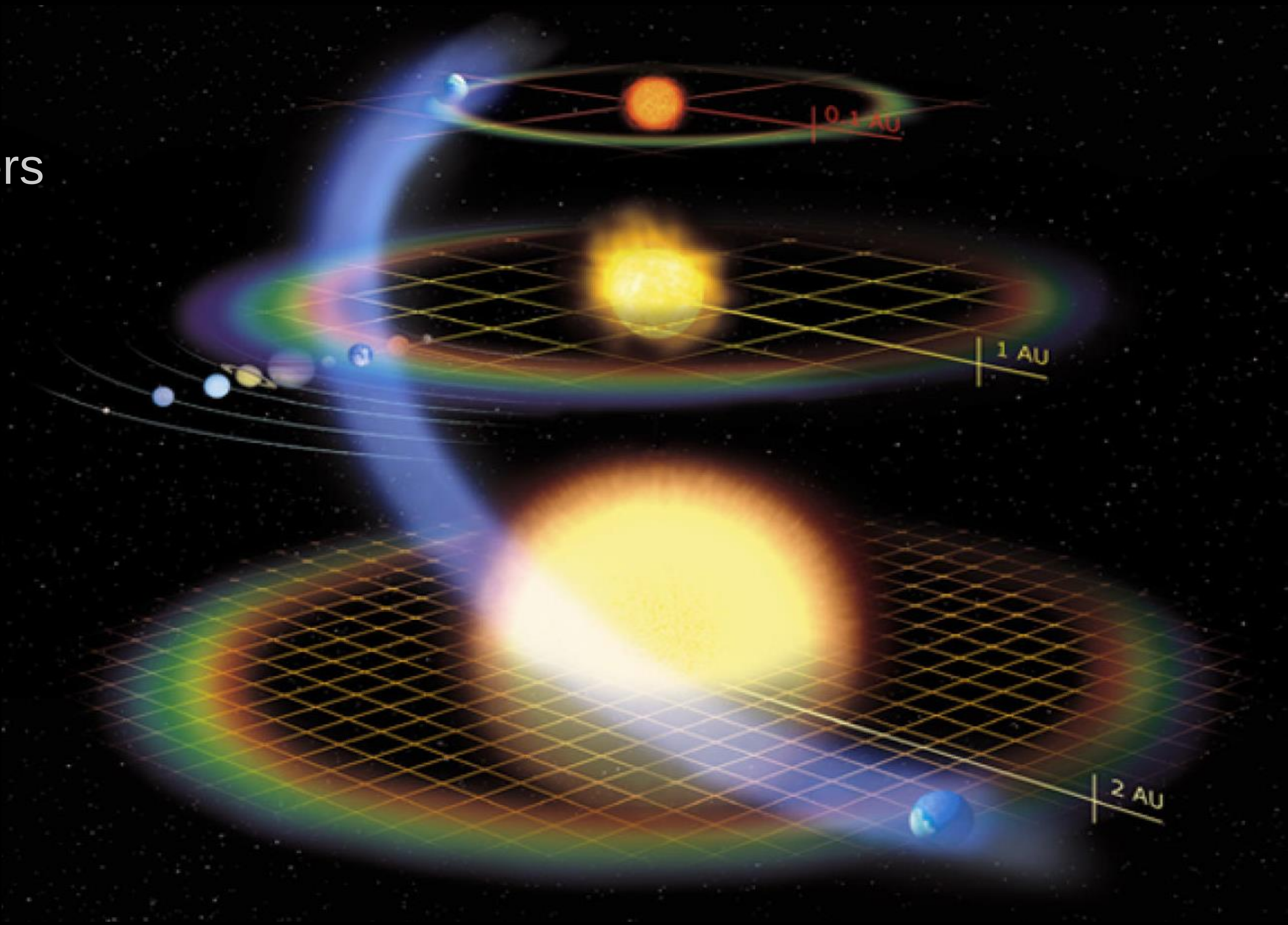
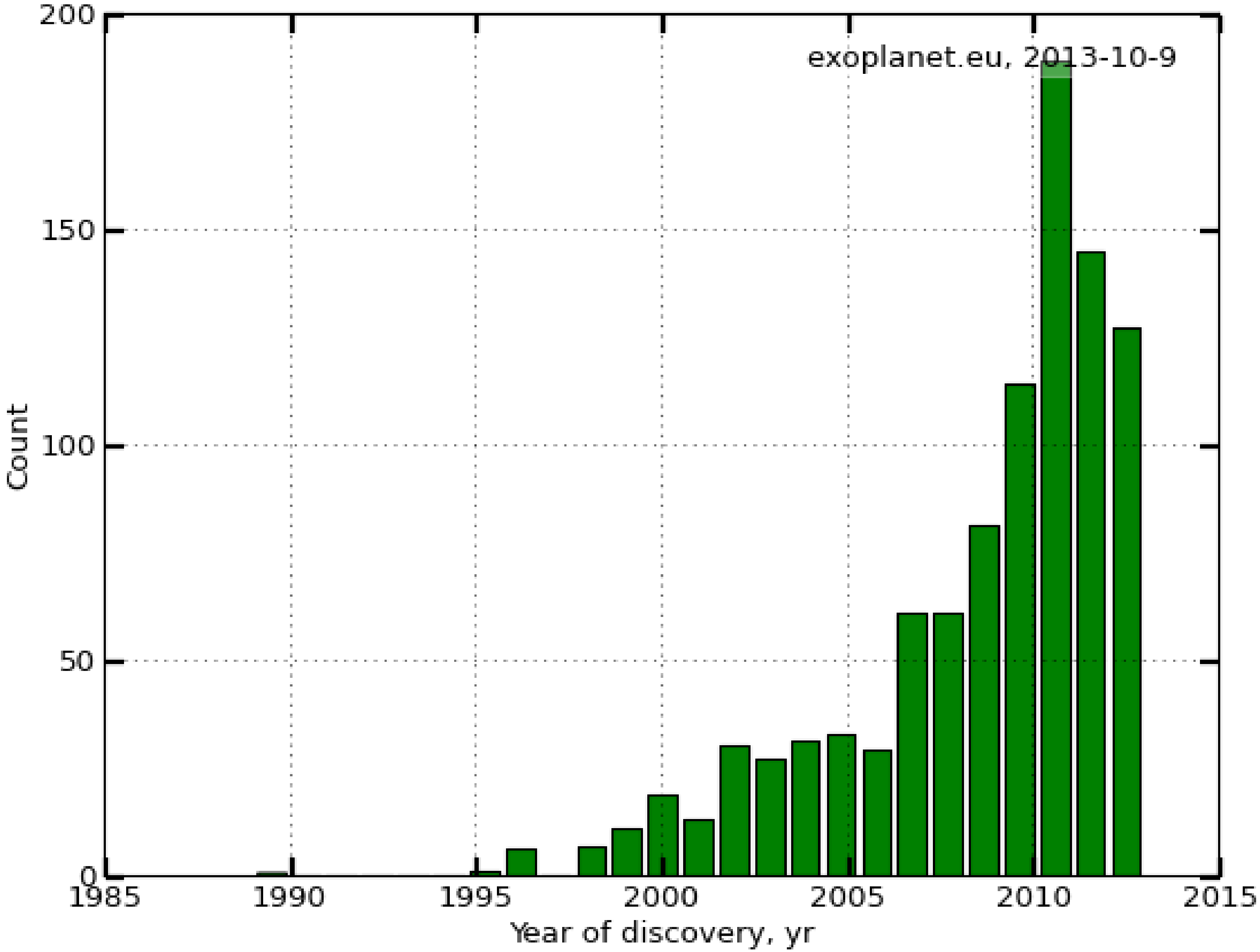
Current Exoplanet Distribution

Ansgar Reiners
IAG



Exoplanet detections

today's exoplanet.eu count is 998



The unseen companion of HD114762: a probable brown dwarf

David W. Latham*, Tsevi Mazeh†, Robert P. Stefanik*, Michel Mayor‡ & Gilbert Burki‡

* Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, Massachusetts 02138, USA
† School of Physics and Astronomy, Raymond and Beverly Sackler Faculty of Exact Science, Tel Aviv University, Tel Aviv 69978, Israel
‡ Observatoire de Genève, Chemin des Maillettes 51, Ch-1290 Sauverny, Switzerland

BROWN dwarfs are substellar objects with too little mass to ignite hydrogen in their cores. Despite considerable effort to detect brown dwarfs astrometrically[1–4], photometrically[4–9], and spectroscopically[10–12], only a few good candidates have been discovered. Here we present spectroscopic evidence for a probable brown-dwarf companion to the solar-type star HD114762. This star undergoes periodic variations in radial velocity which we attribute to orbital motion resulting from the presence of an unseen companion. The rather short period of 84 days places the companion in an orbit similar to that of Mercury around the Sun, whereas the rather low velocity amplitude of about 0.6 km s^{-1} implies that the mass of the companion may be as low as 0.011 solar masses, or 11 Jupiter masses. This leads to the suggestion that the companion is probably a brown dwarf, and may even be a giant planet. However, because the inclination of the orbit to the line of sight is unknown, the mass of the companion may be considerably larger than this lower limit.

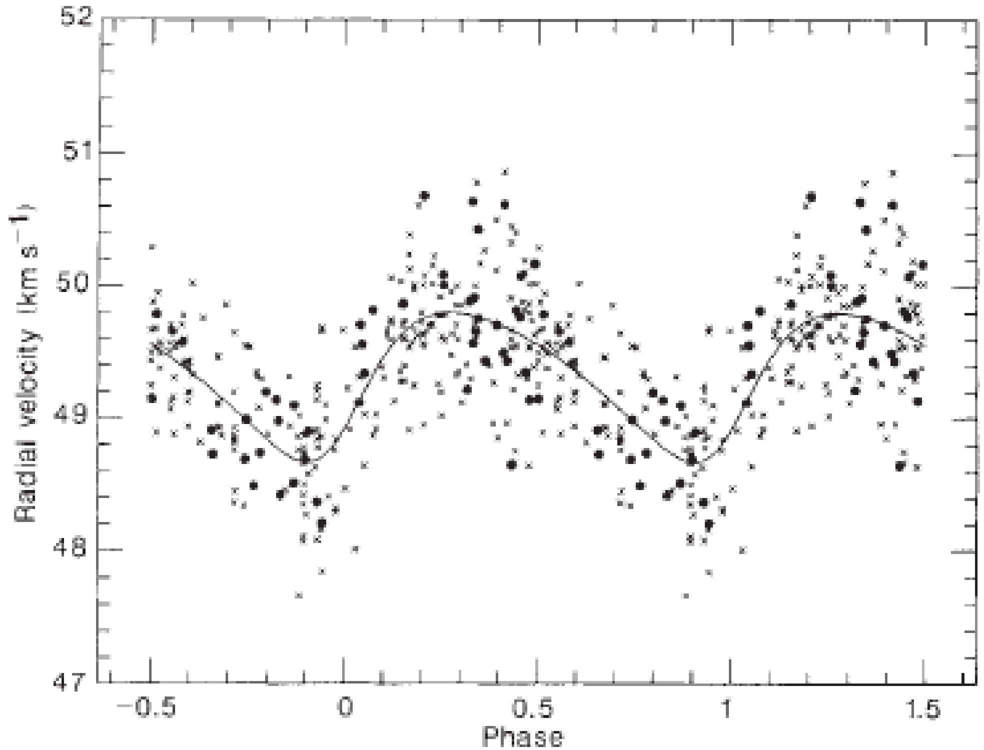


FIG. 2 The orbital solution for the combined data set. The continuous line is the orbital solution with the parameters of Table 1. The CfA velocities are denoted by crosses, the CORAVEL velocities by filled circles.

