909 ( _1)	3936.598 ( _1)	81.0 (2.2)	0.0225 (0.000
<i>OGLE-TR-111</i>	0.52 (0.13)	1.01 (0.04)	4.0144479 ( _41)	3799.7516 ( _2)	88.1 (0.5)	0.0467 (0.005
<i>OGLE-TR-113</i>	1.32 (0.19)	1.09 (0.03)	1.4324757 ( _13)	3464.61665( _10)	88.8-90	0.0229 (0.000
<i>OGLE-TR-132</i>	1.14 (0.12)	1.18 (0.07)	1.689868 ( _3)	3142.5912 ( _3)	81.5 (1.6)	0.0299
<i>HD189733</i>	1.15 (0.04)	1.154 (0.017)	2.218581 ( _2)	3931.12048 ( _2)	85.68 (0.04)	0.031 (0.001)
<i>HD149026</i>	0.330 (0.02)	0.726 (0.064)	2.87598 ( _15)	3527.87455 ( _90)	85.8 (+1.6-1.3)	0.042
<i>TrES-1</i>	0.76 (0.05)	1.081 (0.029)	3.0300737 ( _26)	3186.80603 ( _28)	>88.4	0.0393 (0.001
<i>TrES-2</i>	1.198 (0.053)	1.220 (+.045-.042)	2.47063 ( _1)	3957.6358 ( _10)	83.90 (0.22)	0.0367 (+_12-
<i>TrES-3</i>	1.92 (0.23)	1.295 (0.081)	1.30619 ( _1)	4185.9101 ( _3)	8215 (0.21)	0.0226 (0.001
<i>TrES-4</i>	0.84 (0.20)	1.674 (0.094)	3.553945 ( _75)	4230.9053 ( _5)	82.81 (0.33)	0.0488 (0.002
<i>HD209458</i>	0.657 (0.006)	1.320 (0.025)	3.52474859 ( _38)	2826.628521 ( _87)	86.929 (0.010)	0.047 (+.001-
<i>XO-1</i>	0.90 (0.07)	1.184 (+.028-.018)	3.941534 ( _27)	3887.74679 ( _15)	89.36 (+.46-.53)	0.0488 (0.000
<i>XO-2</i>	0.57 (0.06)	0.973 (+.03-.008)	2.615838 ( _8)	4147.74902 ( _20)	>88.35	
<i>HAT-P-1</i>	0.53 (0.04)	1.203 (0.051)	4.46529 ( _9)	3997.79258 ( _24)	86.22 (0.24)	0.0551 (0.001
<i>HD147506</i>	8.04 (0.40)	0.98 (0.04)	5.63341 ( _13)	4212.8561 ( _6)	>86.8	0.0685 (0.001
<i>HAT-P-3</i>	0.599 (0.026)	0.890 (0.046)	2.899703 ( _54)	4218.7594 ( _29)	87.24 (0.69)	0.03894 (0.00
<i>WASP-1</i>	0.867 (0.073)	1.443 (0.039)	2.519961 ( _18)	4013.31269 ( _47)	>86.1	0.0382 (0.001
<i>WASP-2</i>	0.81-0.95	1.038 (0.050)	2.152226 ( _4)	4008.73205 ( _28)	84.74 (0.39)	0.0307 (0.001
<i>GJ436</i>	0.071 (0.006)	0.374 (0.016)	2.64385 ( _9)	4280.78186 ( _15)	85.90 (0.19)	0.028 (0.001)

