Finding Other Worlds with

SUPERWASP & LCOGT.net

Rachel Street & Tim Lister

- *The Story so far...*
- *Cosmic alignments*
- *Scanning the sky: SuperWASP*
- *Sorting the wheat from the chaff*
- *New Discoveries*

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The Story So Far...

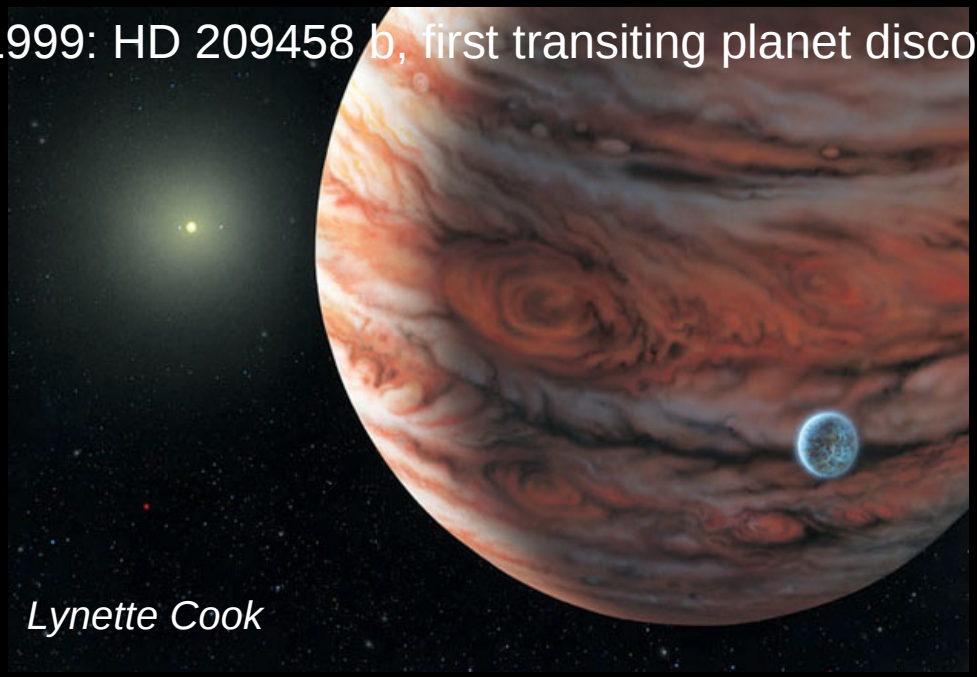
1992: Surprise no. 1: First planets discovered around another star...a pulsar [1]

1995: Surprise no. 2: 51 Peg b, first planet orbiting a Solar-type star [Hot Jupiter]

Migration theory, revisited

1998: First two multi-planet systems found

1999: HD 209458 b, first transiting planet discovered [2,3]