NATURE · VOL 339 · 4 MAY 1989

letters to nature

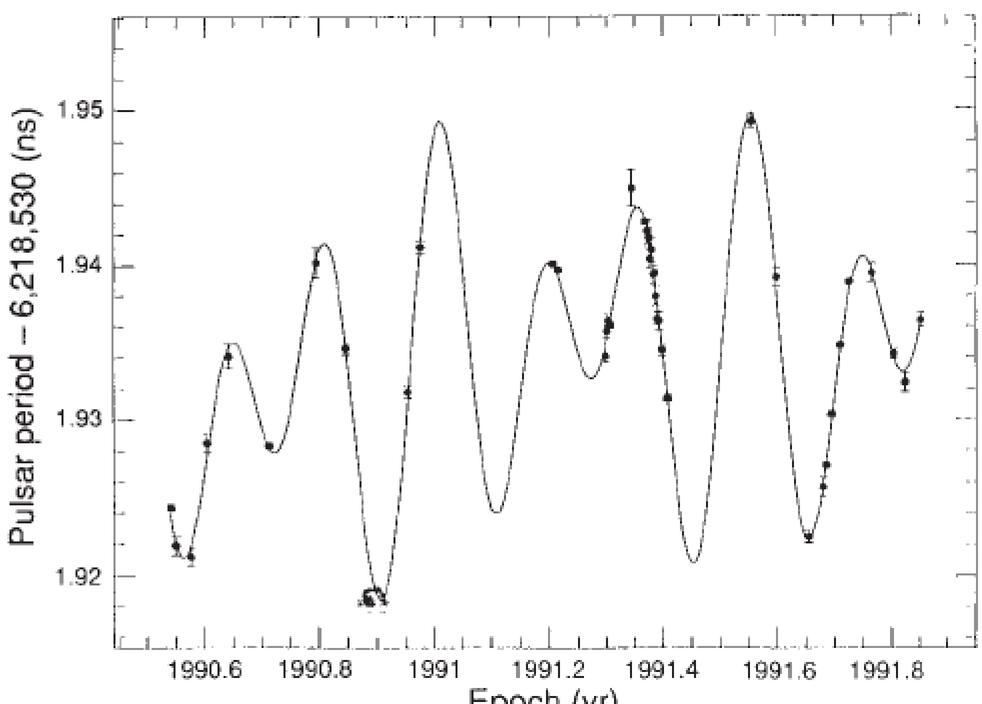
Nature **355**, 145 - 147 (09 January 1992); doi:10.1038/355145a0

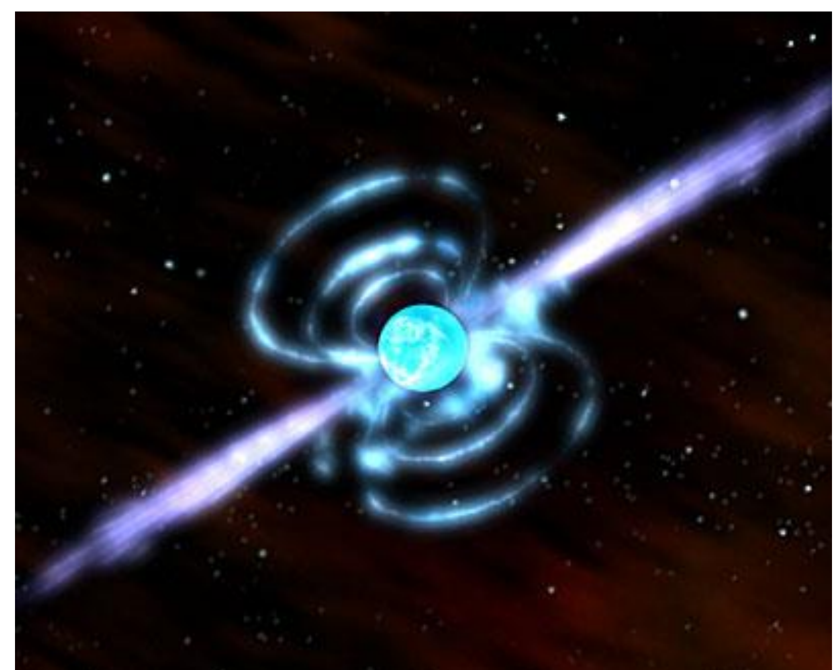
A planetary system around the millisecond pulsar PSR1257 + 12

A. WOLSZCZAN* & D. A. FRAIL†

*National Astronomy and Ionosphere Center, Arecibo Observatory, Arecibo, Puerto Rico 00613, USA
†National Radio Astronomy Observatory, Socorro, New Mexico 87801, USA

MILLISECOND radio pulsars, which are old (~10^9yr), rapidly rotating neutron stars believed to be spun up by accretion of matter from their usually found in binary systems with other degenerate stars[1]. Using the 305-m Arecibo radiotelescope to make precise timing measurements recently discovered 6.2-ms pulsar PSR1257 +12 (ref. 2), we demonstrate that, rather than being associated with a stellar object, the pulsar is planet-sized bodies. The planets detected so far have masses of at least 2.8 $M_\oplus$ and 3.4 $M_\oplus$ where $M_\oplus$ is the mass of the Earth. Their respec pulsar are 0.47 AU and 0.36 AU, and they move in almost circular orbits with periods of 98.2 and 66.6 days. Observations indicate that at leas be present in this system. The detection of a planetary system around a nearby (~500 pc), old neutron star, together with the recent report on to the pulsar PSR1829–10 (ref. 3) raises the tantalizing possibility that a non-negligible fraction of neutron stars observable as radio pulsars n like bodies.





Discovery of the „first“

ARTICLES

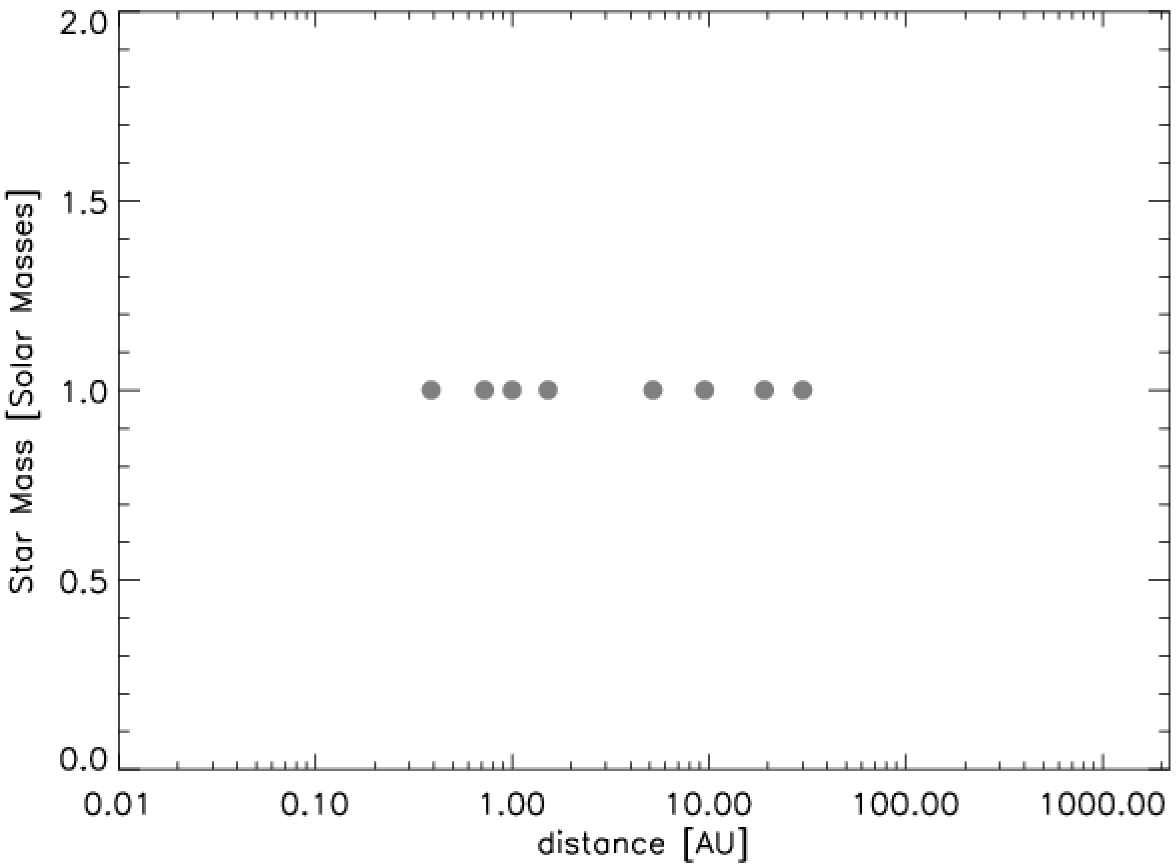
A Jupiter-mass companion to a solar-type star