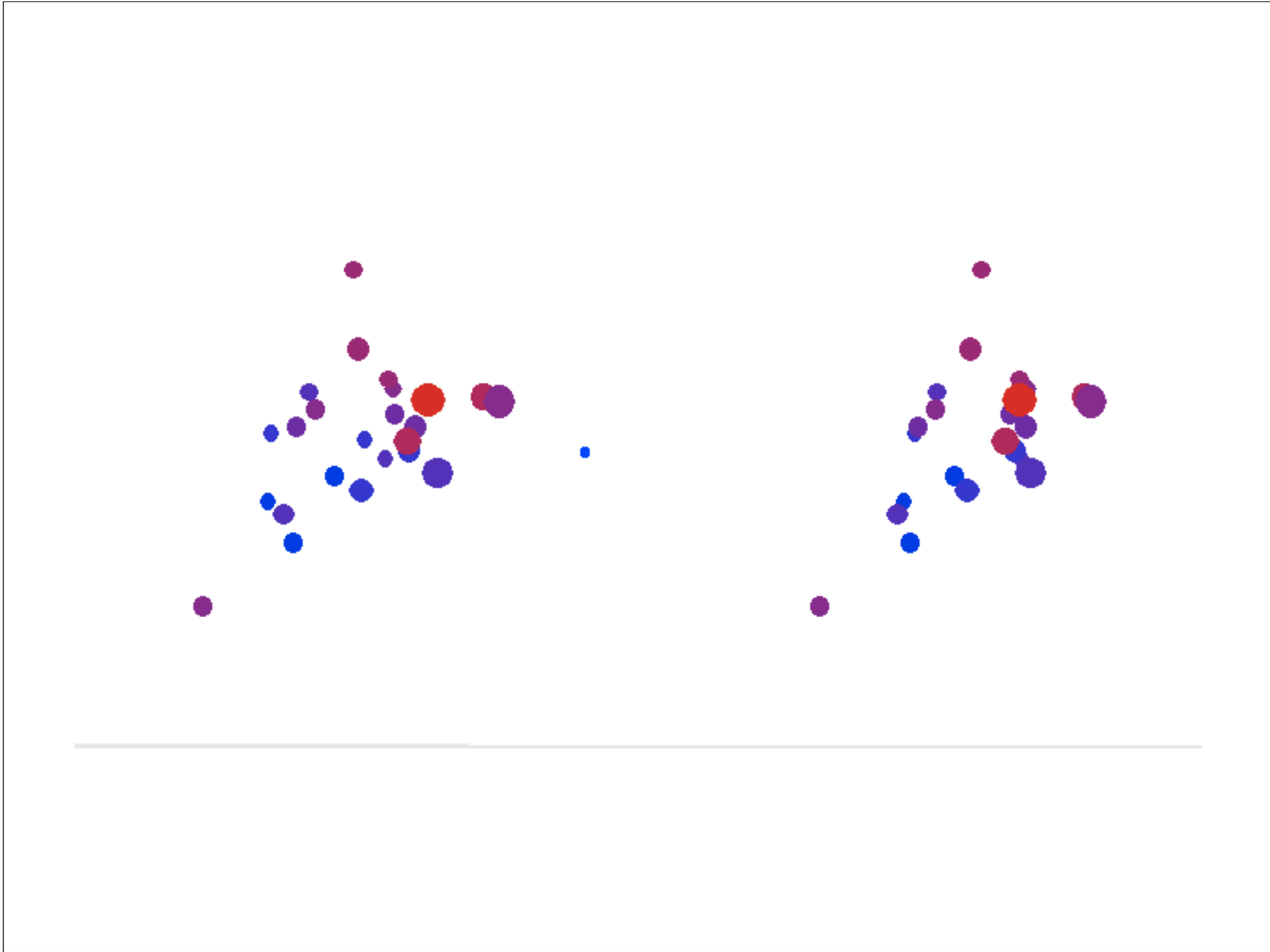
# Discovery rates: Doppler vs transits

■ Doppler detections      ■ Transit detections



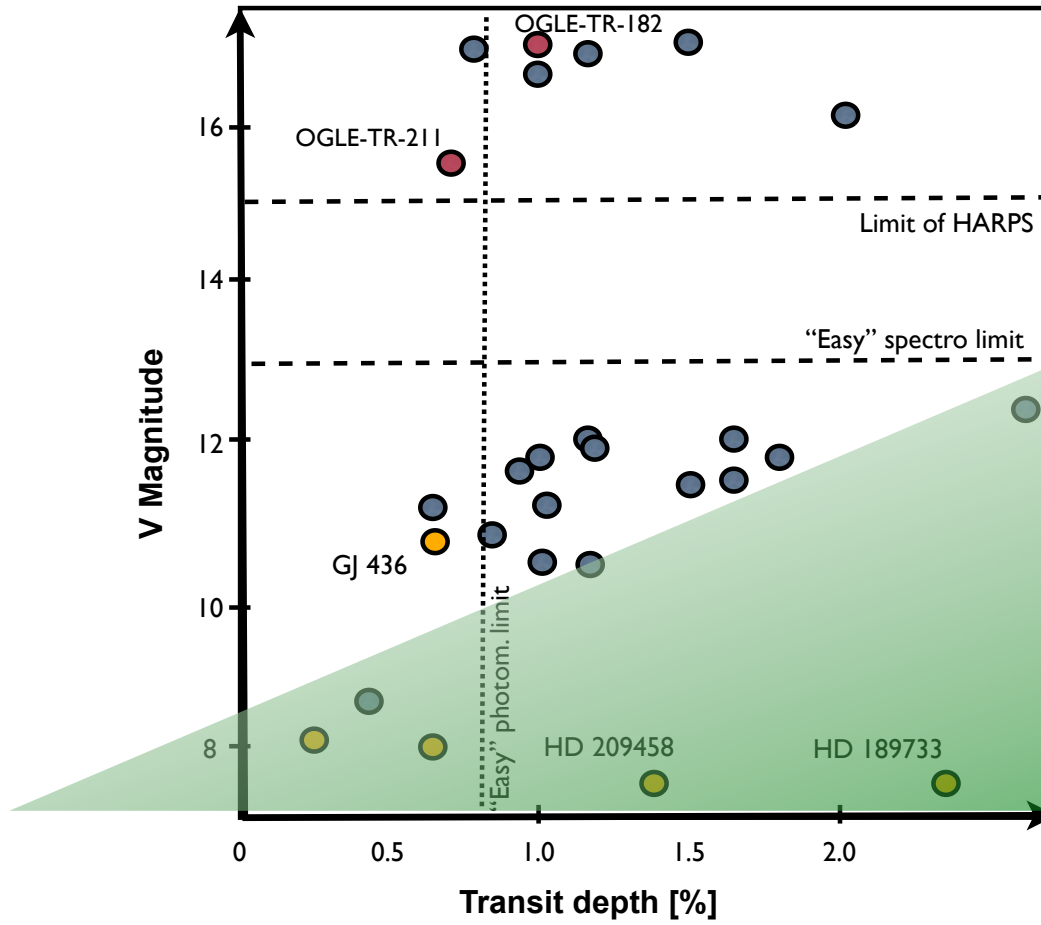
Mass-radius diagram for giant planets







# Transiting planets as of 1/12/07



Planetary atmosphere  
with HST/Spitzer

# HD 189733

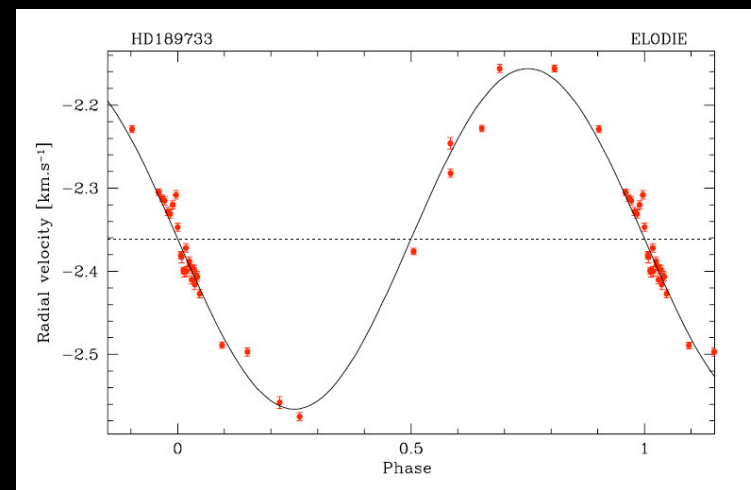
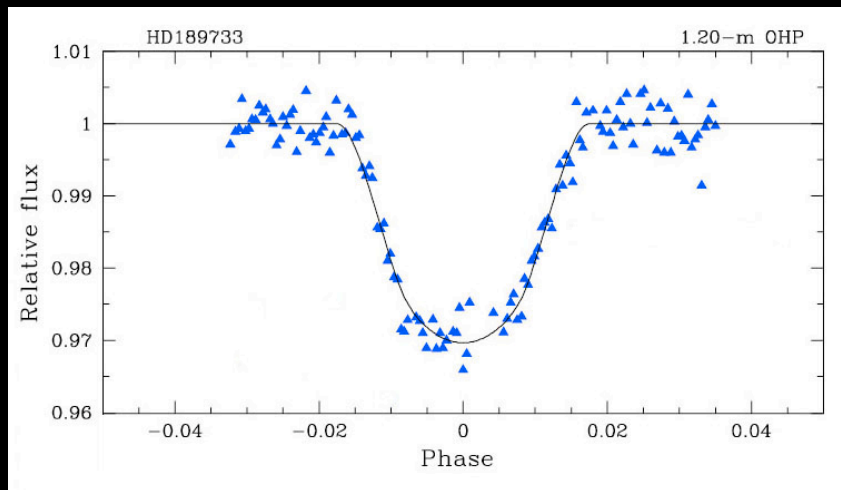
discovered by Elodie metallicity-biased transiting planet search (Geneva+Haute Provence Obs)

active K dwarf (0.8  $R_{\odot}$ )

