Exoplanet Studies Using Warm Spitzer

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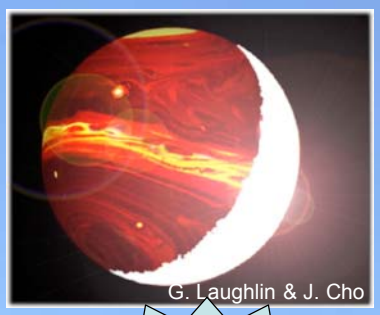
Summary of exoplanet science from Cyrogenic Spitzer



What Warm Spitzer can do (mostly transiting systems):

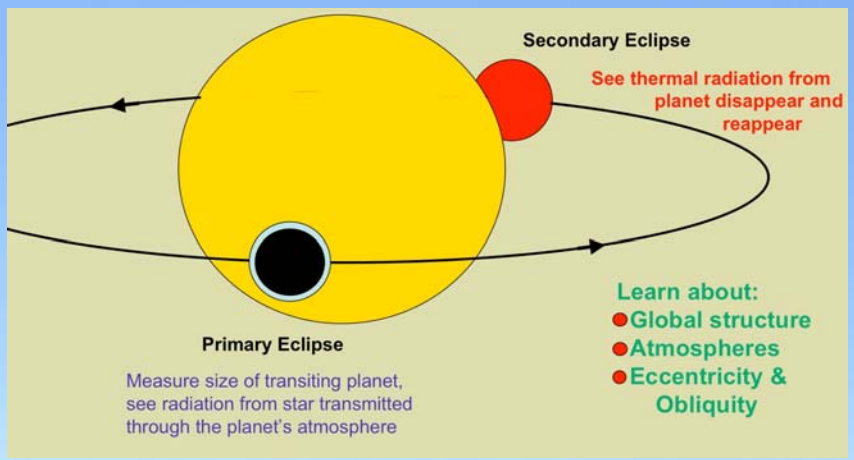
- thermal emission and composition (water, CO)
- precise radii from transits
  - improved radii for giant planets
  - radii for close-in super-Earths
- direct transit searches for "hot Earths"
- transit timing to detect low mass non-transiting planets
- significant complement to Kepler

stable, precise photometry

Why study transits?

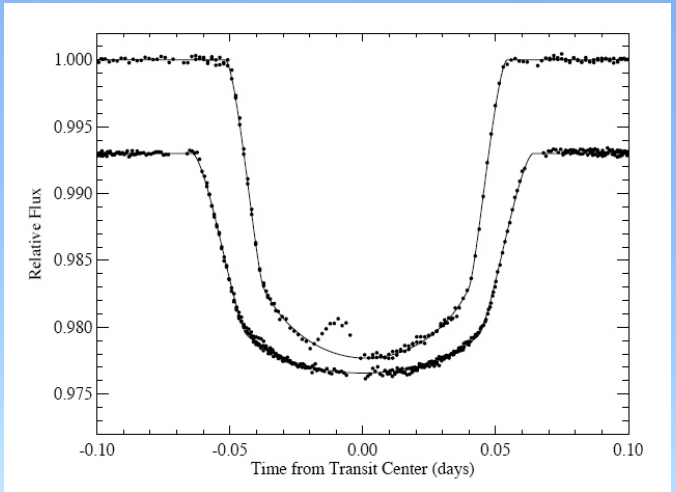
- bulk and atmospheric composition

- clues to formation of solar systems



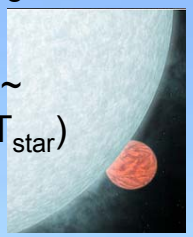
Courtesy Lori Allen

Examples of giant planet transits in the visible (HST)