2001: > 50 known exoplanets

2003: > 100 known exoplanets

2007: > 200 known exoplanets

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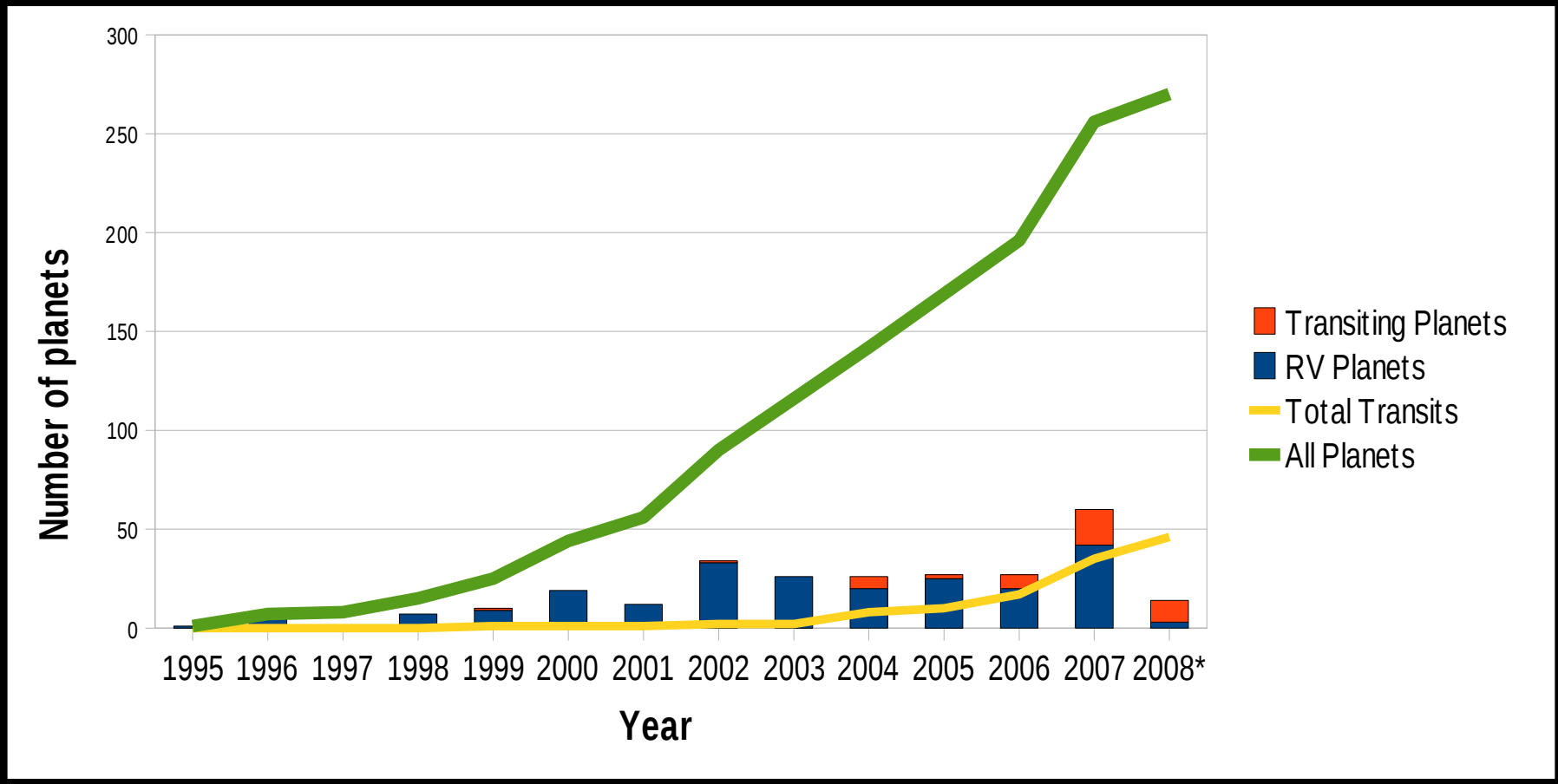
[1] Wolszczan & Frail, 1992, Nat, 355, 145.
[2] Charbonneau, D. et al. 2000, ApJ, 529, 1115.
[3] Henry, G. et al. 2000, ApJ, 529, L41.

Planet discoveries



2000: WASP0 prototype
> much work <
2004: SuperWASP-N operational
2006: SuperWASP-S operational