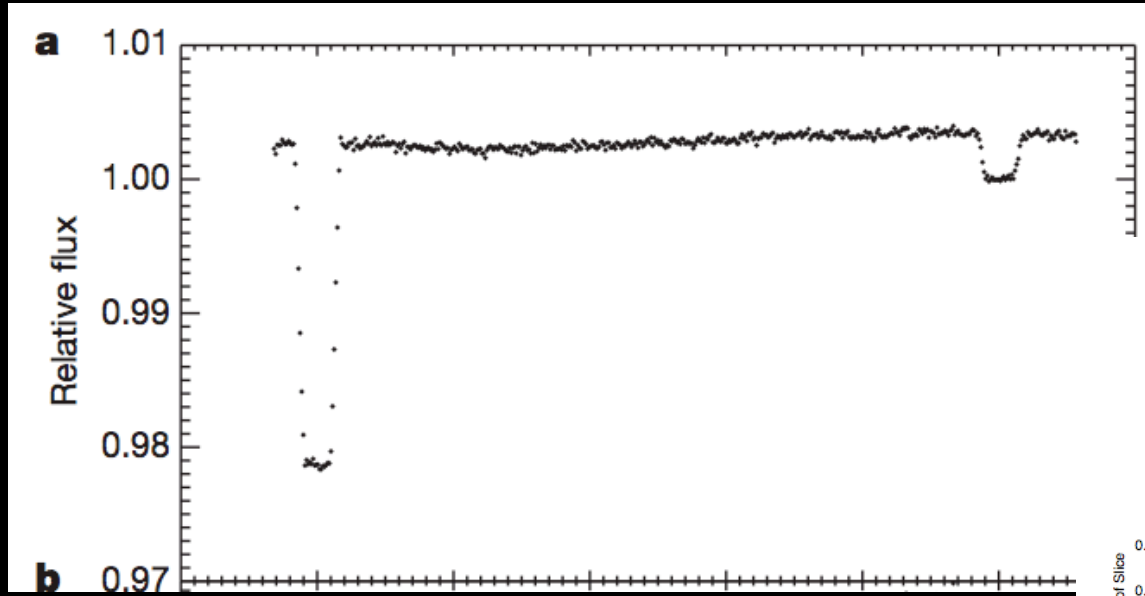
$V=7.7$  mag

$P = 2.2$  days

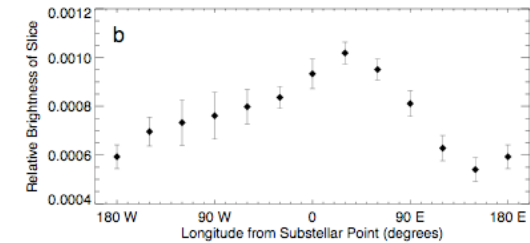
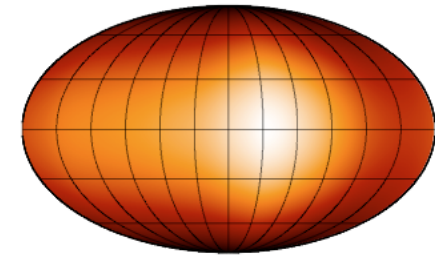
$R^*/R_{pl} = 0.15$



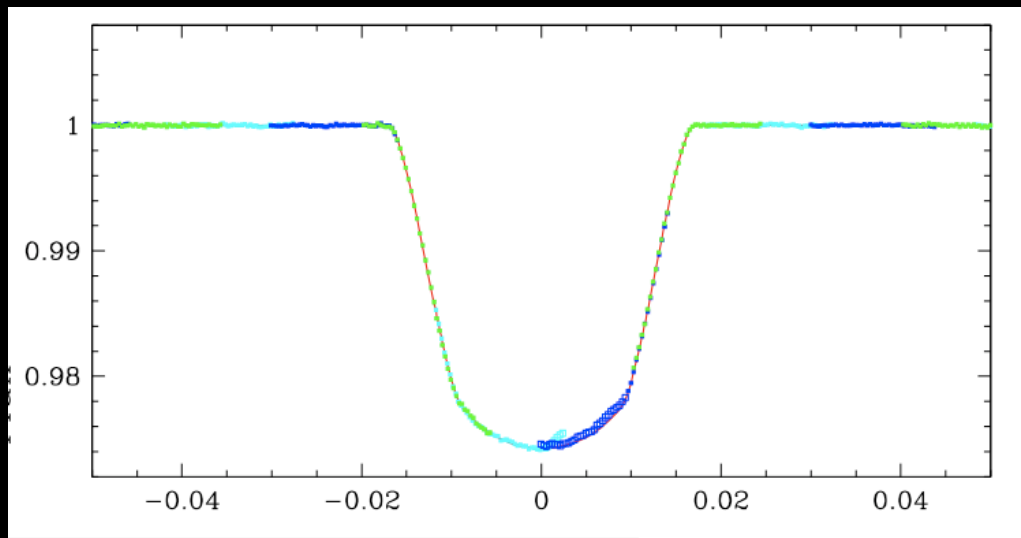
Bouchy et al. 2005



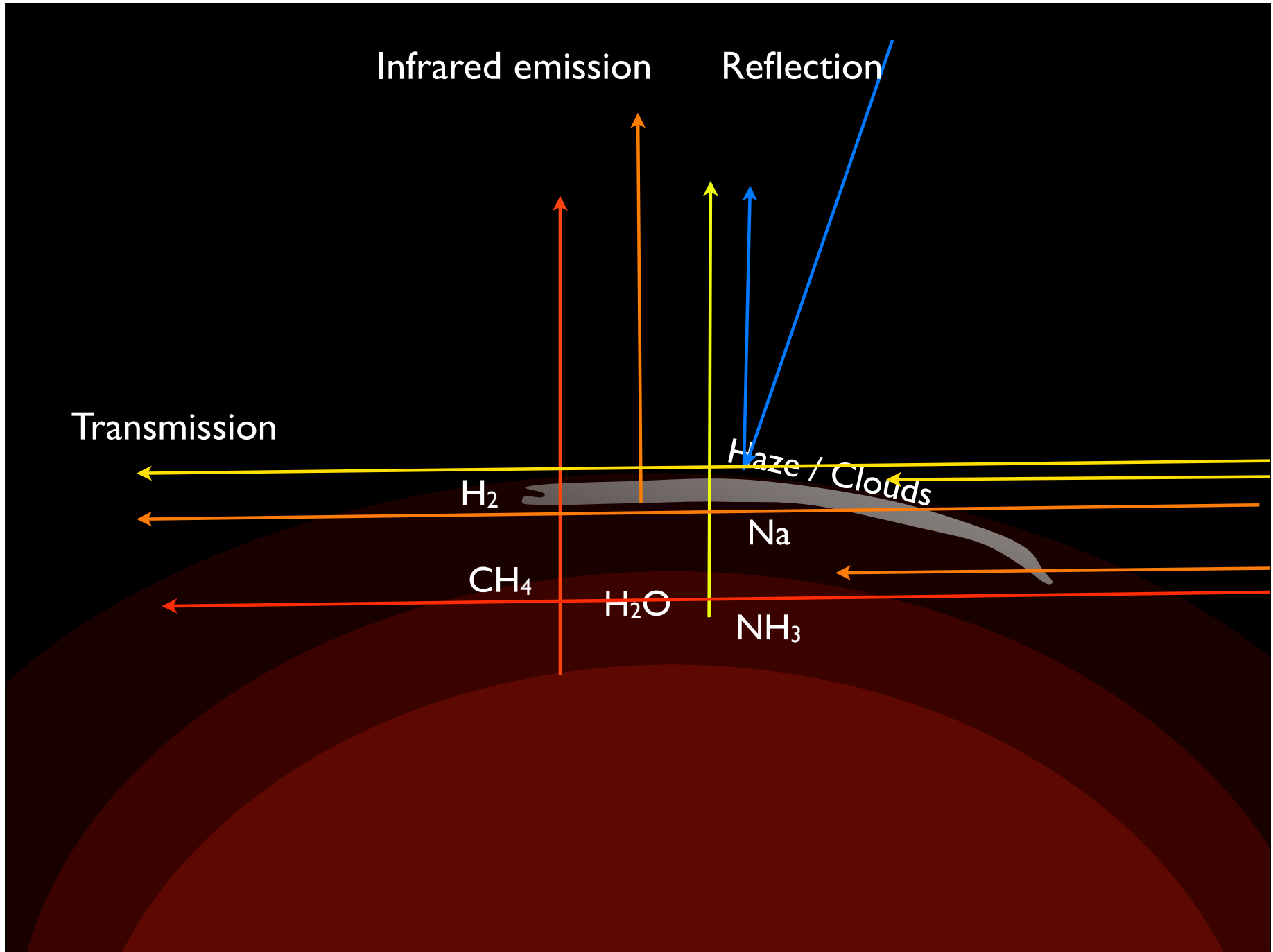
Spitzer 8 $\mu$  time series (Knutson et al. 2007)