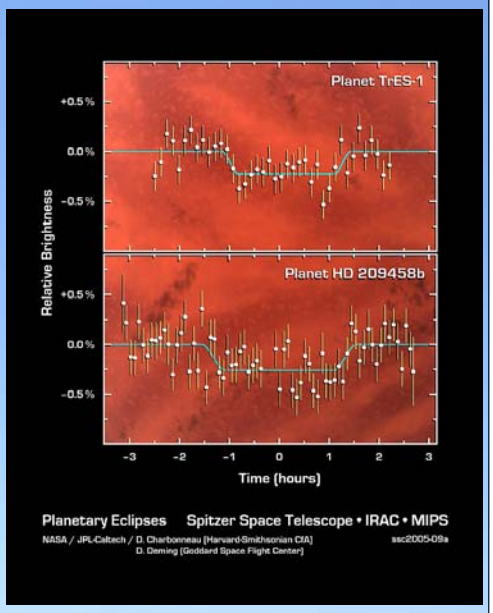
Secondary Eclipse Thermal Emission

Spitzer enables direct detection of IR light from the planets



eclipse depth ~ $(R_p/R_{star})^2(T_p/T_{star})$

yields T ~ 1100K



eclipse depth ~ $(R_p/R_{star})^2(T_p/T_{star})$

Dominant term

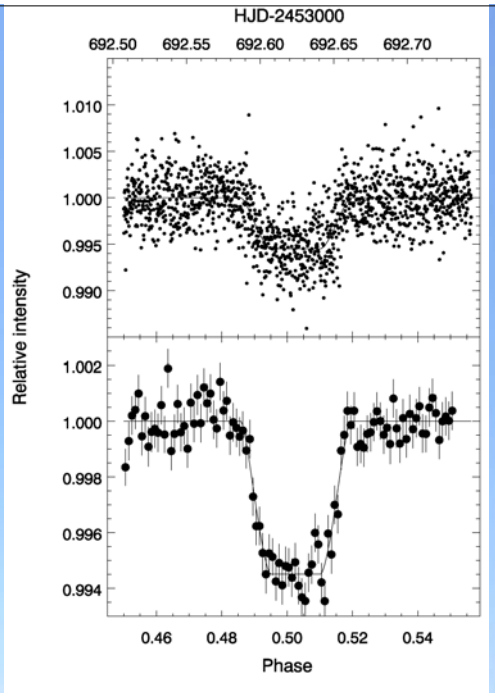
$T_p \sim T_{star}\ \Delta^{0.5}$

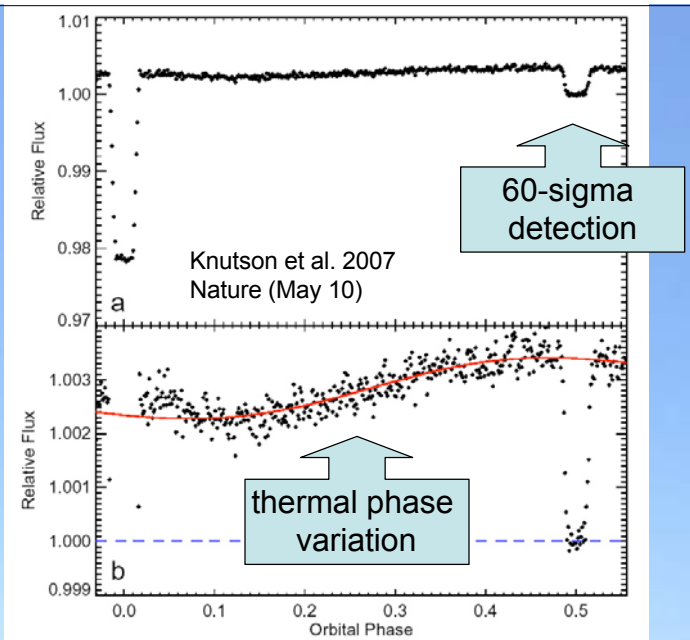
lower main-sequence stars give higher S/N planet detection