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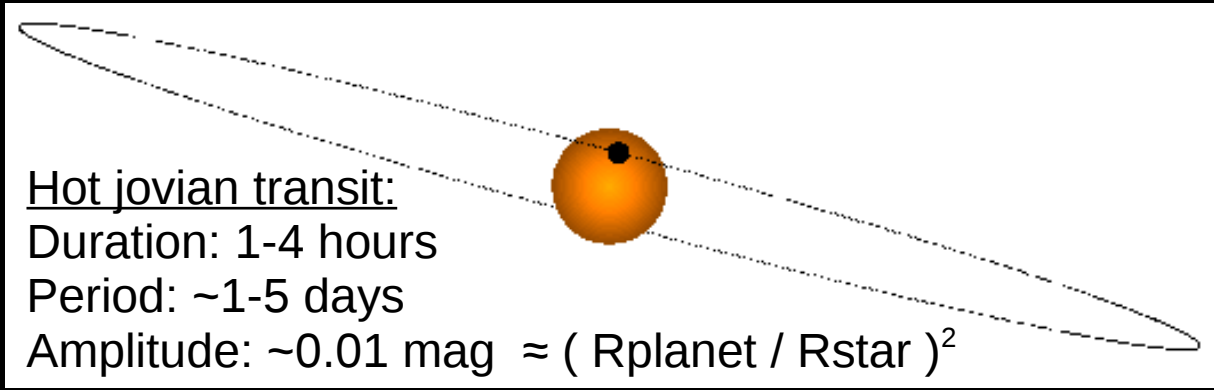
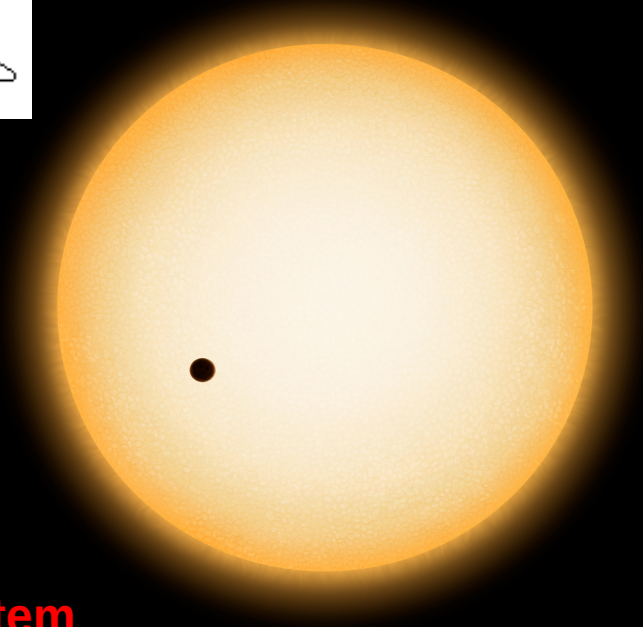
Cosmic Alignments



Hot jovian transit:
Duration: 1-4 hours
Period: ~1-5 days
Amplitude: ~0.01 mag ≈ (Rplanet / Rstar)^2

→ Selection effects favour:
Large planets
Small stars
Short period



~10% of hot Jupiter class planets should transit

RV: ~1% of solar neighborhood stars harbor hot Jupiters
~50% of stars are dwarfs

Need to monitor very large numbers of stars!

Transit data + RV = complete characterization of system

Wide range of further study possible

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Scanning the skies:

SUPERWASP

Queen's University Belfast · University of St. Andrews · KEELE UNIVERSITY · The Open University · University of Leicester · SAAO

- Robotic, dedicated ultra-wide field photometric survey

- 8 cameras per station
→ 486.72 sq deg. total field of view
→ ~ 200,000 – 1,000,000 stars measured every exposure

- Two stations: La Palma (from 2004)
South Africa (from 2006)

- Observe planets fields every 8mins
All sky survey fields at least every day

- ~58 GB raw image data / station / night

- Photometric database inc. 24 million unique objects
>113 billion datapoints

- Automated data reduction and transit search

www.superwasp.org
Pollacco, D. et al. (2006), Ap&SS, 304, p.253.