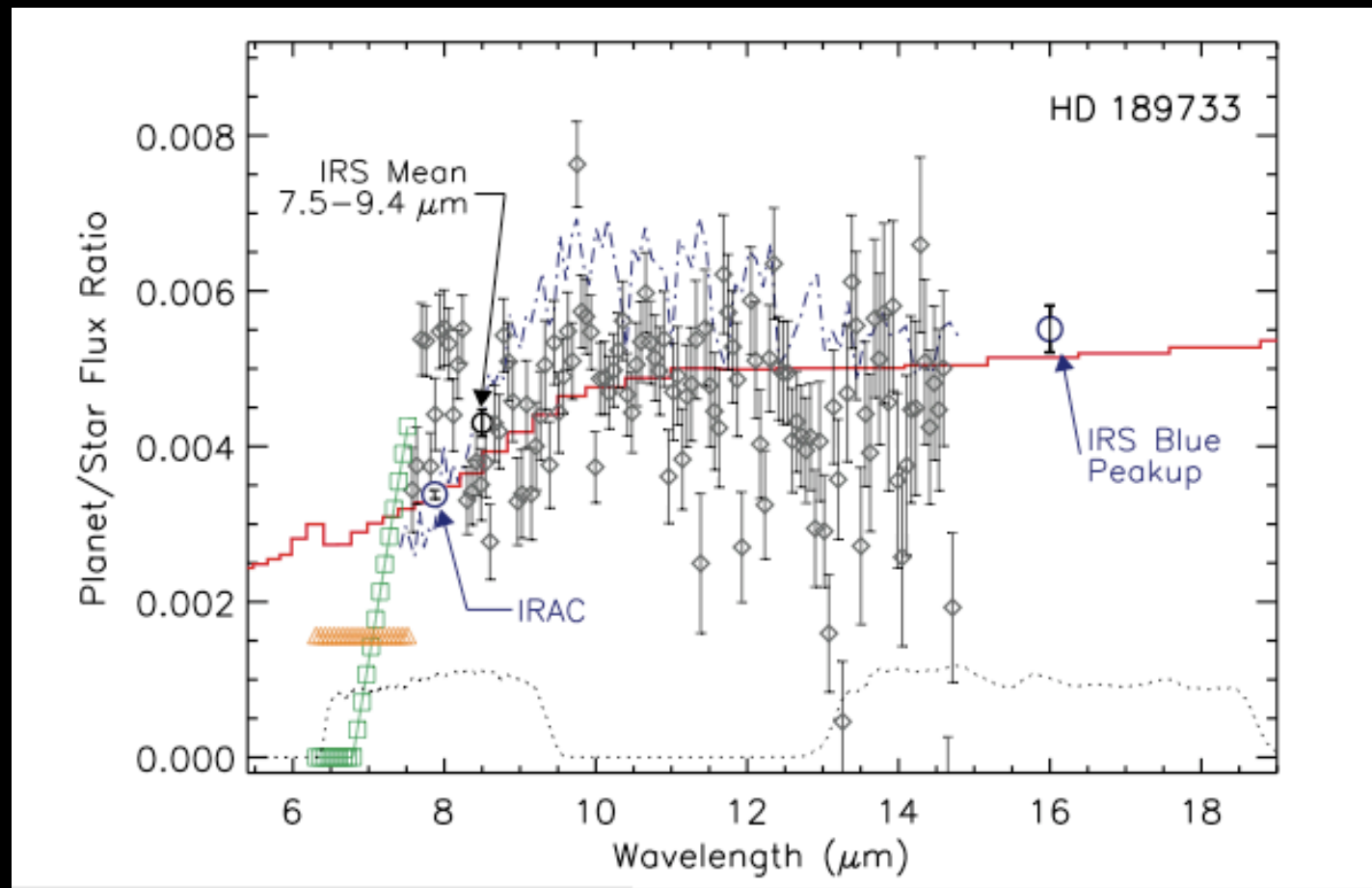
Surface temperature map for HD 189733 with Spitzer



HST/ACS grism time series (Pont et al. 2007)



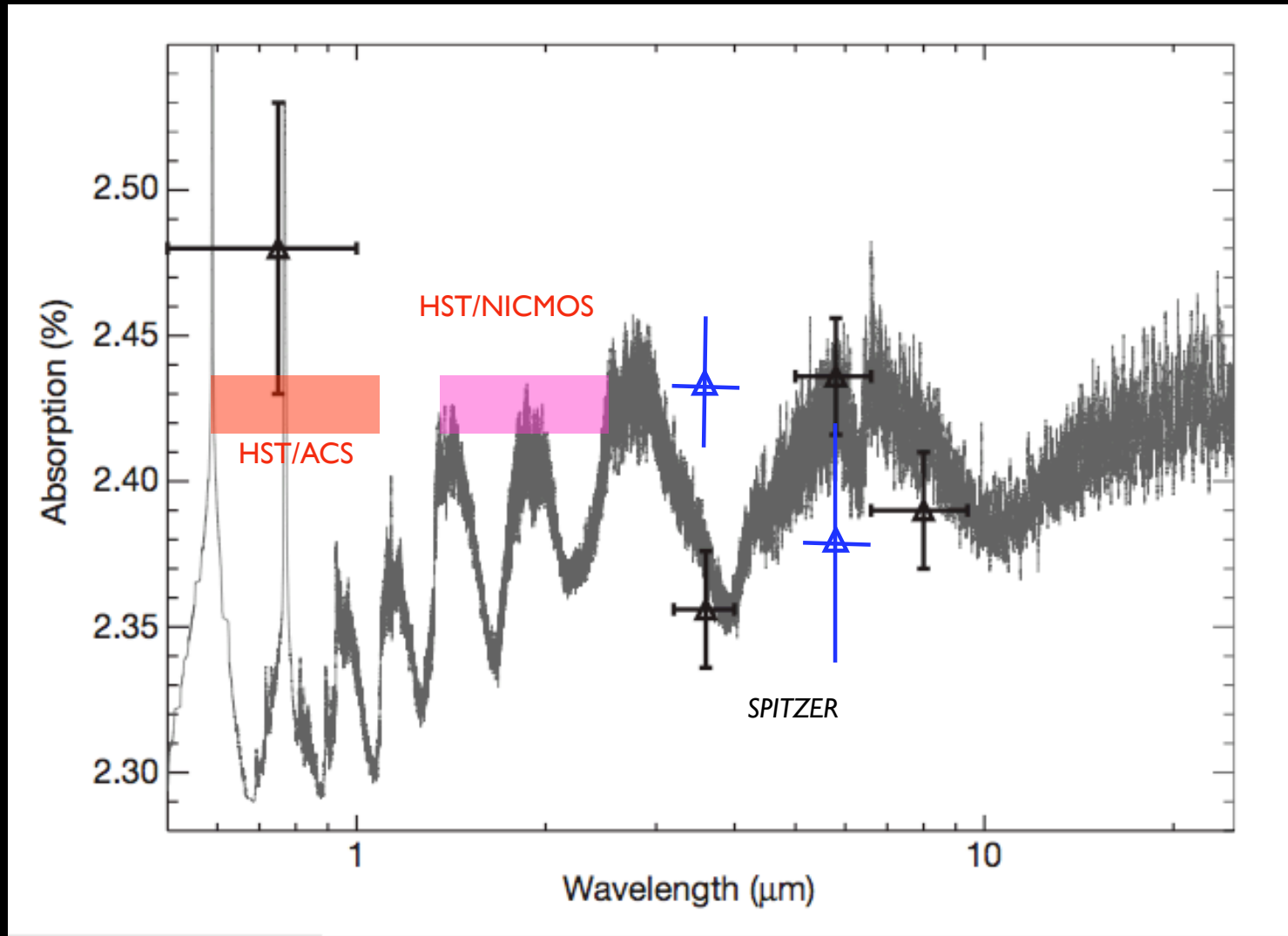
# Emission spectrum of HD 189733 during secondary eclipse