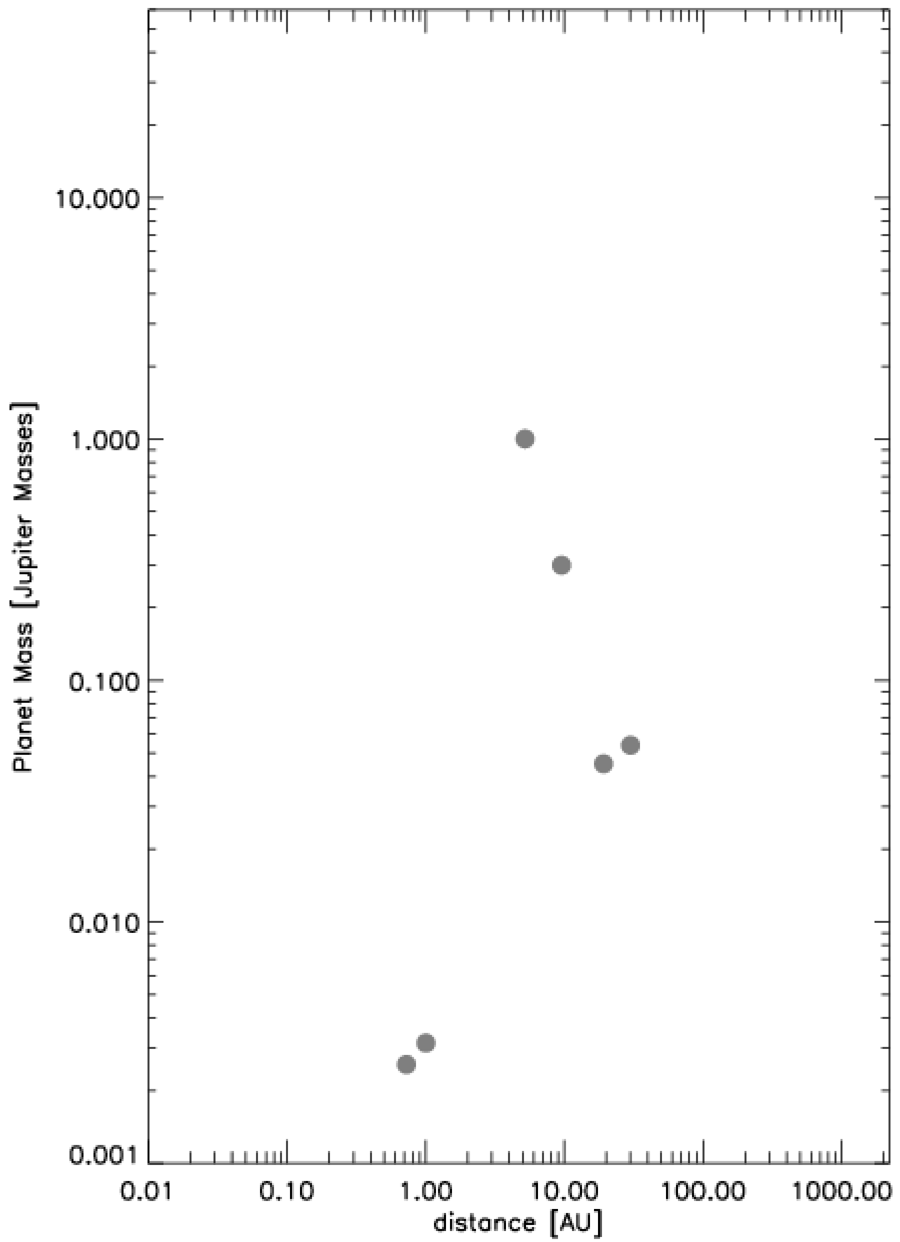
Michel Mayor & Didier Queloz

Geneva Observatory, 51 Chemin des Maillettes, CH-1290 Sauverny, Switzerland

The presence of a Jupiter-mass companion to the star 51 Pegasi is inferred from observations of periodic variations in the star's radial velocity. The companion lies only about eight million kilometres from the star, which would be well inside the orbit of Mercury in our Solar System. This object might be a gas-giant planet that has migrated to this location through orbital evolution, or from the radiative stripping of a brown dwarf.

The solar system





Detection techniques

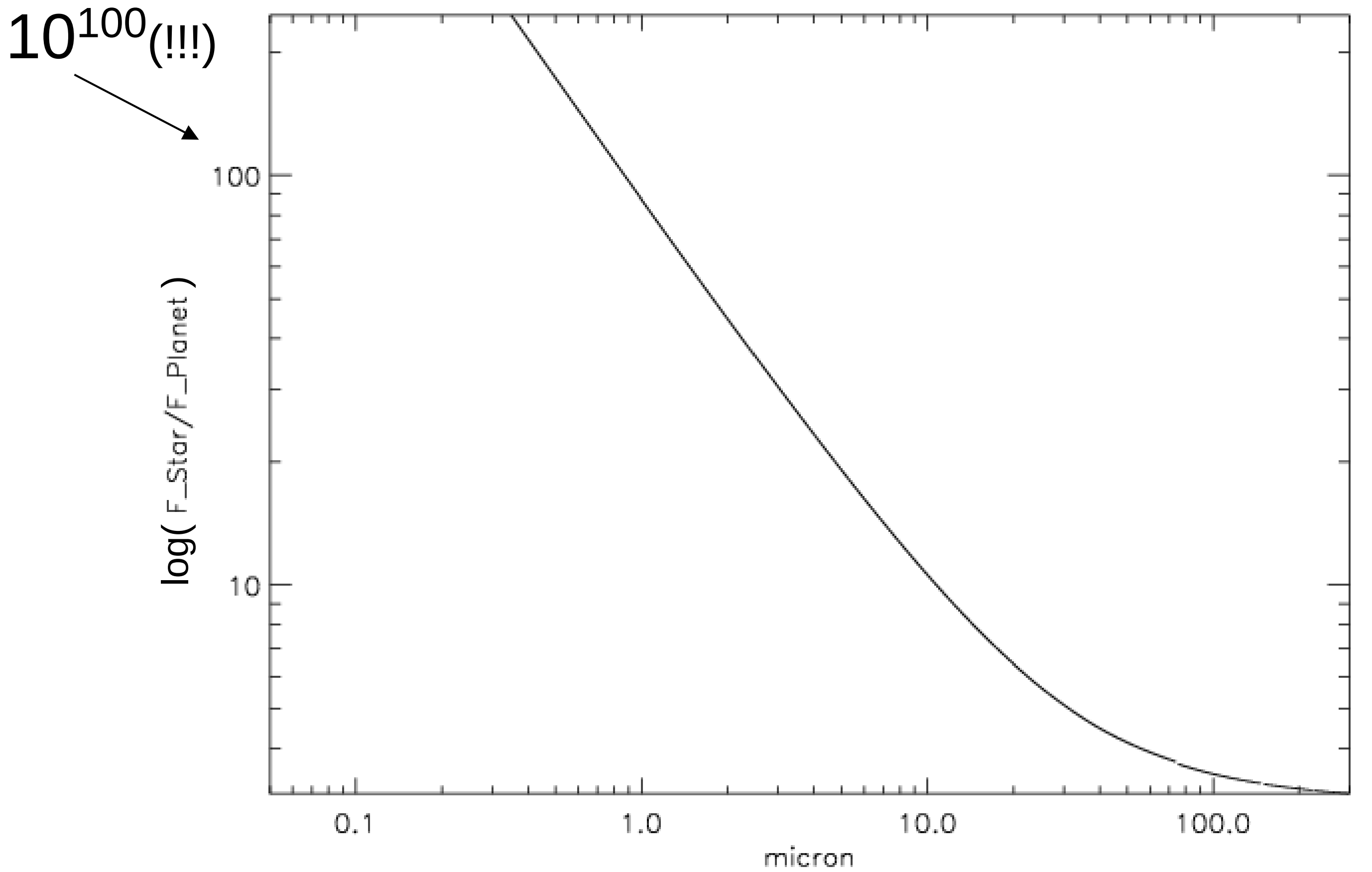
1. Imaging
2. Transit
3. Microlensing
4. Radial Velocities
5. Timing

Stars are a billion times brighter…

...than their planets.

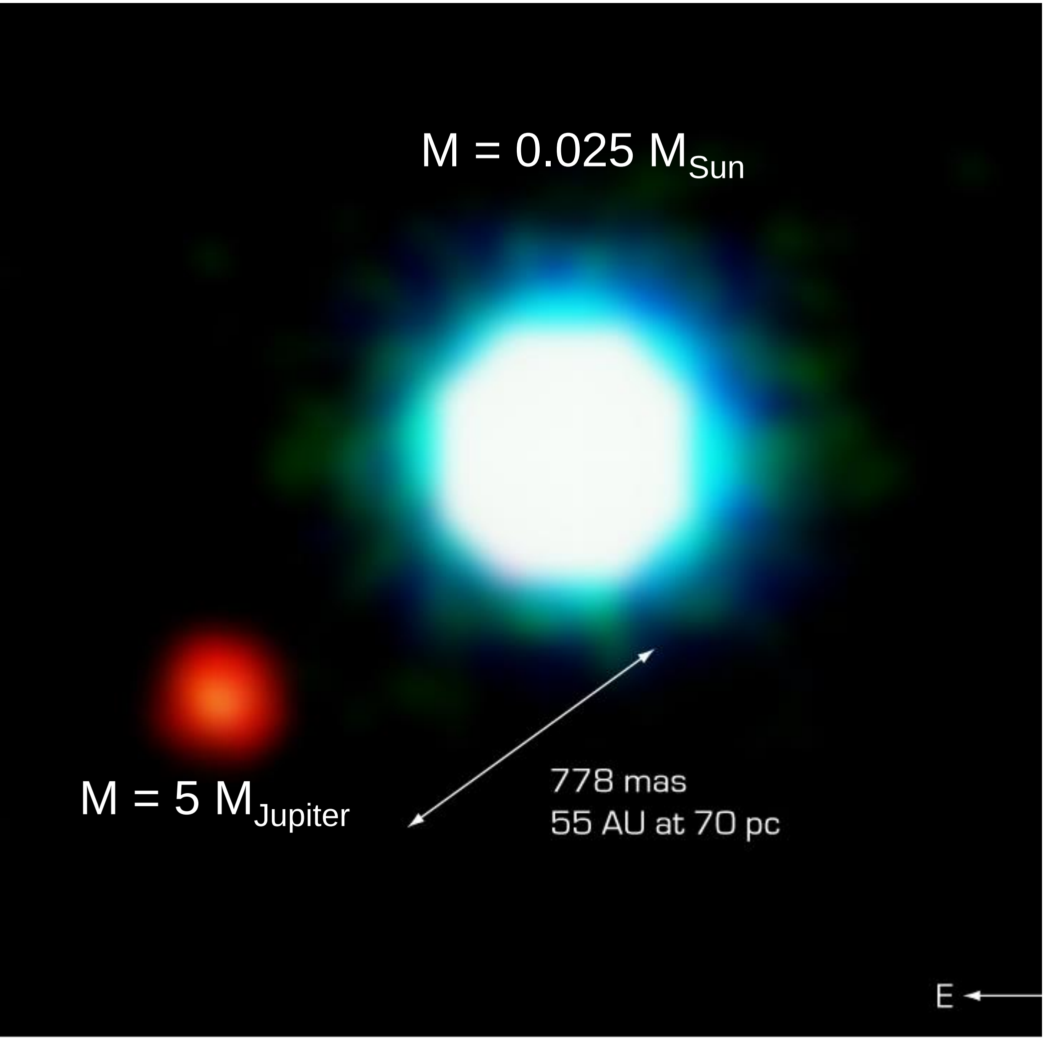
Star/Planet constrast assuming pure blackbodies (no reflexion)