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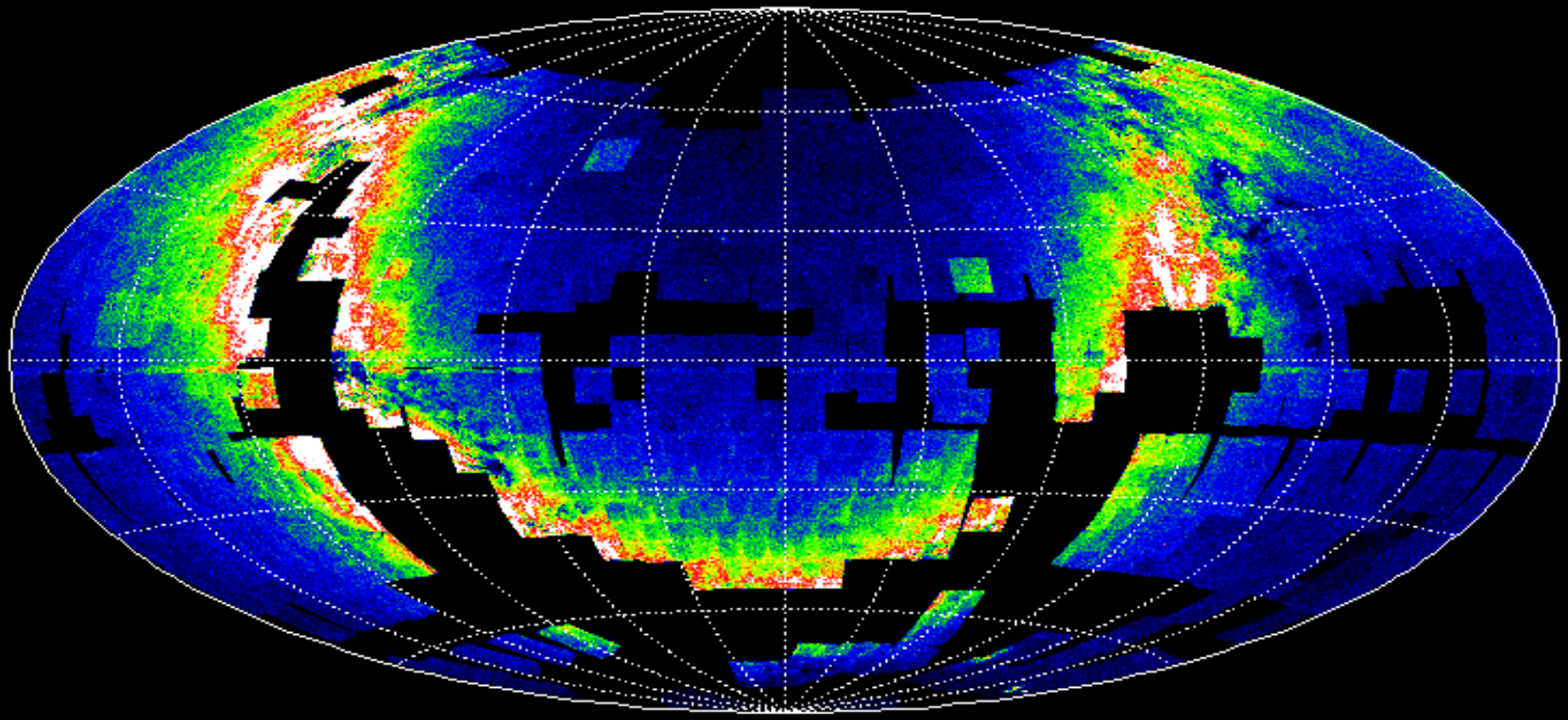
Co-ordinated Global Follow-Up Program

- Currently 363 'A' transit candidates widely distributed in RA & Dec
- Unavoidably high fraction of false positives

→ Need large-scale, efficient and flexible follow-up to pre-select candidates



SuperWASP sky coverage

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Co-ordinated Global Follow-Up Program

- LCOGT is a major contributor to the 2007-2008 follow-up campaign

Photometry		Spectroscopy	
48 hrs	IAC 80cm (Tenerife)	64 hrs	NOT/FIES (La Palma)
60 hrs	Liverpool Telescope (La Palma)	16 hrs	TNG/SARG (La Palma)
175 hrs	24-inch (Keele,UK)	56 hrs	INT/IDS (La Palma)
~60 hrs	1m JGT (St. Andrews)	40 hrs	OHP-1.93m/*Sophie* (France)
>150 hrs	Swiss 1.2m/*EulerCam*	80-120 hrs	Swiss 1.2m/*Coralie* (ESO, La Silla)

>520 hrs **Tenagra 0.81m (Arizona)**
23 hrs **FTN (Hawai'i)**
41 hrs **FTS (Siding Spring)**

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The Scoreboard To Date...