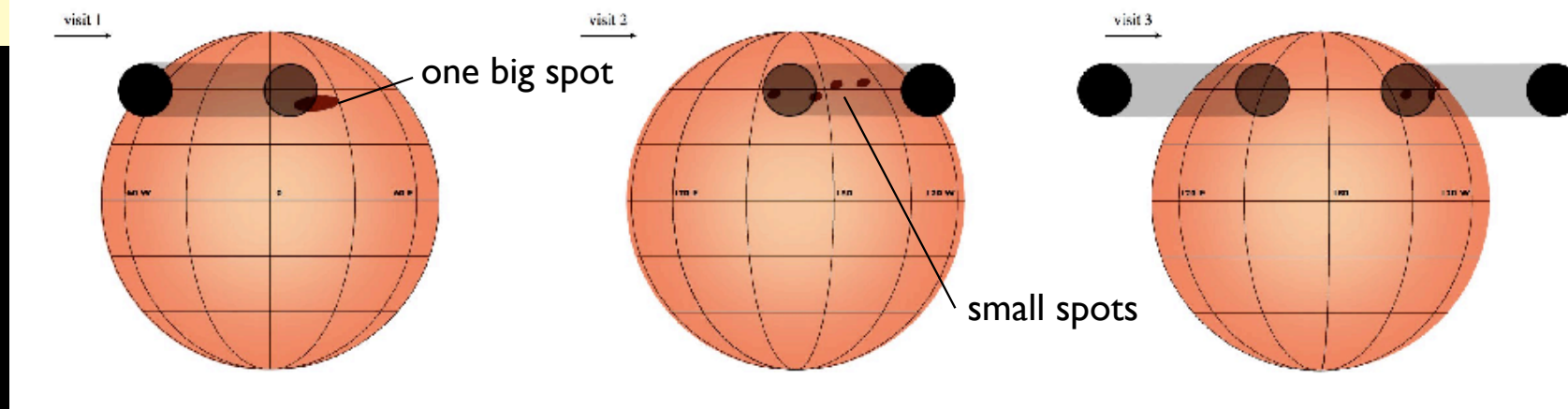
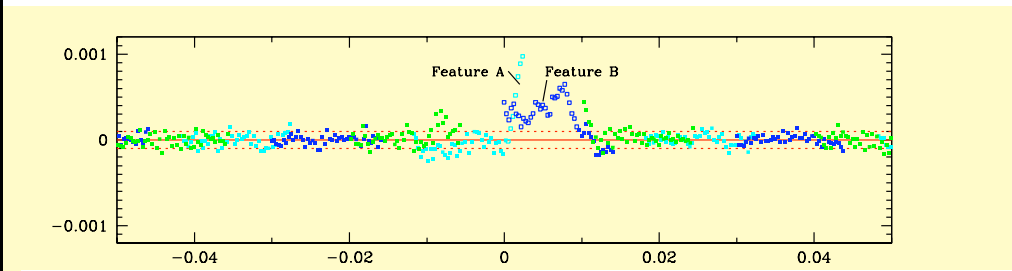
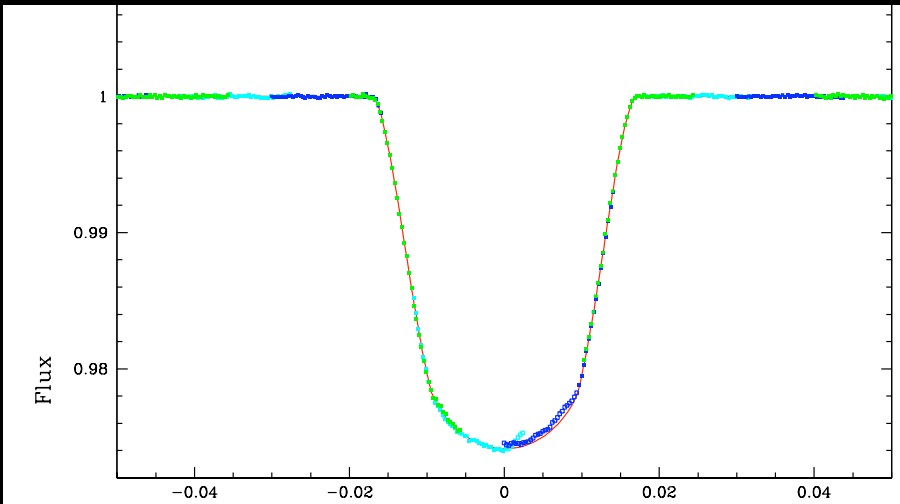
MOST reflection

Deming et al. 2006, Grillmair et al. 2007, Swain et al. 2007

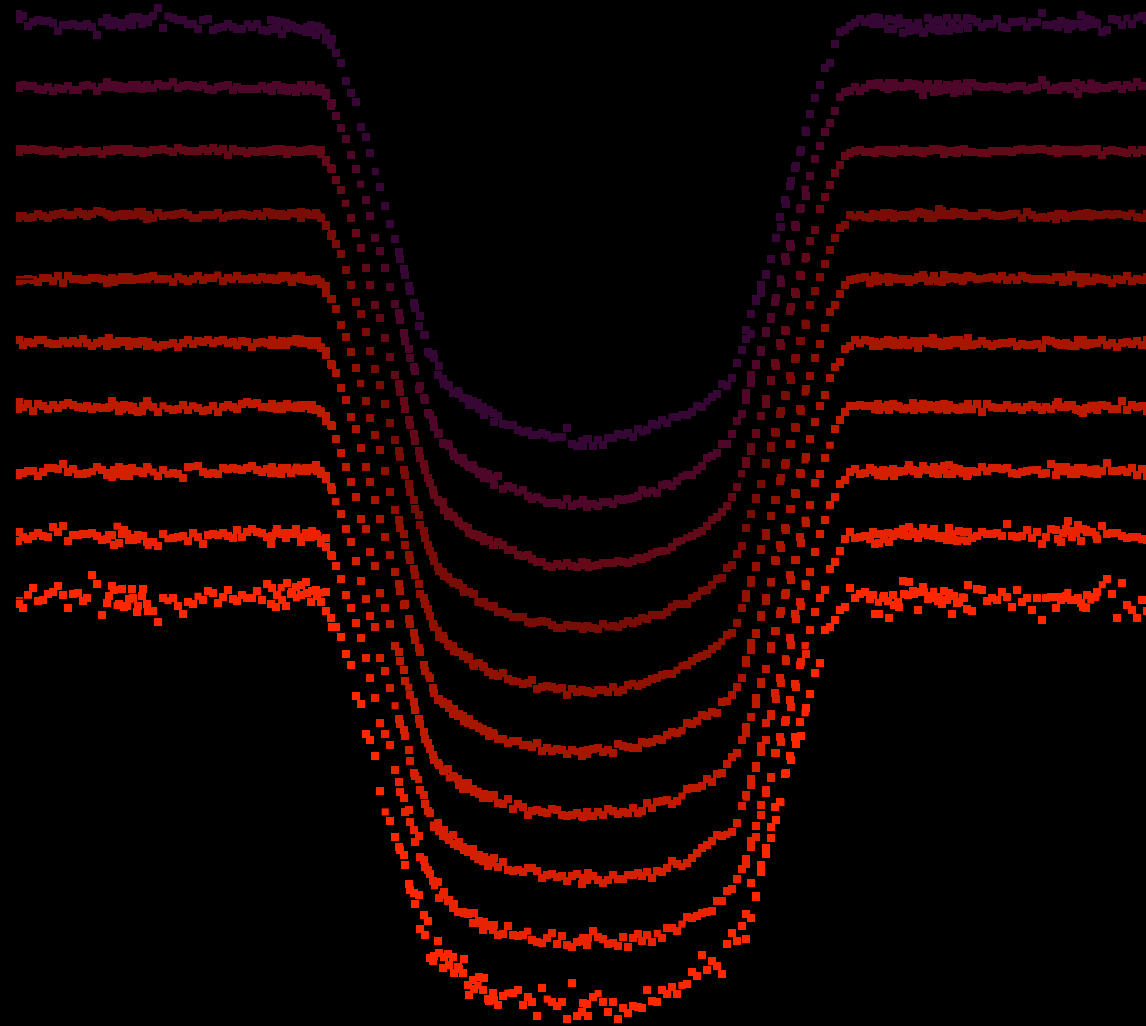
# Transmission spectrum of HD 189733 during transit