approx. Sun / Jupiter



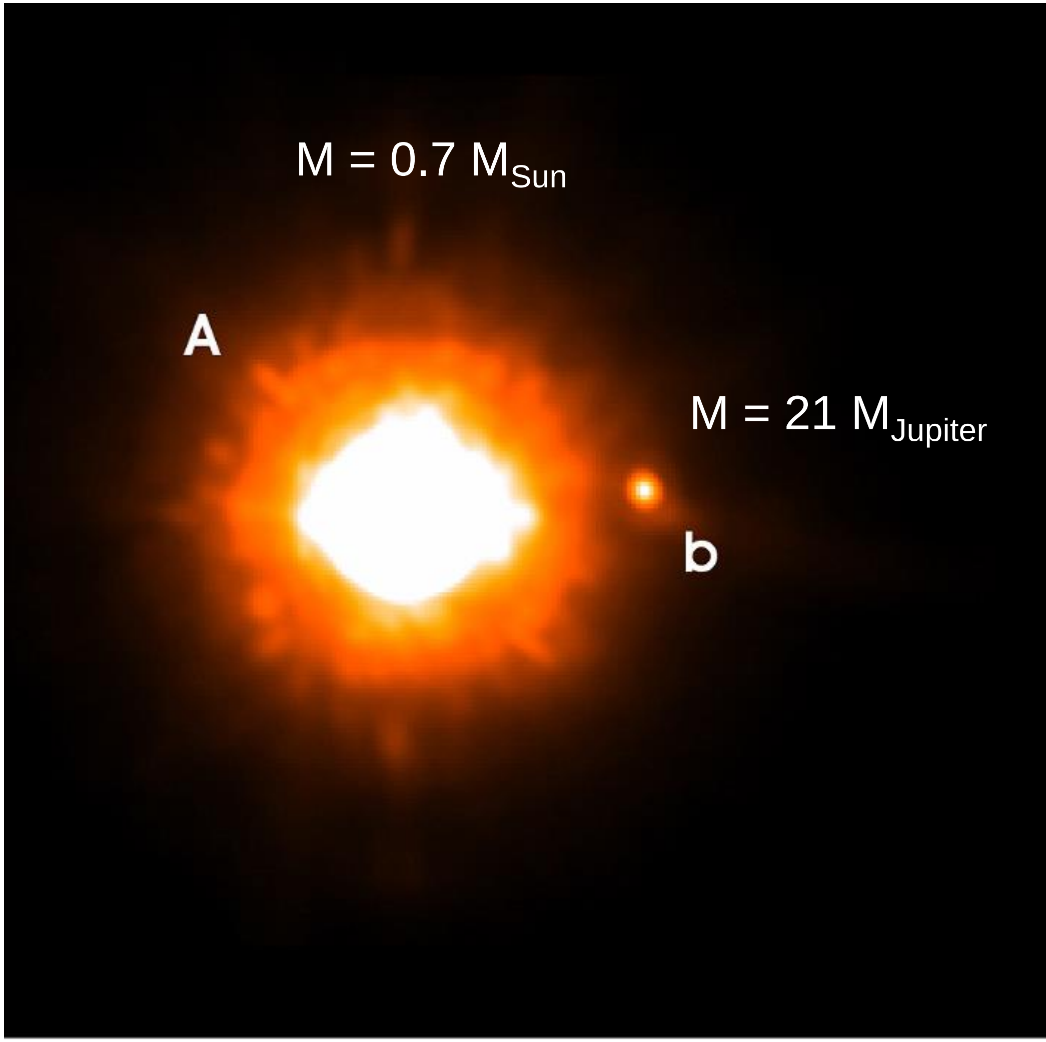
Important: reflected light

First “Star + Planet” images



NACO Image of the Brown Dwarf Object 2M1207 and GI

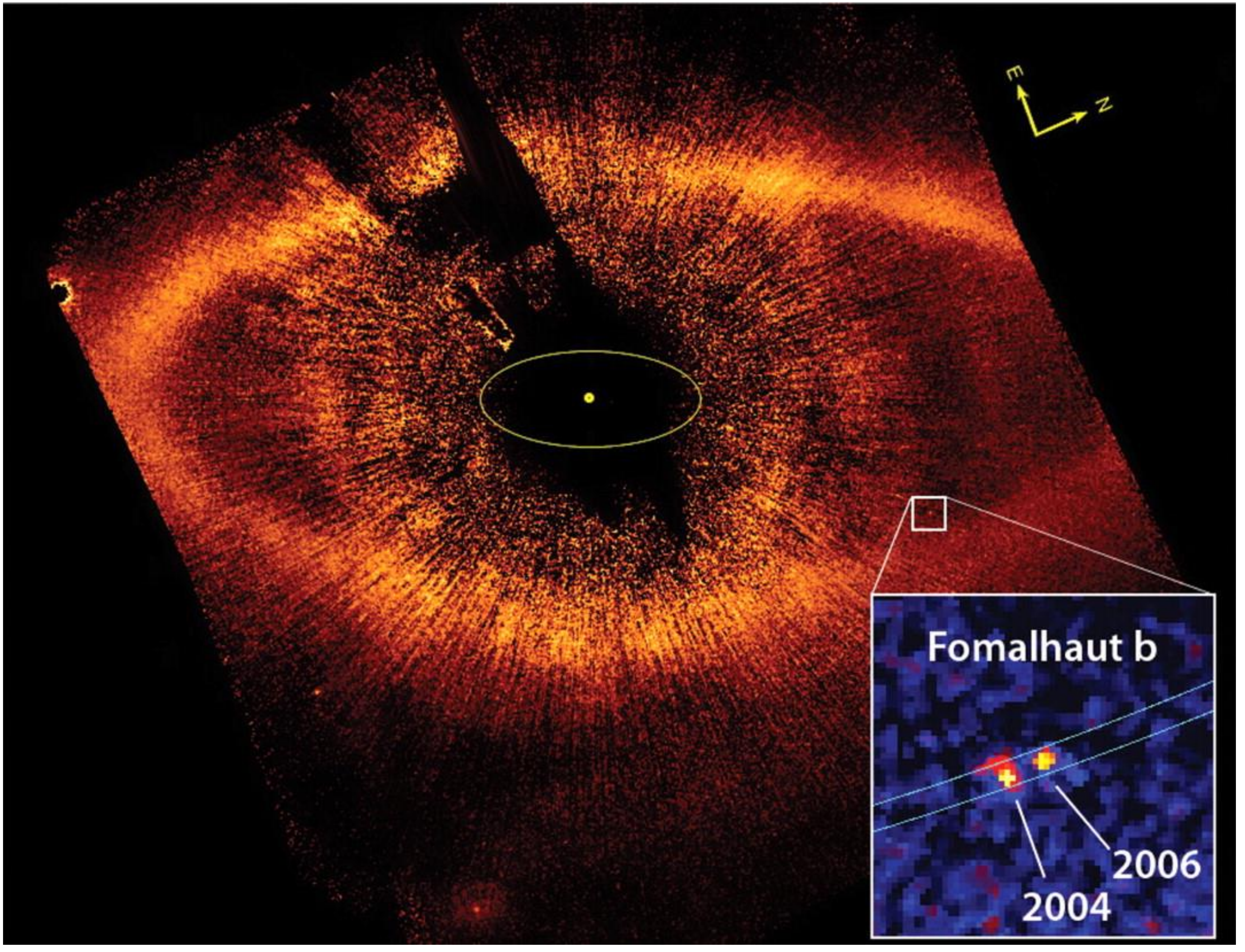
ESO PR Photo 26a/04 (10 September 2004)



The Sub-Stellar Companion to GQ Lupi
(NACO/VLT)

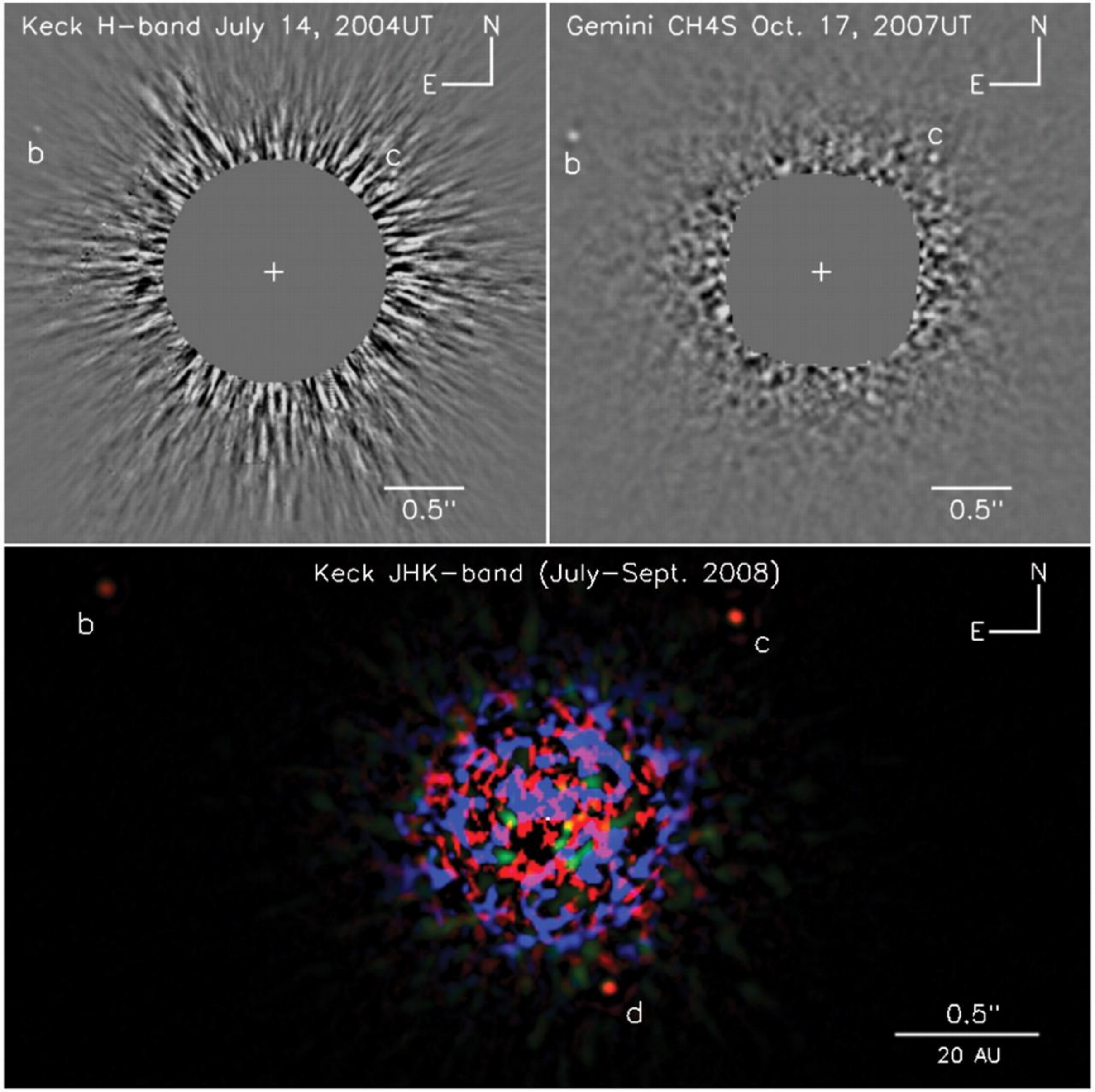
pril 2005)