Tenagra

59 targets observed to date
- 11 rejected (identified EB neighbor blended in SW data)
- 7 no transit seen (probable ephemeris drift)
- 14 need more data, no conclusions yet (e.g. poor data)
- 5 low-mass eclipsing binaries
- 3 triple star systems
- 2 targets with data to be reduced

11 promising candidates need more data
All 5 new northern-hemisphere confirmed planets
1 new southern-hemisphere confirmed planet

FTN	11 targets observed	inc. 2 confirmed planets
FTS	12 targets observed	inc. 3 confirmed planets

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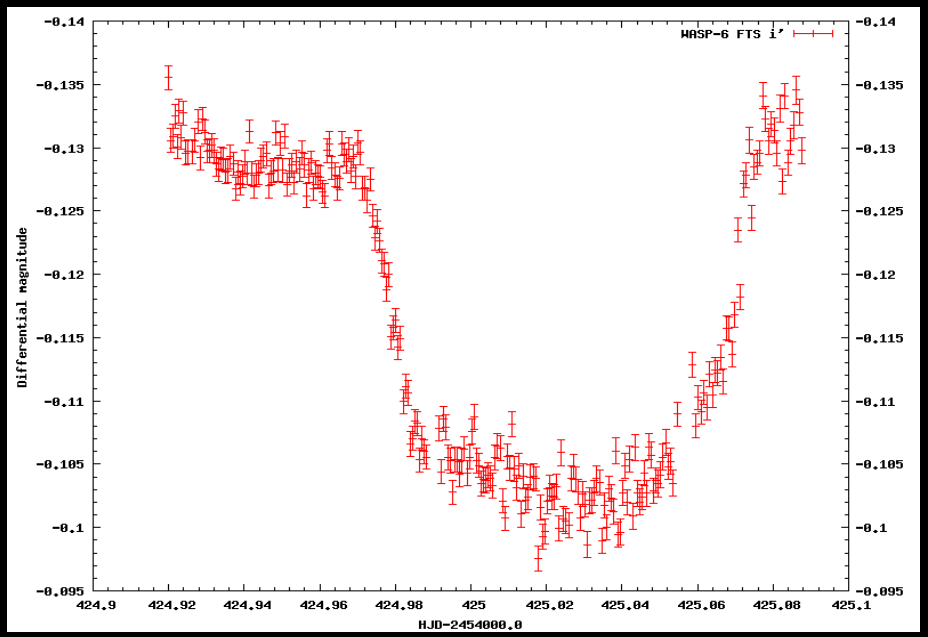
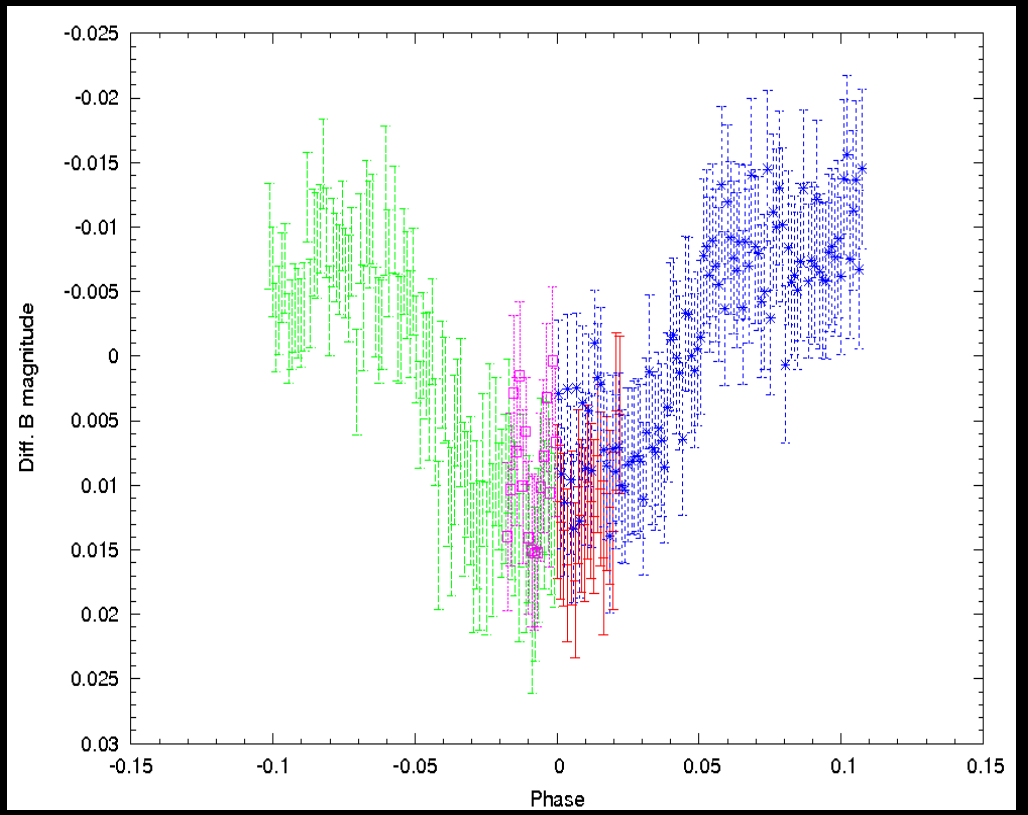
Data on Top Candidates