Tinetti et al. 2007, Winn et al. 2006 [Ehrenreich et al. 2007](#)

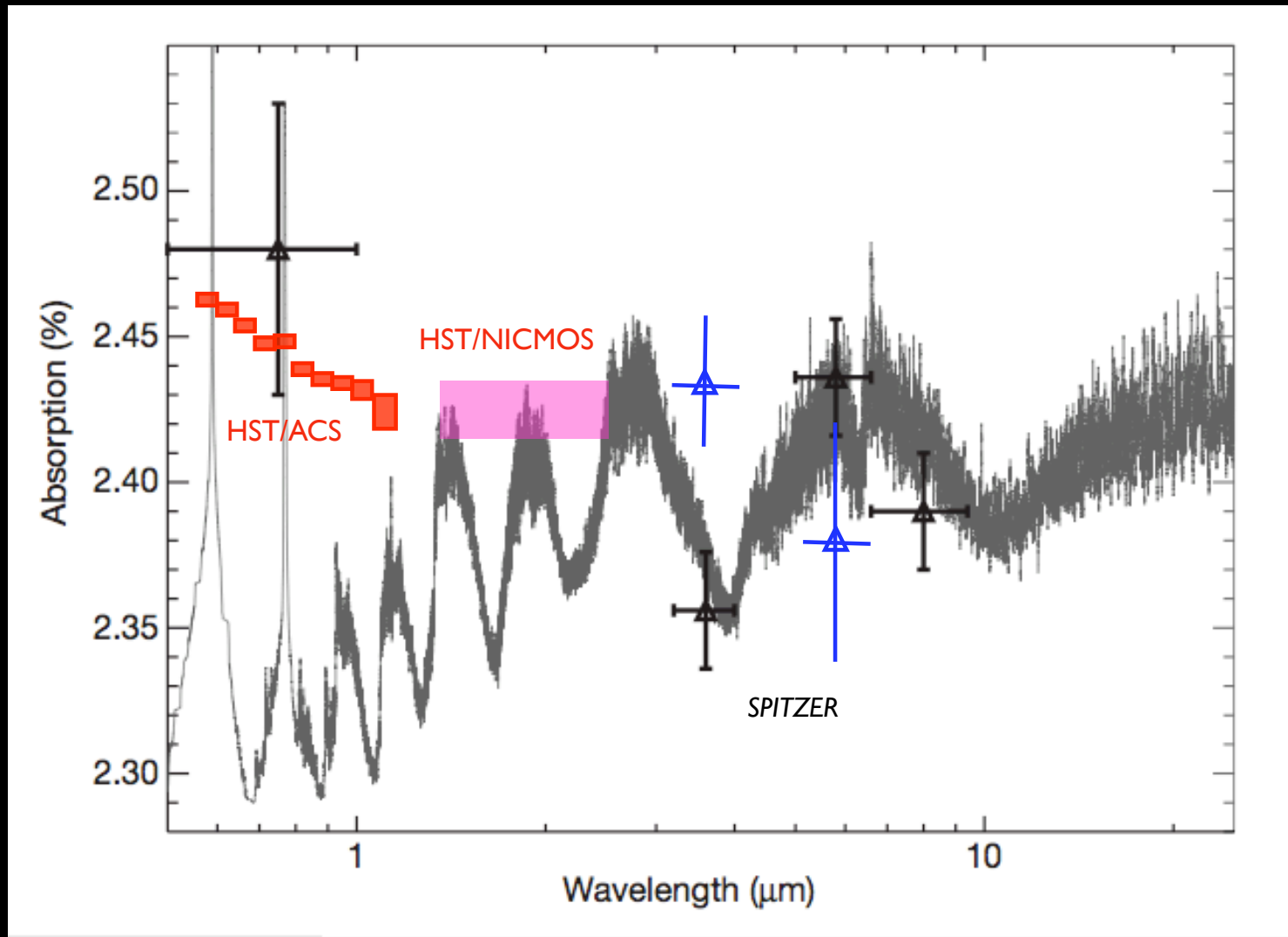


# Transmission spectrum of HD 189733 during transit





# Transmission spectrum of HD 189733 during transit



Tinetti et al. 2007, Winn et al. 2006 [Ehrenreich et al. 2007](#)