First “direct” images of extrasolar planets



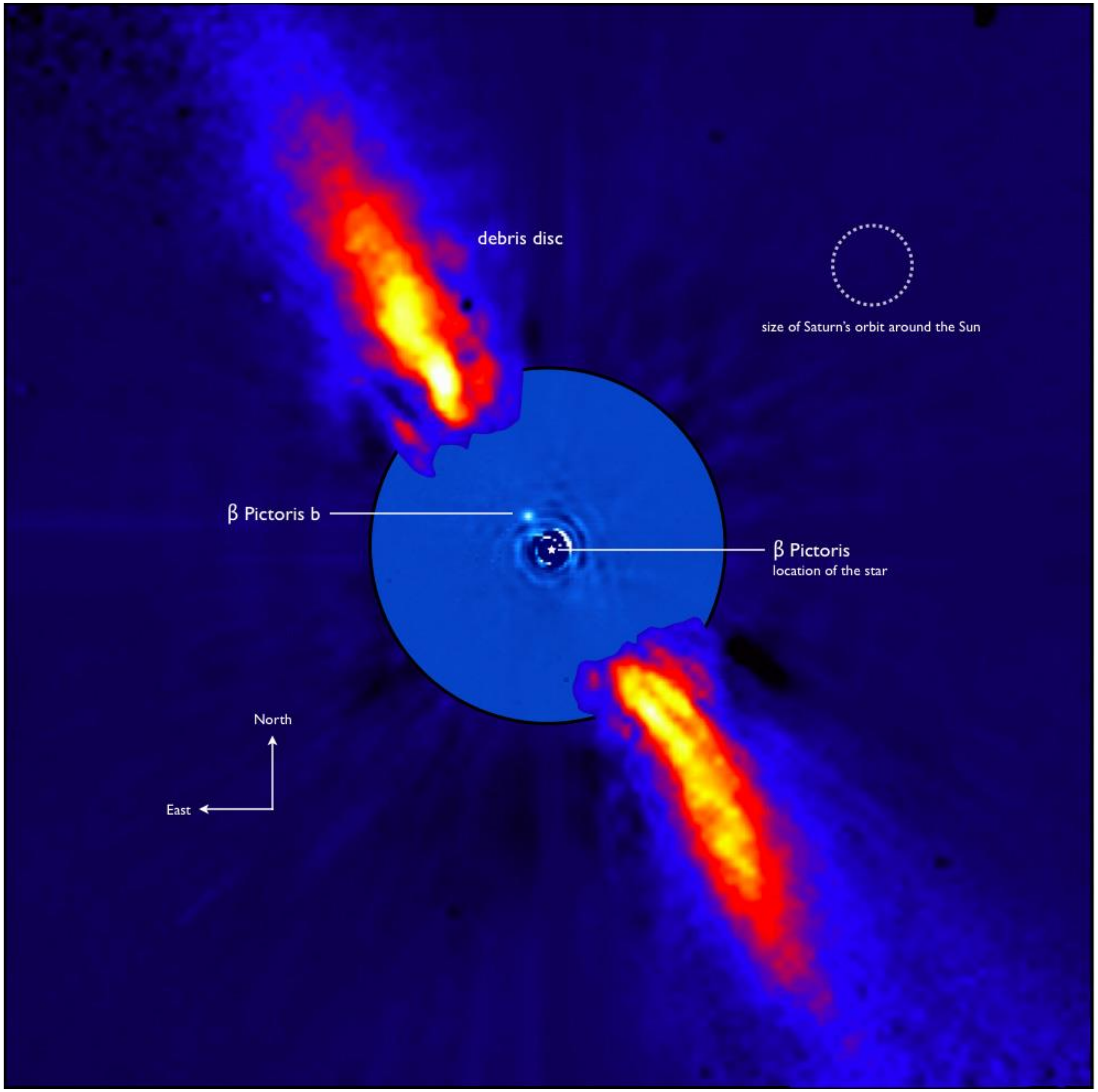
Kalas et al., 2008

First “direct” images of extrasolar planets



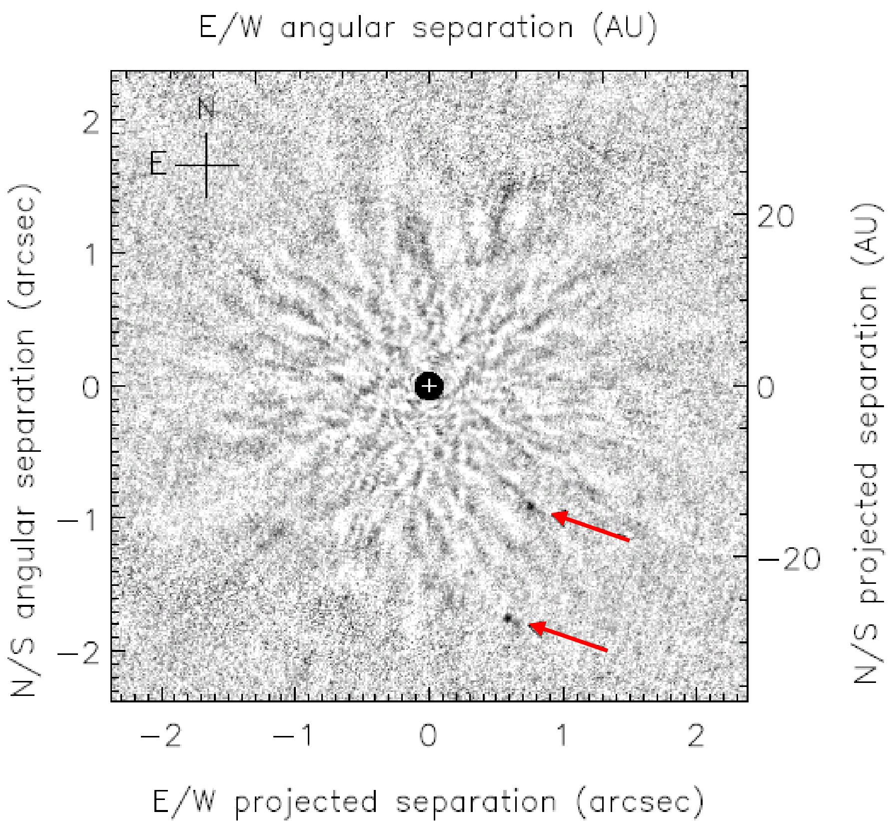
Marois et al., 2008

First “direct” images of extrasolar planets