FTS SDSS-i band data, WASP 6
2007 Nov 20



Tenagra B band data, WASP-12
2008 Mar 27/28

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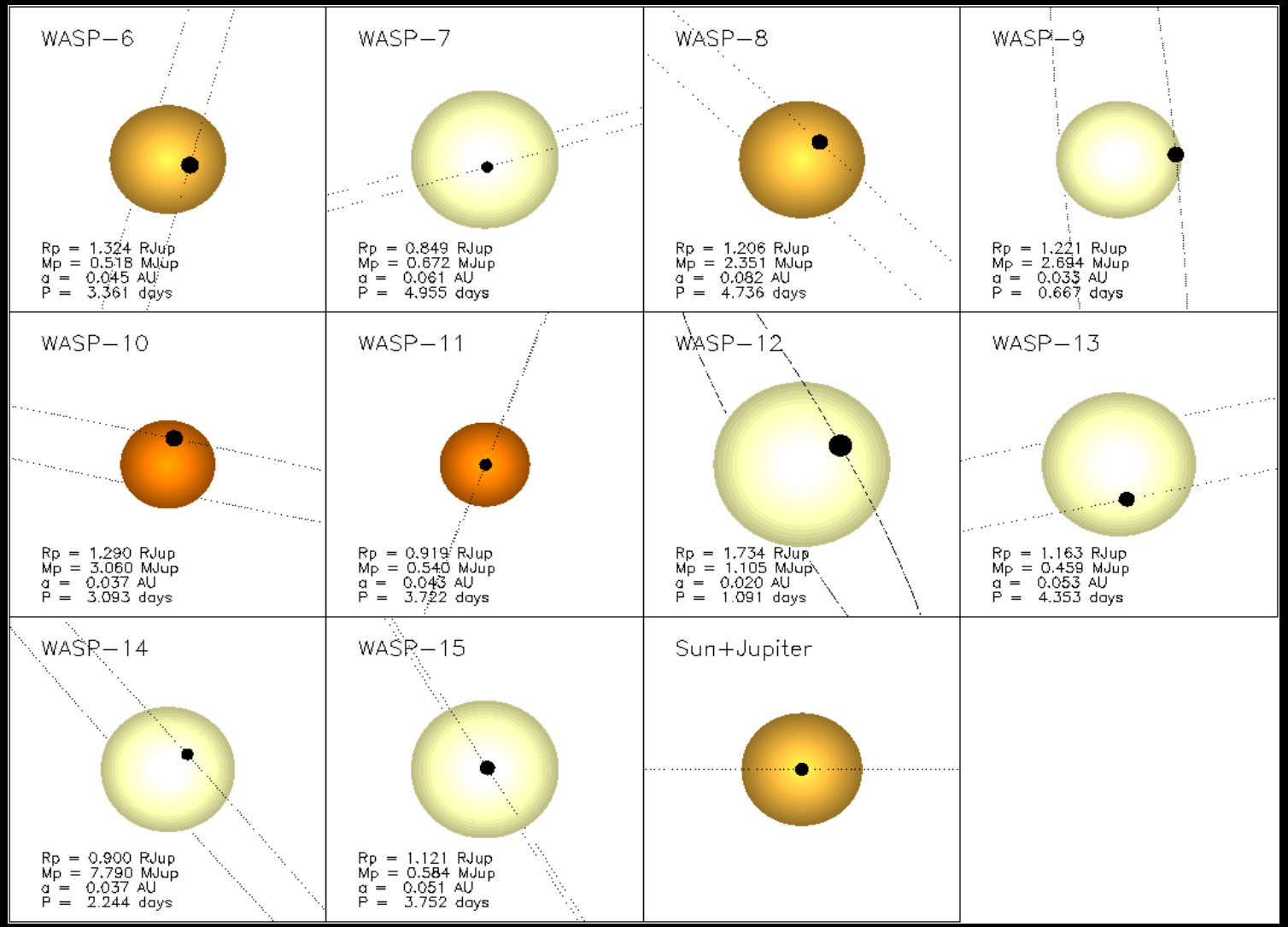
The new WASP Planets