# HD209458b's atmosphere at twilight

*Molecular bands dominates mid-infrared absorption (??)*

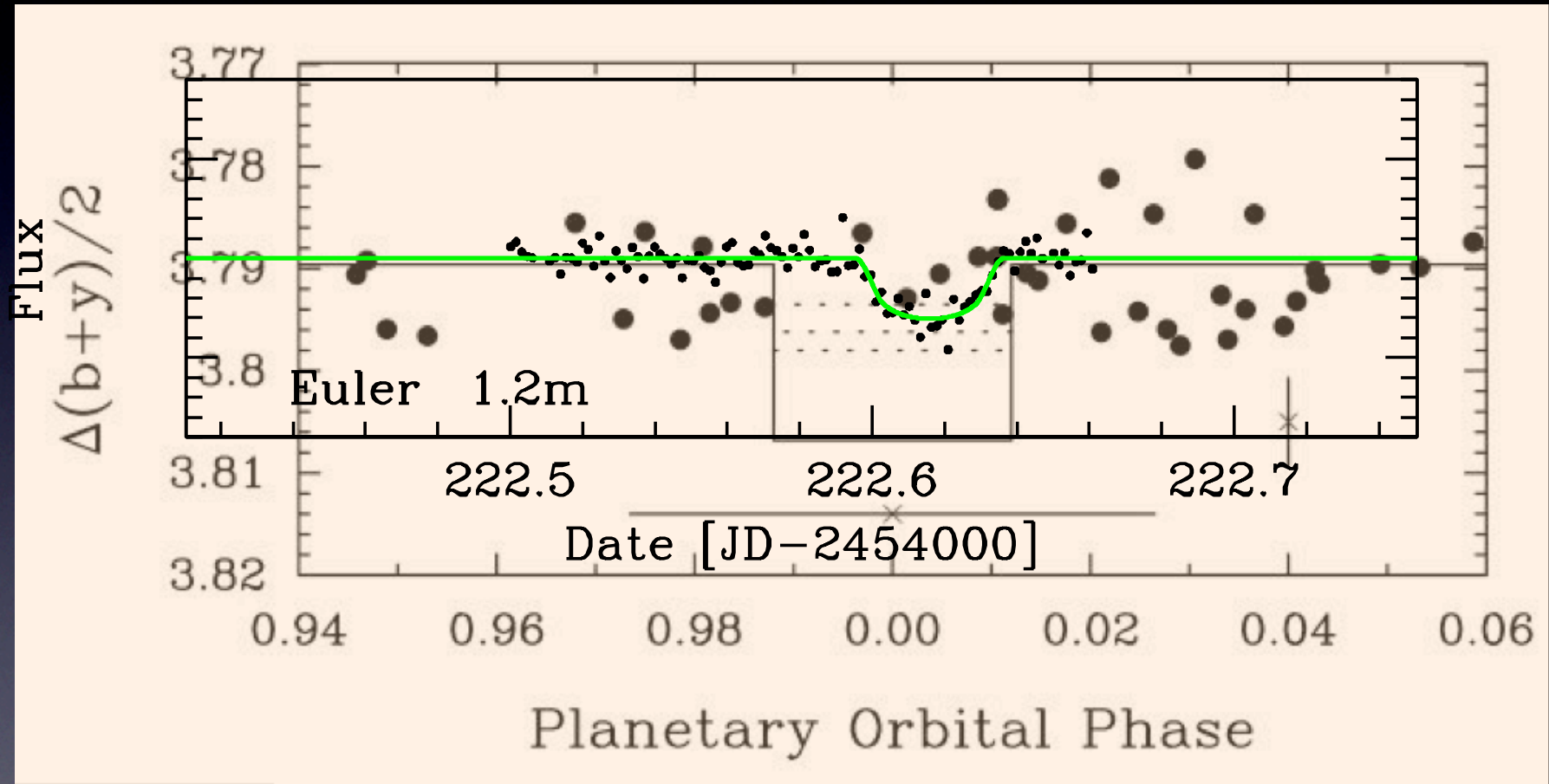
*Sub-Micron-sized particle haze intercept near-infrared and red*



# GJ 436b : the first transiting hot Neptune

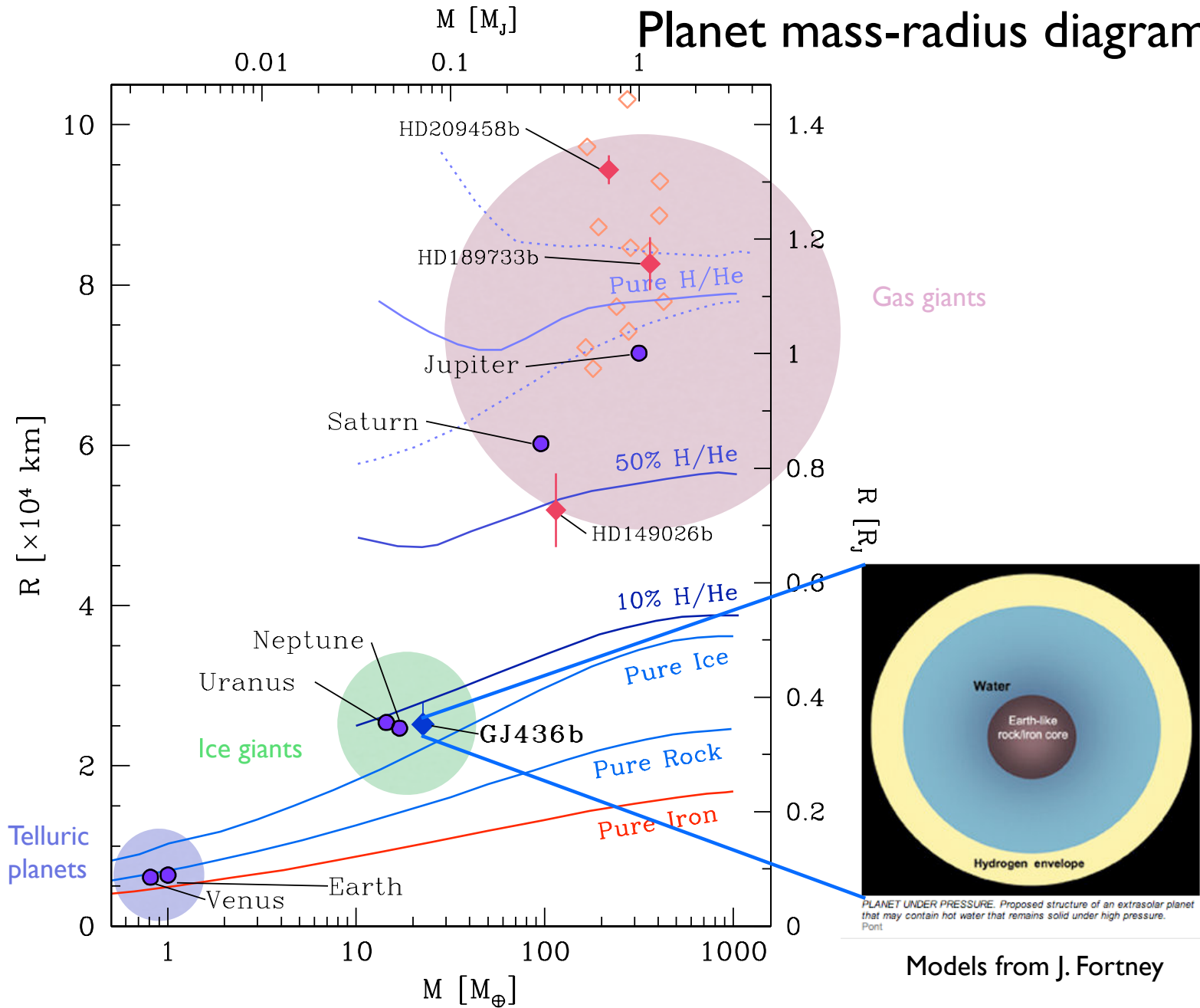


# Transits of the hot Neptune around GJ 436



Butler et al. (2004), Maness et al. (2007), Gillon et al. (2007)

# Planet mass-radius diagram



# Spitzer 8 $\mu$ observations of GJ436

*transit* :  
planet larger than an “Ocean Planet”