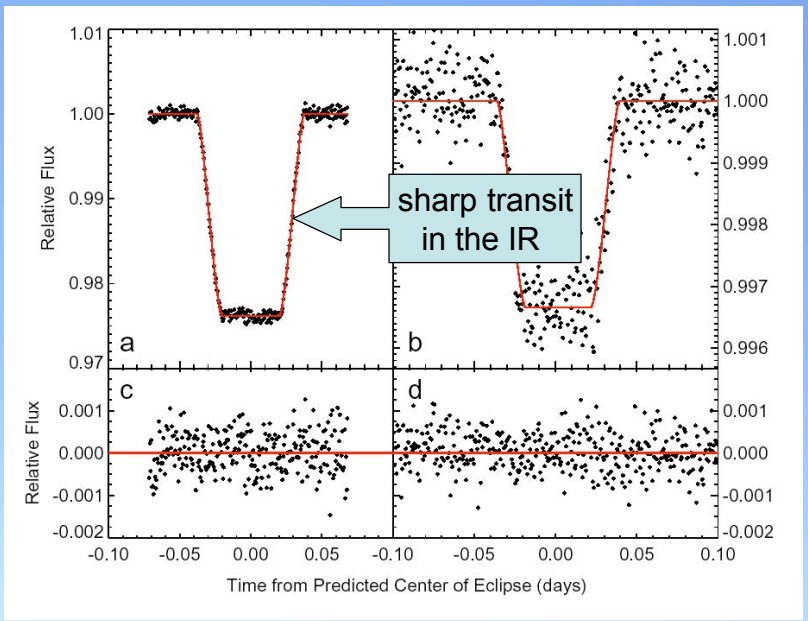
HD 189733b (K3V)

32σ detection at 16 μm

Deming et al. 2006 ApJ 644, 560

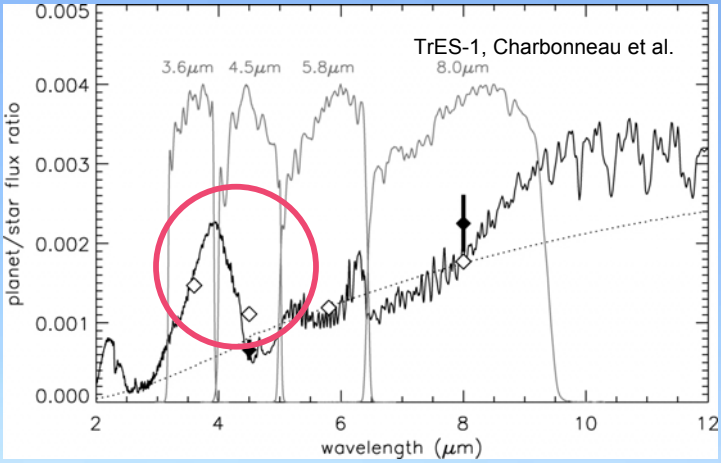






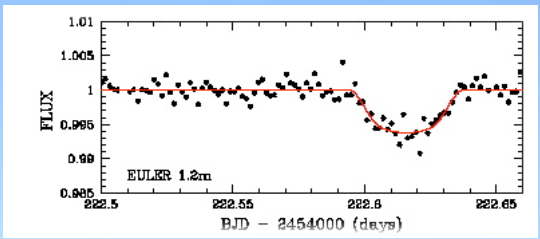
Knutson et al. 2007 Nature (May 10)

3.6 & 4.5 μm secondary eclipses using Warm Spitzer
Can in principle measure water & CO absorption,
if ground observers can measure thermal continuum



How many transiting systems by 2009?