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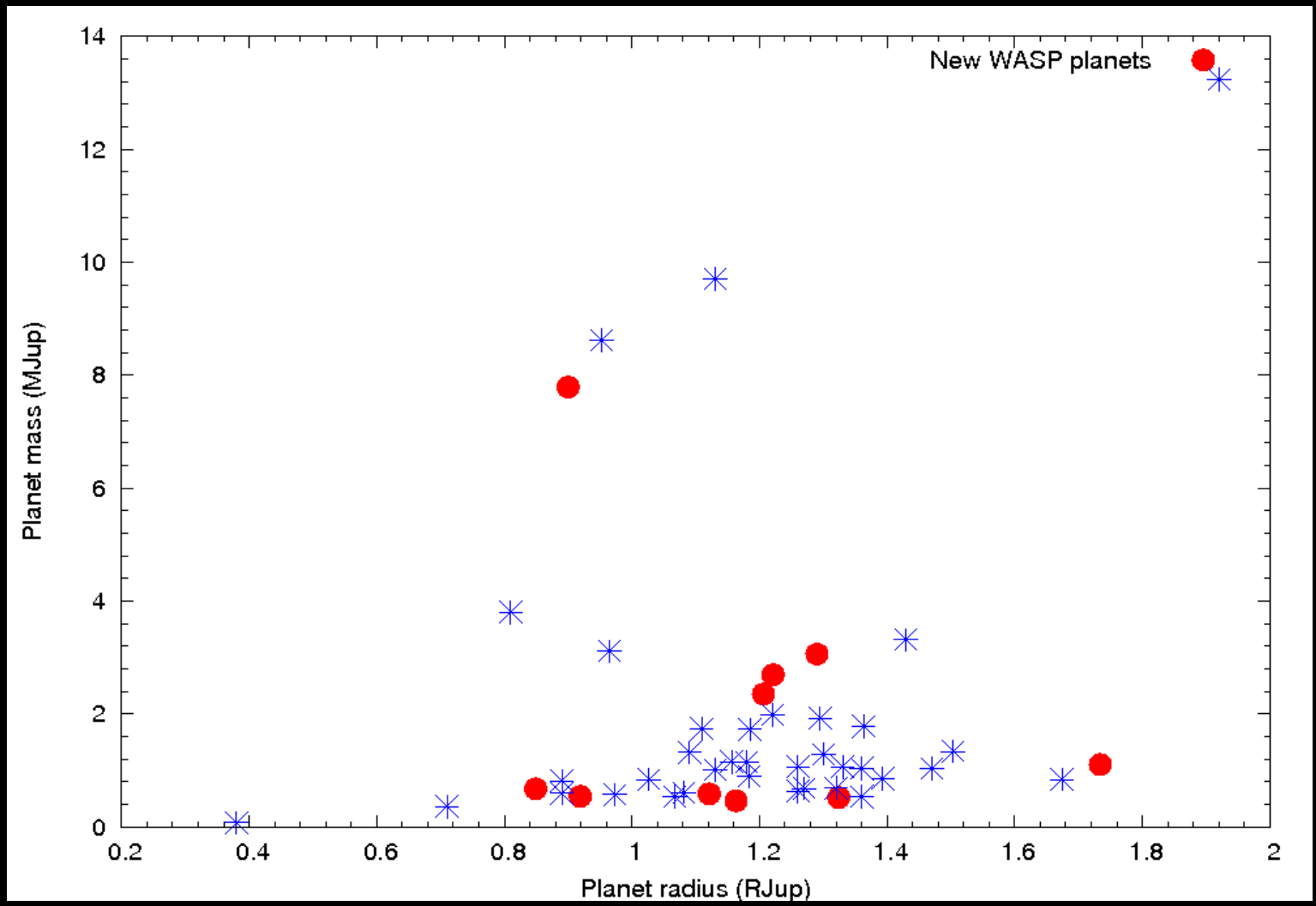
In Context