*eclipse*:  
8 $\mu$  temperature 710 K - 100K hotter than equilibrium T

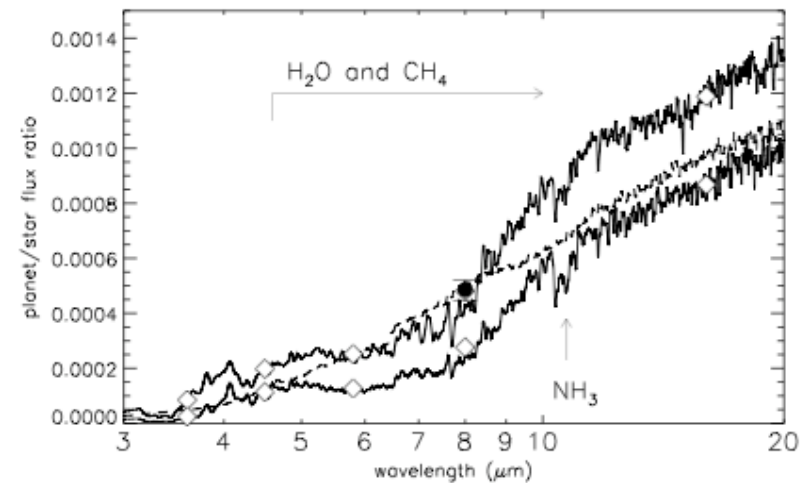
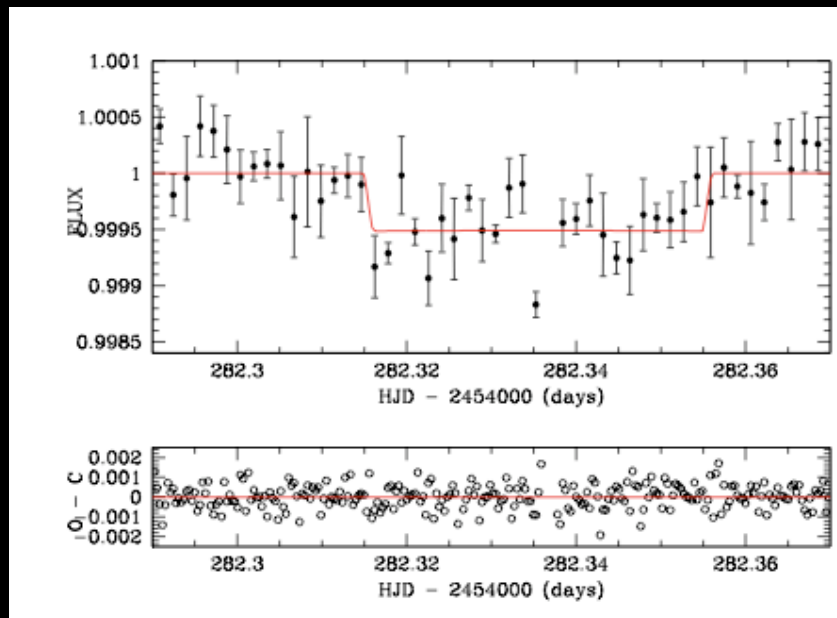
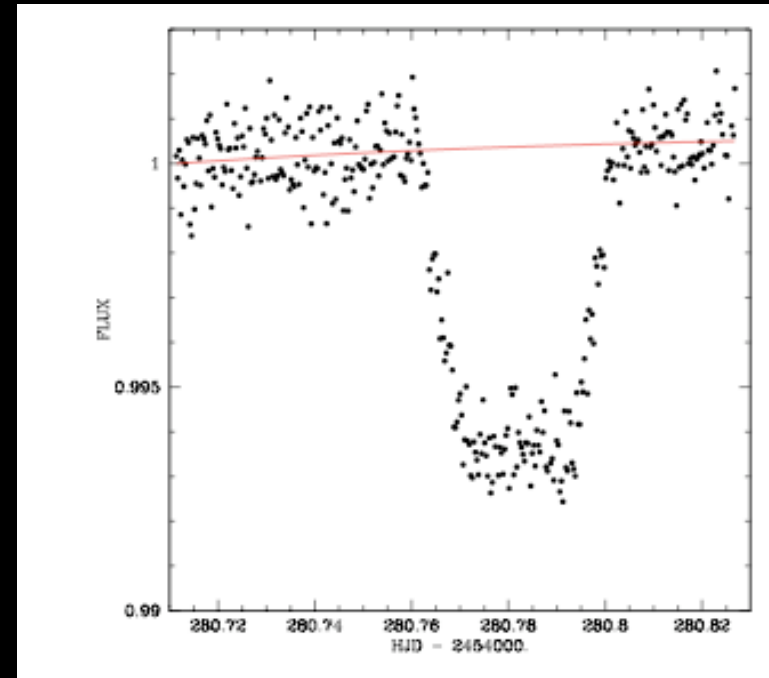
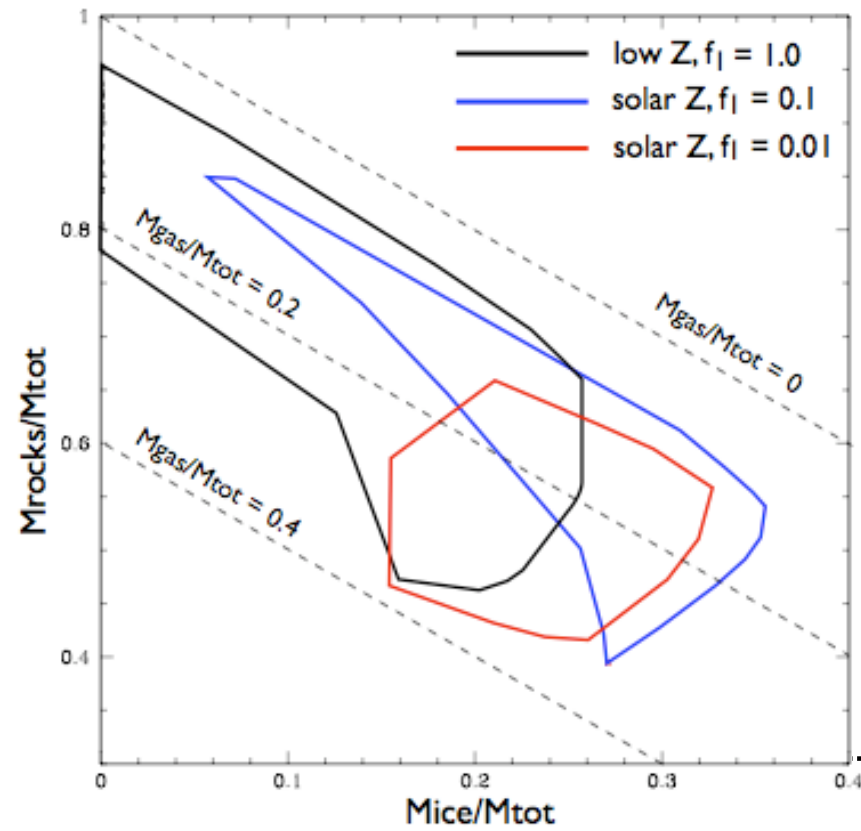


Fig. 2. Model planet-star flux ratios for GJ 436 b assuming that the absorbed stellar flux is redistributed across the planet. Gillon et al., Deming et al., Demory et al. 2007



Figueira, Pont, Mordasini, Georgy, Alibert, Benz

# Outlook

Ground-based surveys find 10+ transiting planets per year ( $10 < V < 12$ )

Corot is now reaching result stage ( $12 < V < 16$ )

Brighter transiting planets are of high value ( $V < 10$ )

With HST and Spitzer, complete IR emission and transmission spectrum of the atmosphere of HD 189733b, and maybe HD 209456b

Larger aperture and stability needed for smaller planets (JWST?)

Interpretation of coarse planetary atmosphere spectrum is a challenge  
(--> TPF/Darwin?)