Extrasolar planets

Q:

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Extrasolar planets

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A:

Stars outshine their planets an enormous amount in the optical and the near IR.

Detecting exoplanets





Doppler Method

Transit Method

Andrew Howard, Caltech

Doppler search



NASA exoplanets site

Known extrasolar planets in 2014: a study in selection biases

Winn and Fabrycky 2015



Figure 1

Approximate masses and orbital distances of known planets based on an October 2014 query of the exoplanets.eu encyclopedia (Schneider et al. 2011). This plot does not consider selection biases and glosses

Hot Jupiters – first to be discovered with Doppler searches, but RARE



Andrew Howard, Caltech

Determination of Orbital Distance from Star to Planet



Period = 4.2 days

Kepler's 3rd Law: $P^2 = a^3$

Units: P in years, a in AU

Solve for a: a = 0.05 AU

Proximity: Temp = 1800 C

Andrew Howard



Andrew Howard, Caltech

Formation of hot Jupiters

It is likely that these Jupiter-mass planets form at several AU (as in our Solar System) and then migrate close in to their star, by either dissipative interactions with the protoplanetary disk or by planet-planet interactions

Thus their existence is not a challenge to the condensation theory of planet formation





Giant Planets are more common around stars rich in metals! This is a clue to planet formation!

Andrew Howard Caltech

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A:

Planetary cores are formed of elements which can be solid in protoplanetary disks, ie elements heavier than H and He. Higher metallicity stars will find it easier to form these cores.

Transit method



ΗT				
LIGH				
	TIME			

NASA exoplanets site

Transit observations



Q:

how can we use the light curve to infer the size of the planet?



Andrew Howard Caltech

Observations are (just) reaching Earth mass



How about the majority of planetary systems?



Observations are just allowing us to detect Earth-mass planets. Plot shows percent of systems with a given planet size, from Howard (2013)

These numbers are corrected for selection effects from how the planets were found

Smallish planets are more common than large ones!



Small planets are ubiquitous!

Most stars have close-in "super-Earth" Planets!

Why doesn't the Solar System have a super-Earth?

Howard 2013

What are these super-Earths anyway?



All Planets Above Have M = 6.4 M_E and R = 2.9 R_E

Different admixtures of H/He, water, rock, iron

Andrew Howard



Howard et al 2013 show masses and radii of wellstudied planets. Solar system objects are in green Q: what are the objects which are way above the model for a pure H planet?

Figure 2 | Masses and radii of well-characterized planets. Extrasolar planets are denoted by