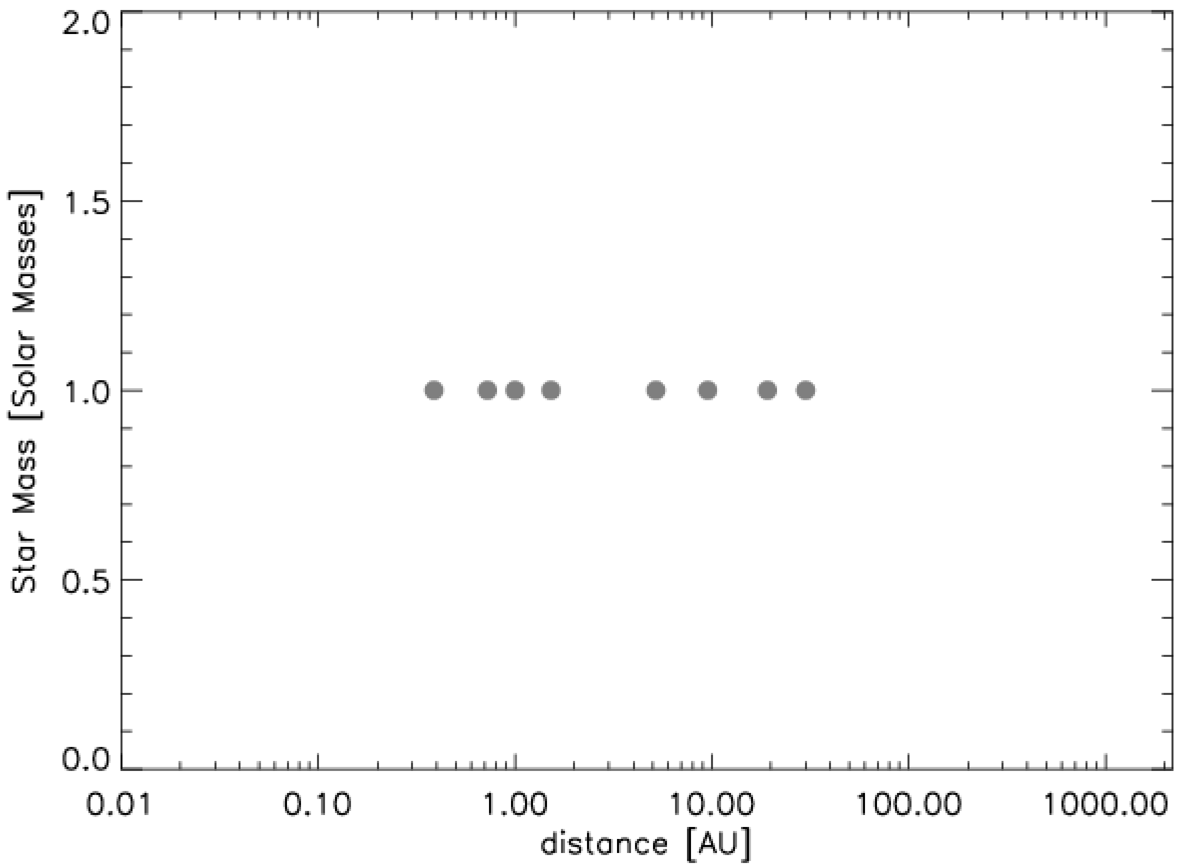
Lagrange et al., 2008

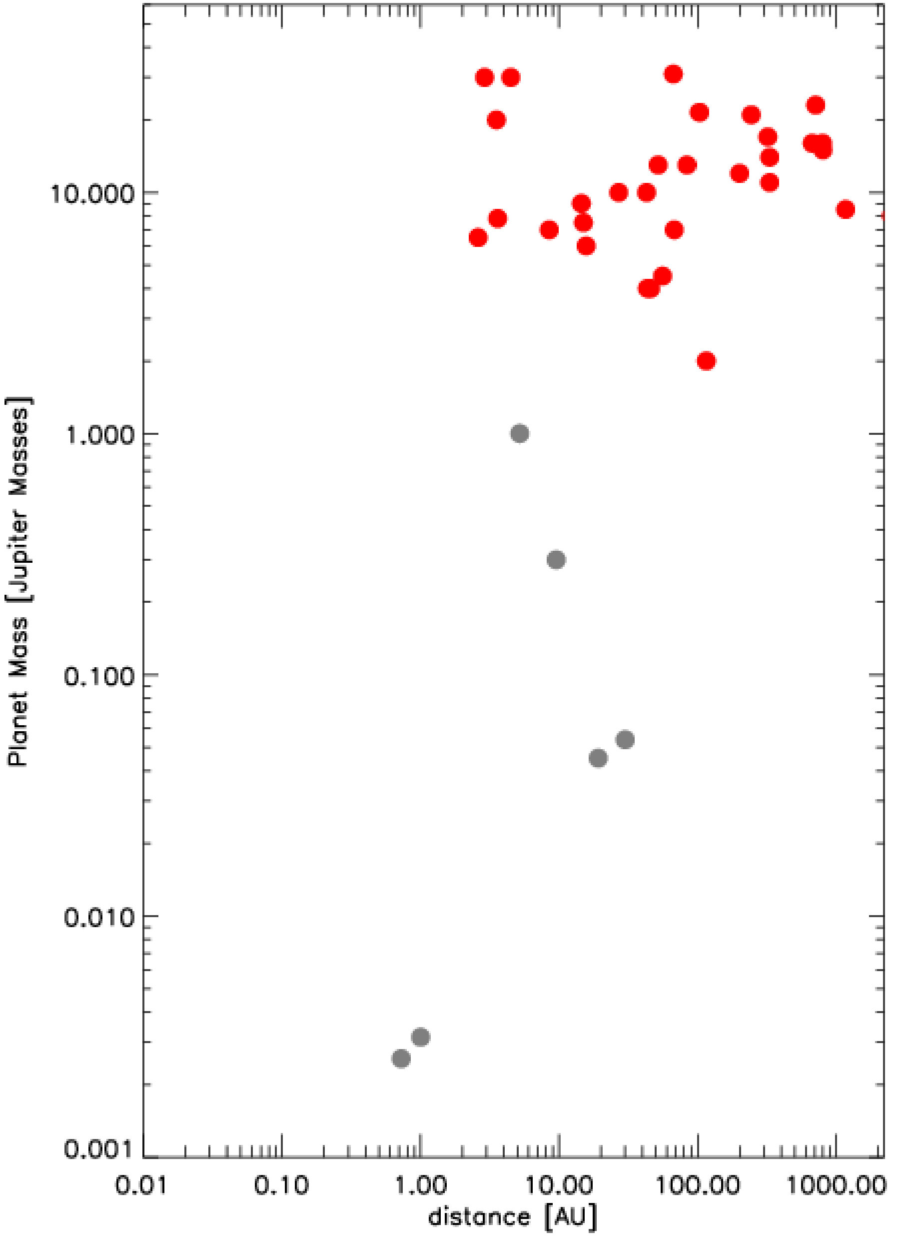
First “direct” images of extrasolar planets



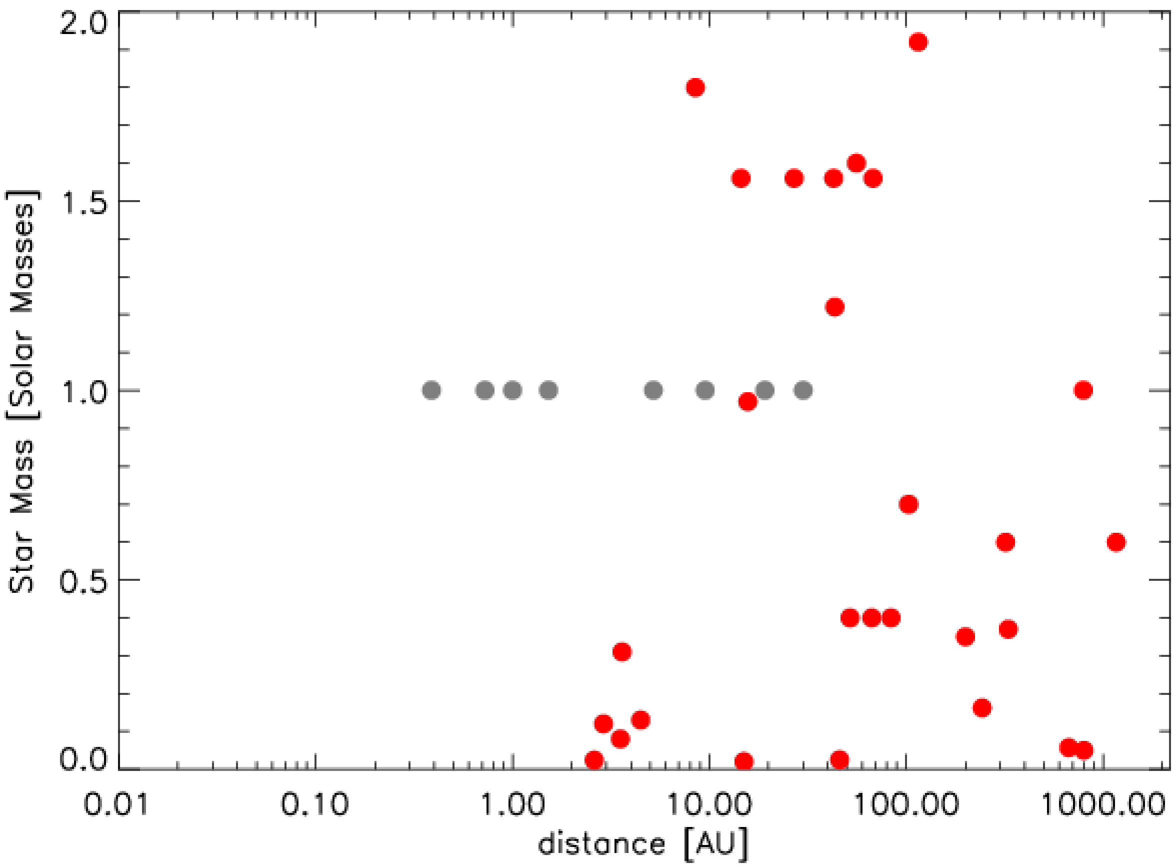
Thalmann et al., 2009

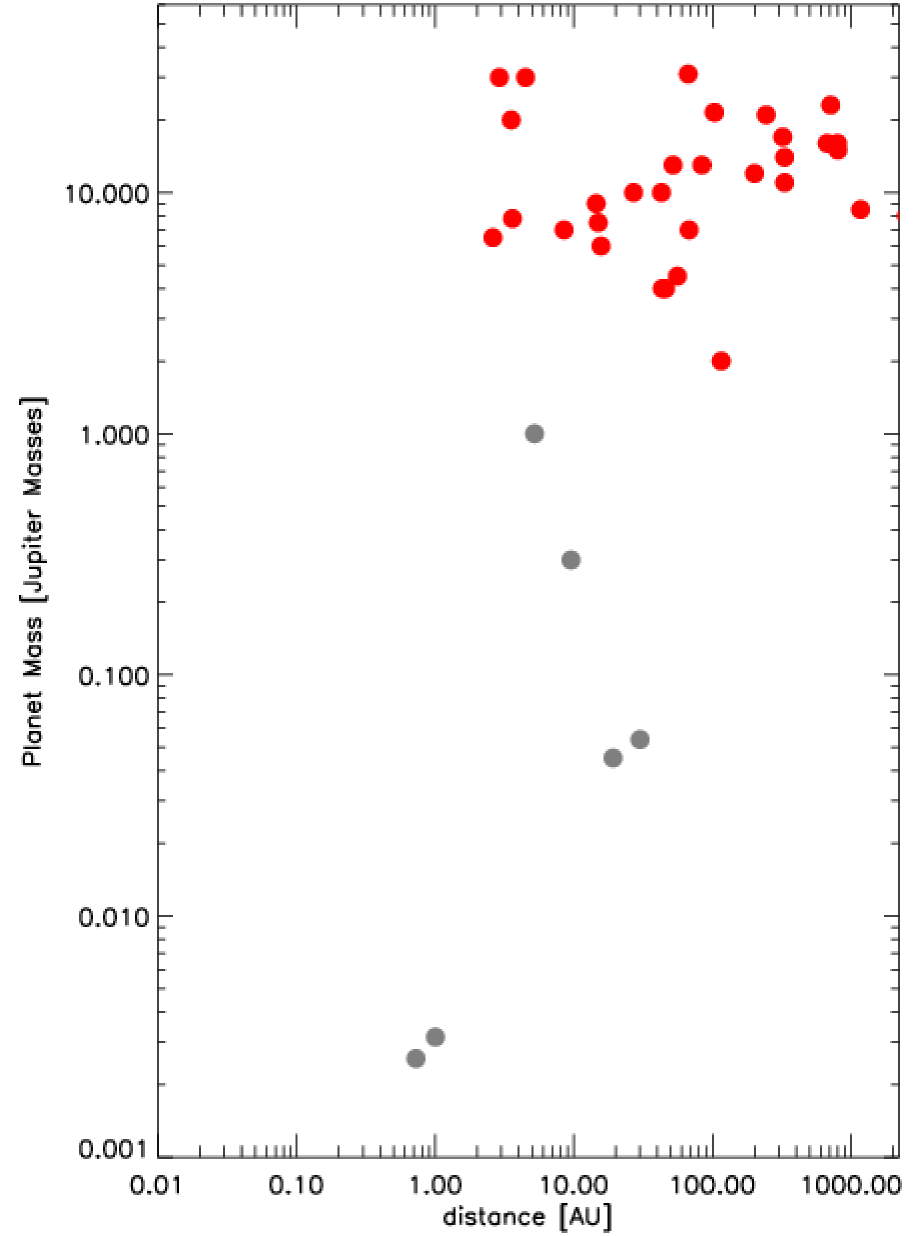
Planets detected with the imaging technique