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Data from exoplanets.eu & WASP

In Context

"Bloated" planets

Planet	Mass/*MJ*	Radius/*RJ*	Period/*d*
TrES-4b	0.84	1.674	3.554
WASP-12b	1.105	1.735	1.091
HD 209458b	0.69	1.32	3.525

- *Burrows et al 2007:*
  Increased planetary atmospheric opacities, retain internal heat

- *Baraffe et al 2003:*
  Irradiation alone cannot explain large radii → extra heat source?

- *Mandushev et al. 2007 (TrES-4b):*
  → Larger than predicted radius for its orbital separation & age

Burrows et al. 2007 ApJ 661, 502
Burrows et al. 2003, ApJ, 594, 545
Baraffe et al. 2003 A&A 402 701.
Fortney, J. et al. 2007, ApJ, 659, 1661
Mandushev et al. 2007, ApJ, 667, L195

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In Context

SuperGiant Planets?

- Type-II migration (gap forming) more efficient for low-mass stars
  [Ida & Lin 2005 ApJ 626, 1045]

Planet	Mass/*MJ*	Radius/*RJ*	Host type
HAT-P-2b	8.62	0.951	F8
WASP-14b	7.790	0.9	F9

[Loeillet et al. 2008 A&A, 481, p.529]

→ Density ~12.5 g cm^{-3}

Gas giants ~1 g cm^{-3}
Low mass stars >50 g cm^{-3}

- Different formation mechanism?

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Future work

- New planet papers due out soon, inc. LCOGT data
- Analysis of low-mass binaries
- Improved identification techniques for false positives (blends, triples etc)
- New candidates still being identified from SW-N & SW-S
- 11 promising targets still in queue with some data already
- Continuous dataflow is prompting pipeline development

...watch this space!

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Who cares about planets?

- Theories of planet formation revolutionized by exoplanet discoveries
  - → Pulsar planets
  - → Hot Jupiters
  - → Planetary migration
- Distinctions between planets, brown dwarfs and stars
- Astrobiology
  - → Looking for other habitable systems

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