- **Currently there are 13 with V < 13**
- **Expect ~ 20 by early 2008**
- **A transiting "hot Neptune" recently announced**
- **Discovery rate is accelerating**



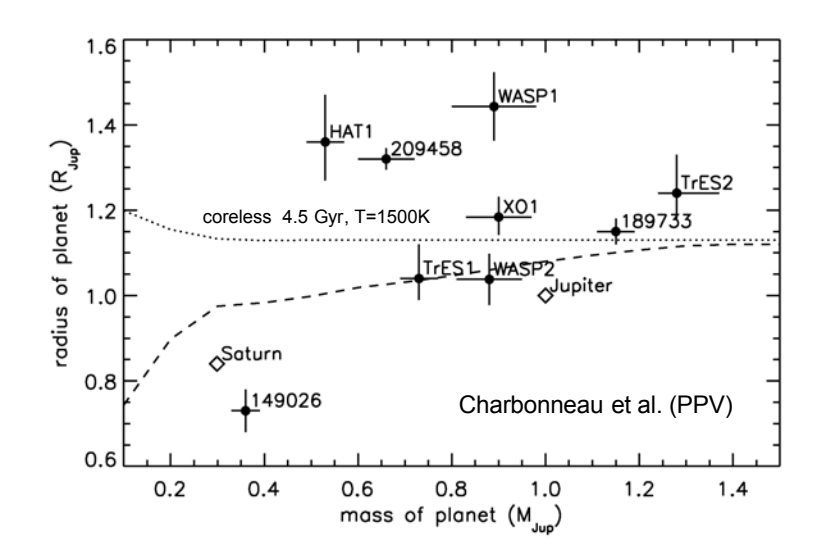
transit of GJ 436b
Gillon et al.

Arguably by 2009:

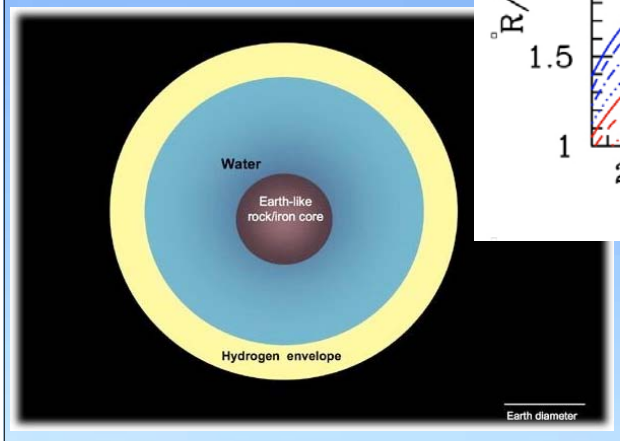
–100 transiting hot Jupiters

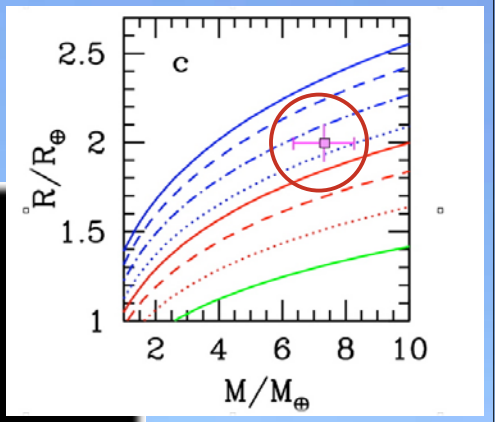
–10 hot Neptunes

Transit radius precision depends on precise photometry - Spitzer provides both precise photometry, and absence of stellar limb darkening



Warm Spitzer can measure radii of super-Earths, e.g., "Ocean Planets"

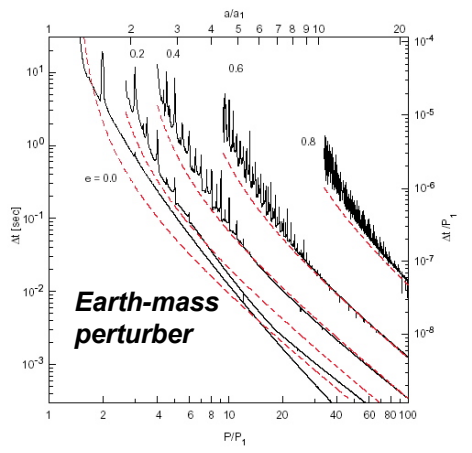




GJ876d

Warm Spitzer will be sensitive to close-in super-Earths in systems already known to contain a hot Jupiter:

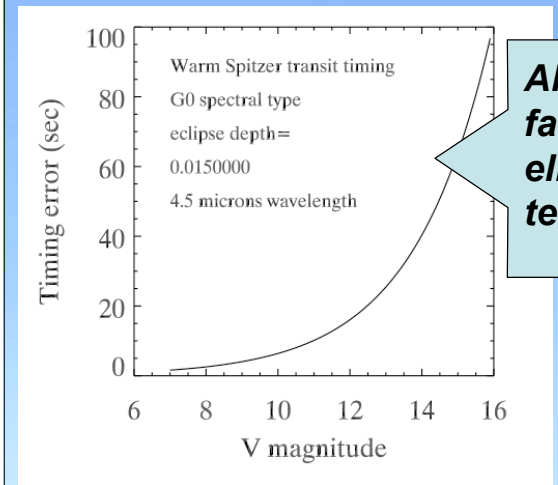
- **via direct transit searches**
- **via transit timing perturbations**



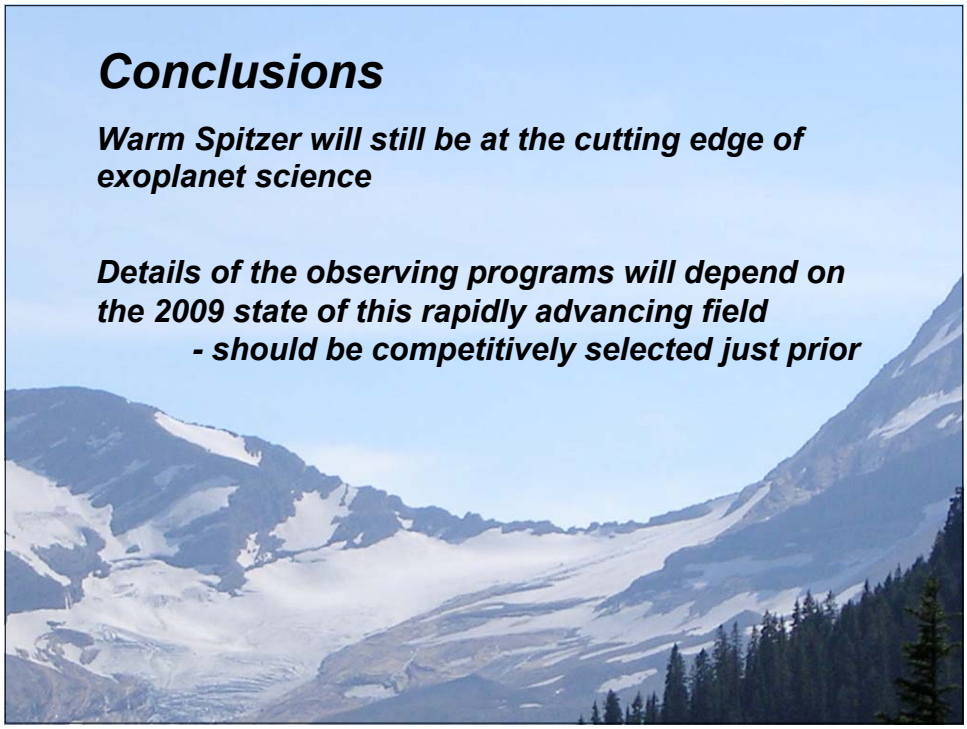
both techniques benefit from resonances

Holman & Murray 2005
Science 307, 1288

Warm Spitzer complements Kepler - transit timing



Also, false-positive elimination for terrestrial transits


Conclusions
Warm Spitzer will still be at the cutting edge of exoplanet science
Details of the observing programs will depend on the 2009 state of this rapidly advancing field
- should be competitively selected just prior