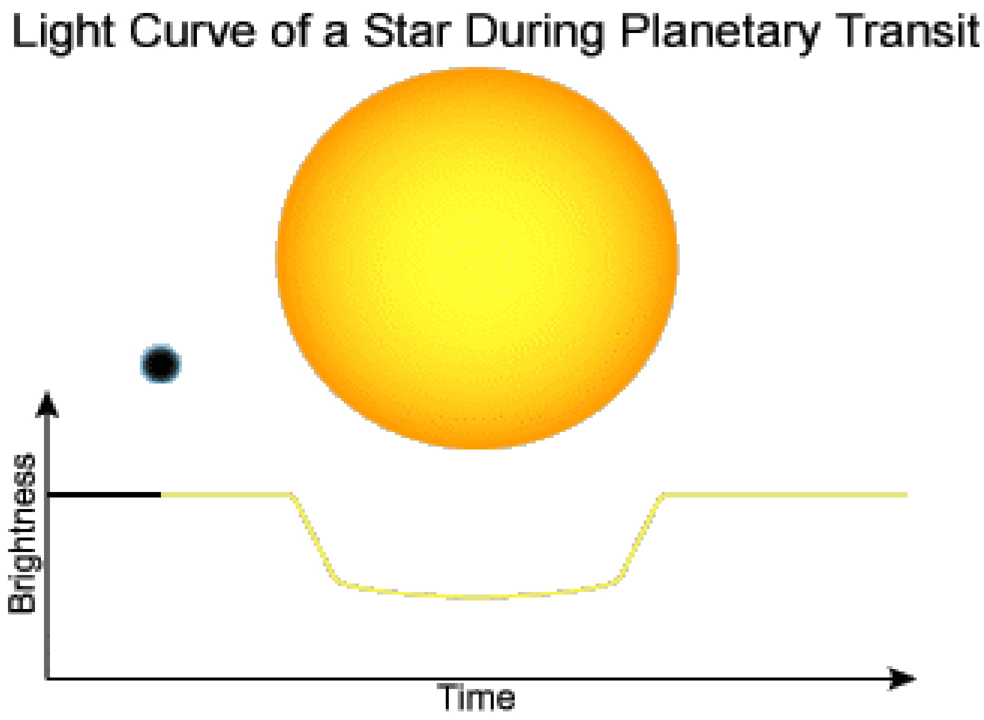


Planets detected with the imaging technique



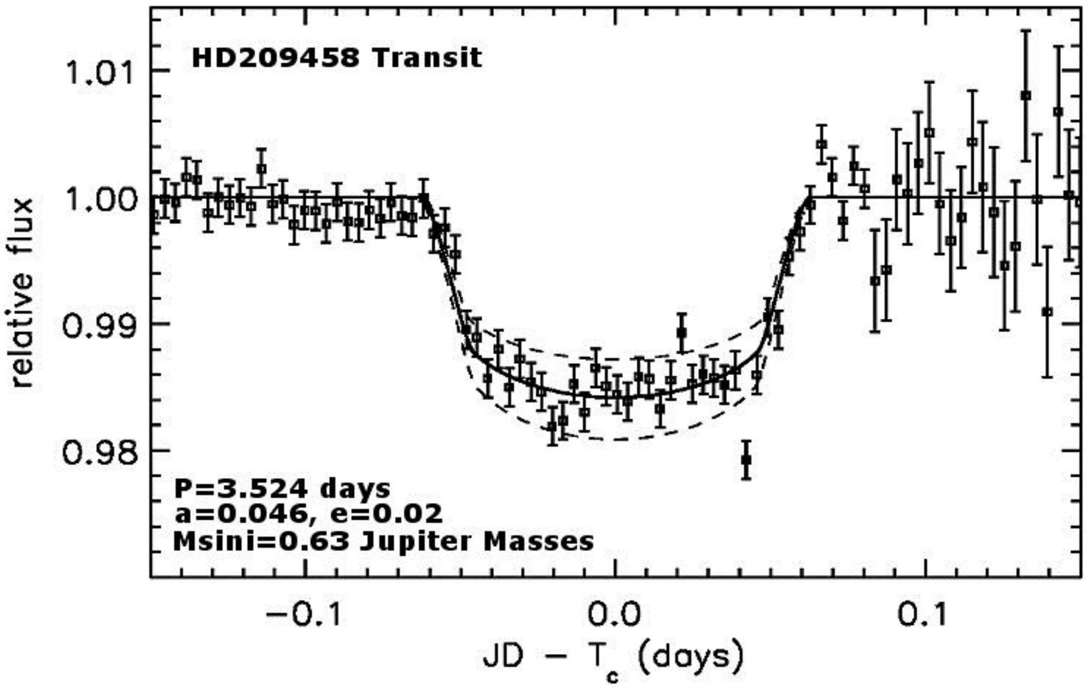


Transits

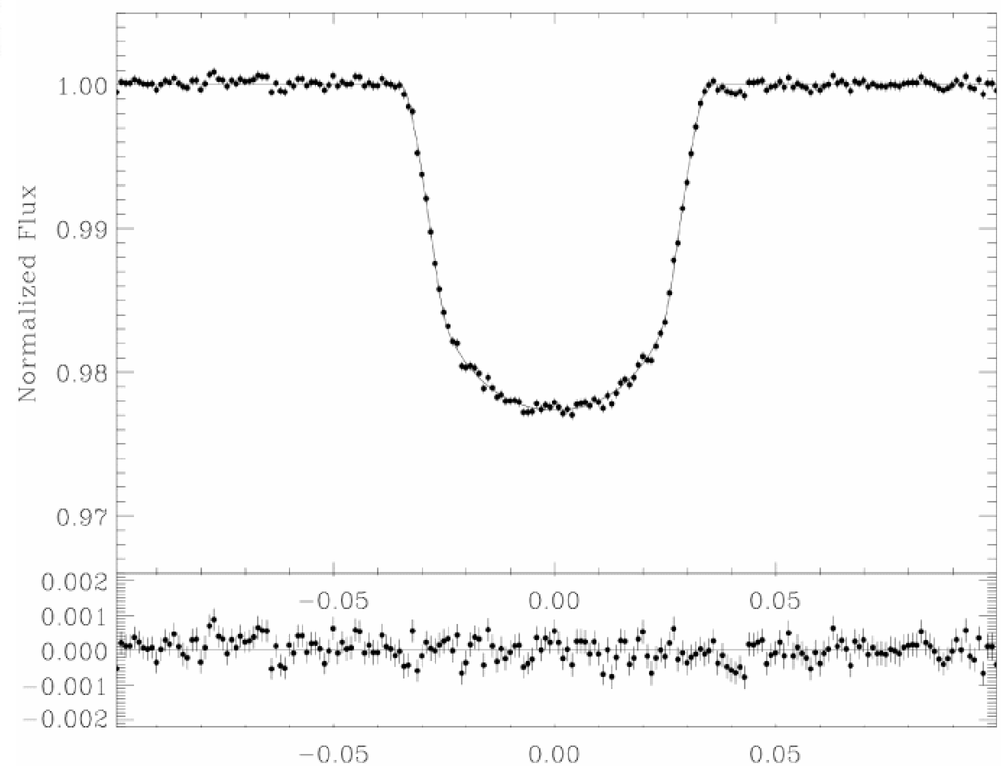


Light Curve of a Star During Planetary Transit
Brightness
Time

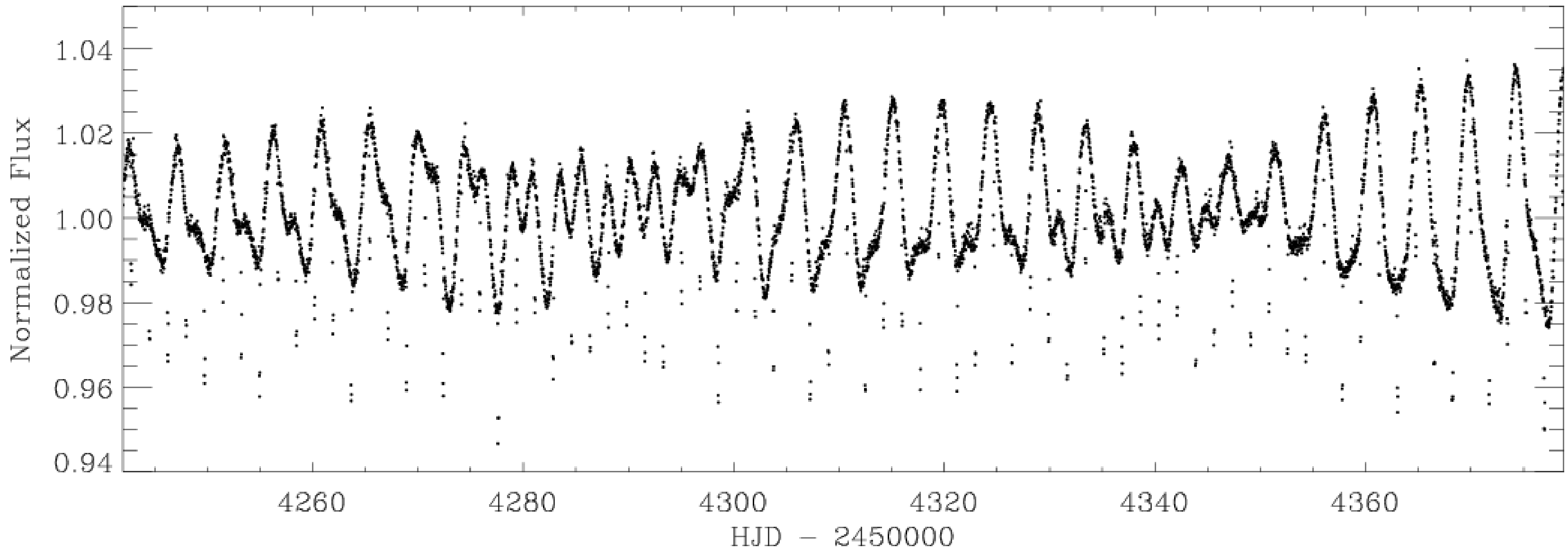
Transits



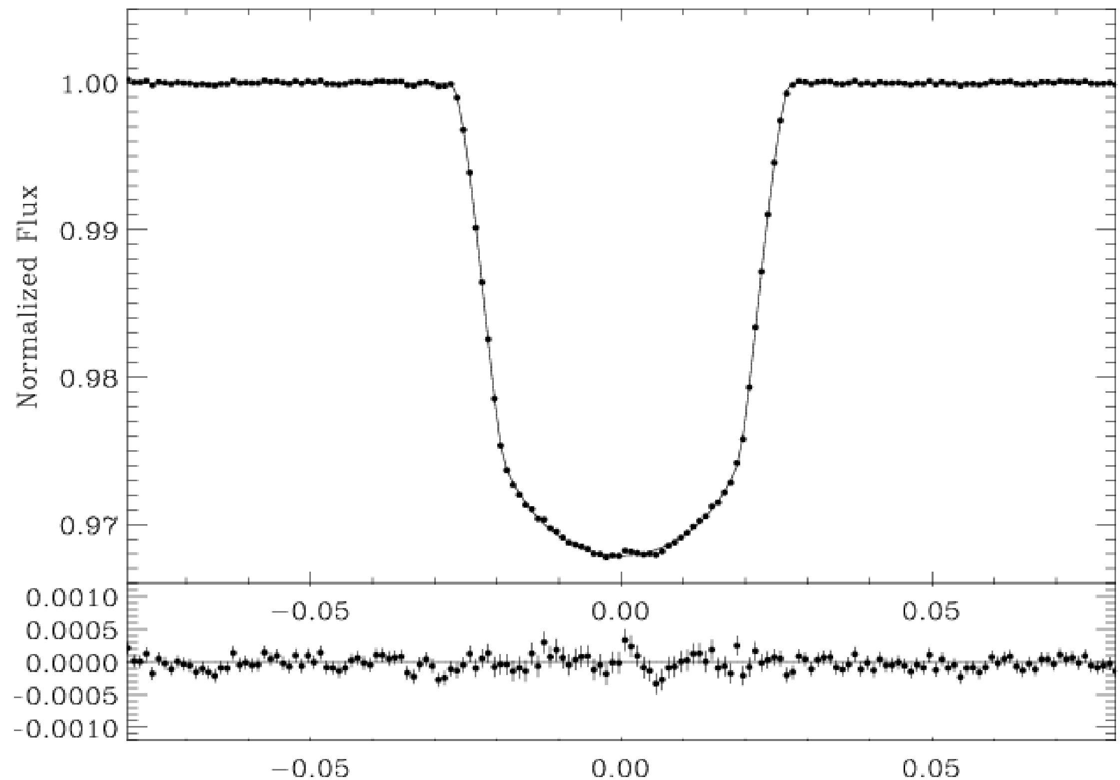
CoRoT Exo-1b



CoRoT Exo-2b

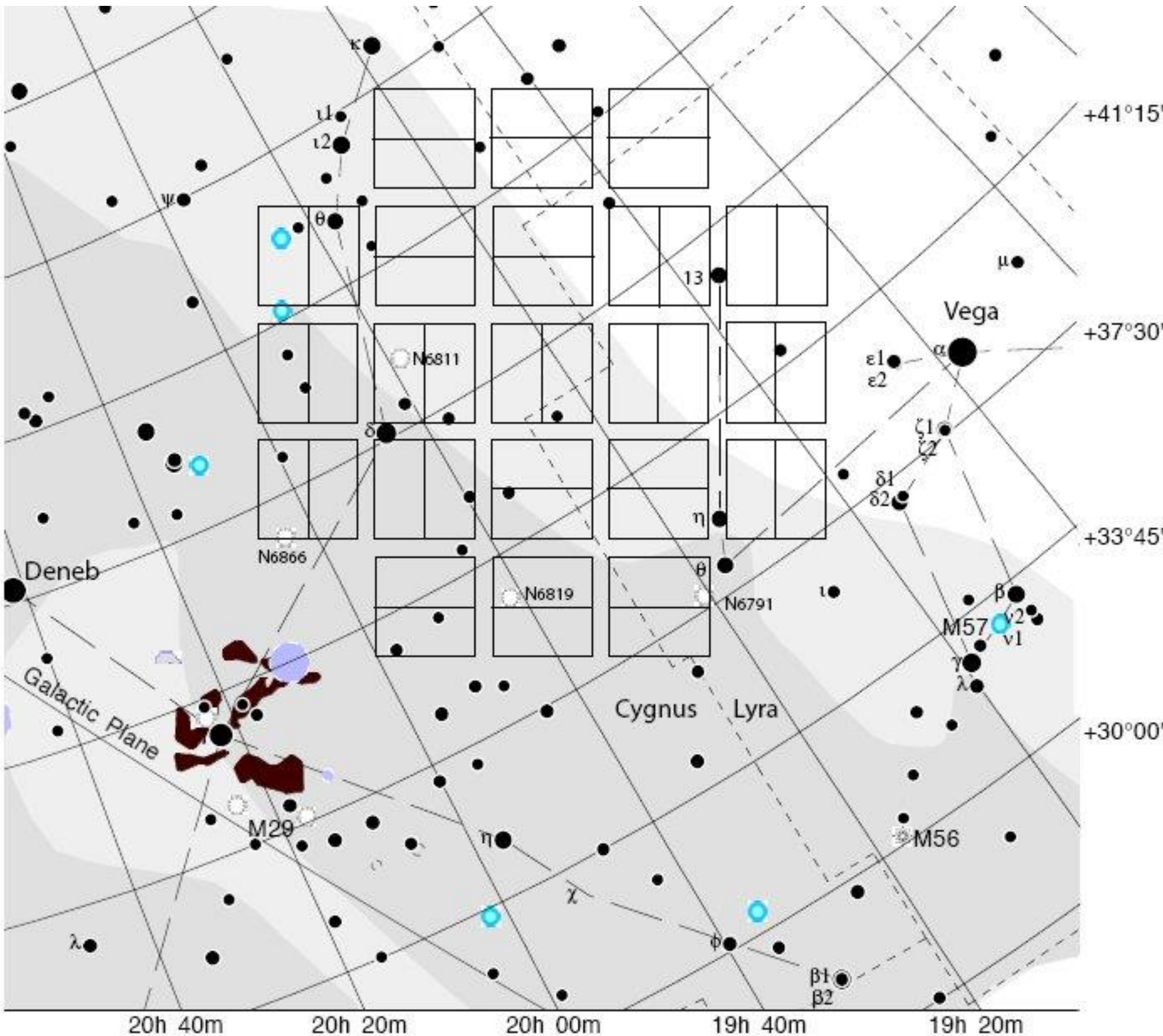


1.04
1.02
1.00
0.98
0.96
0.94
Normalized Flux
4260
4280
4300
4320
4340
4360
HJD − 2450000

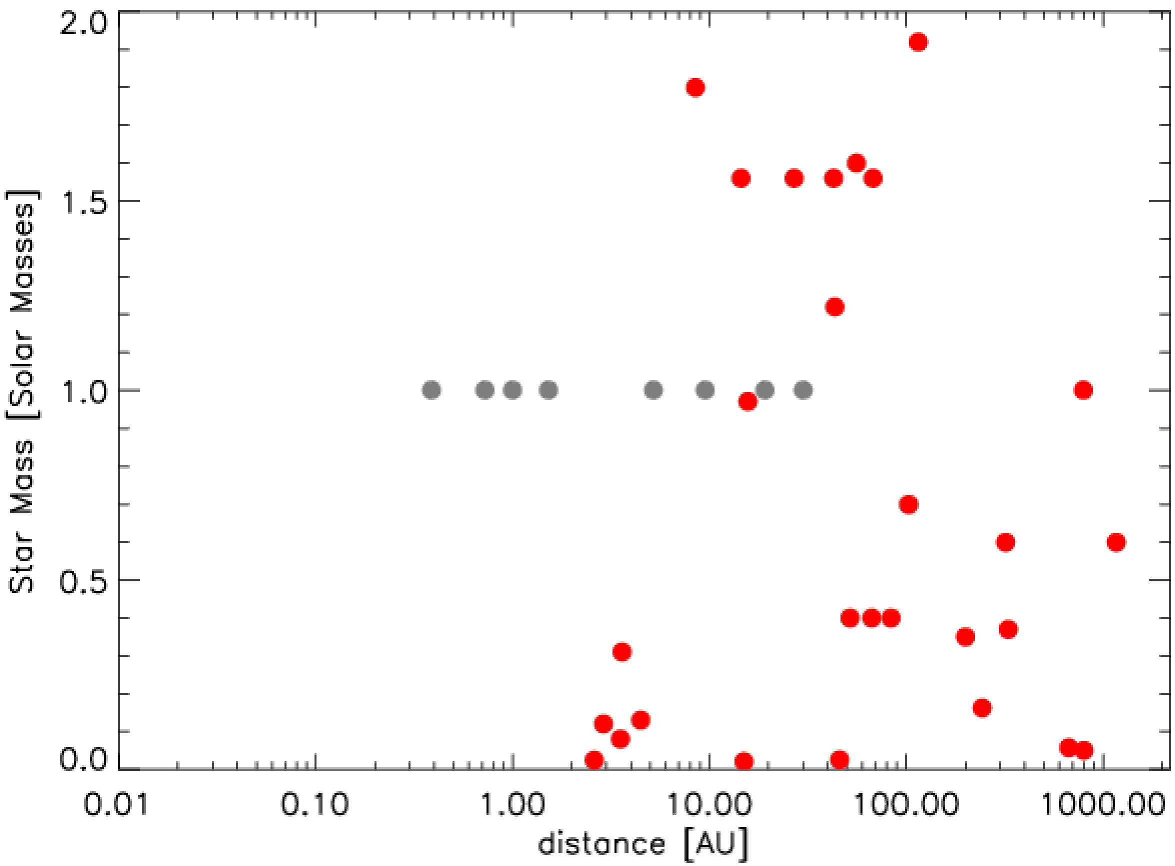


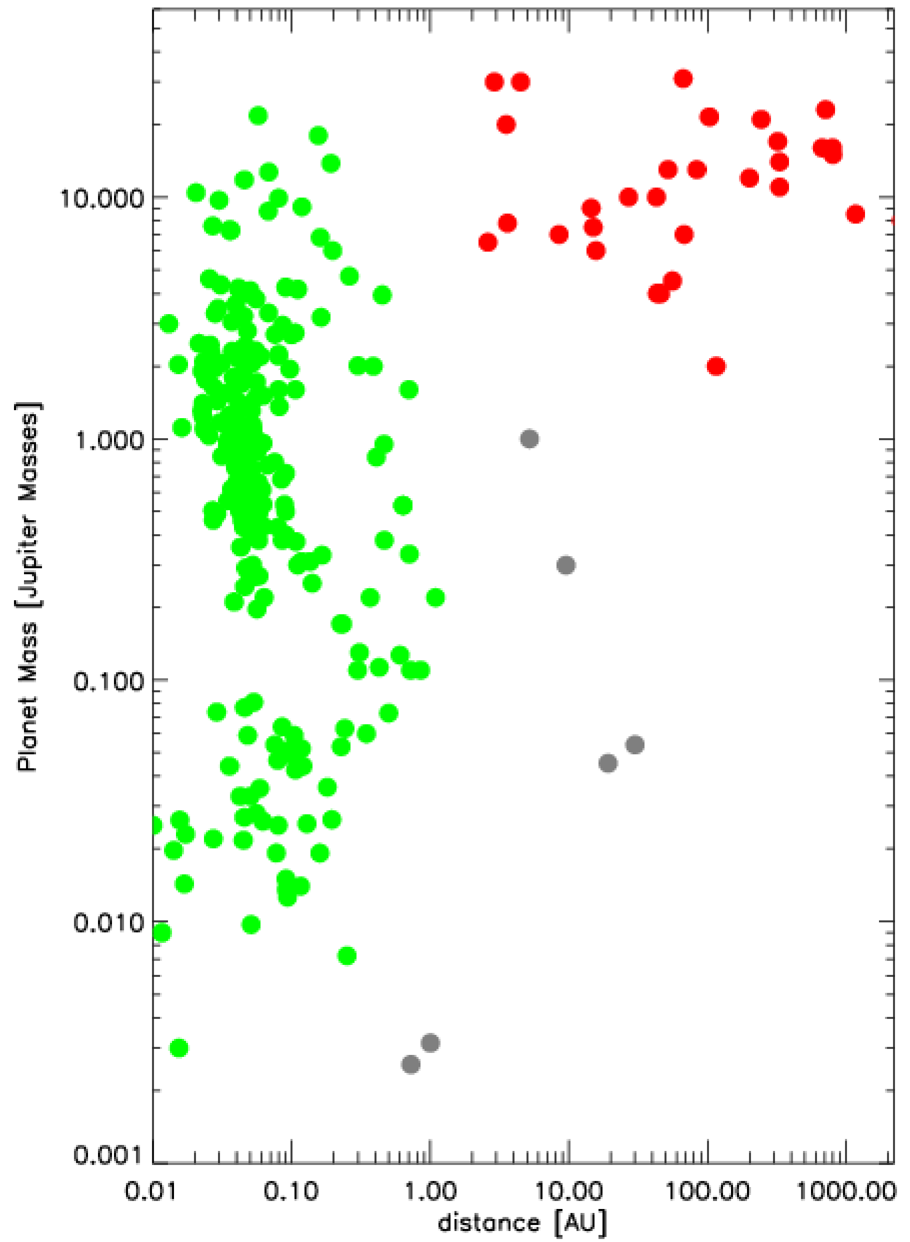
1.00
0.99
0.98
0.97
Normalized Flux
−0.05
0.00
0.05
0.0010
0.0005
0.0000
-0.0005
-0.0010
−0.05
0.00
0.05

Kepler Field of View

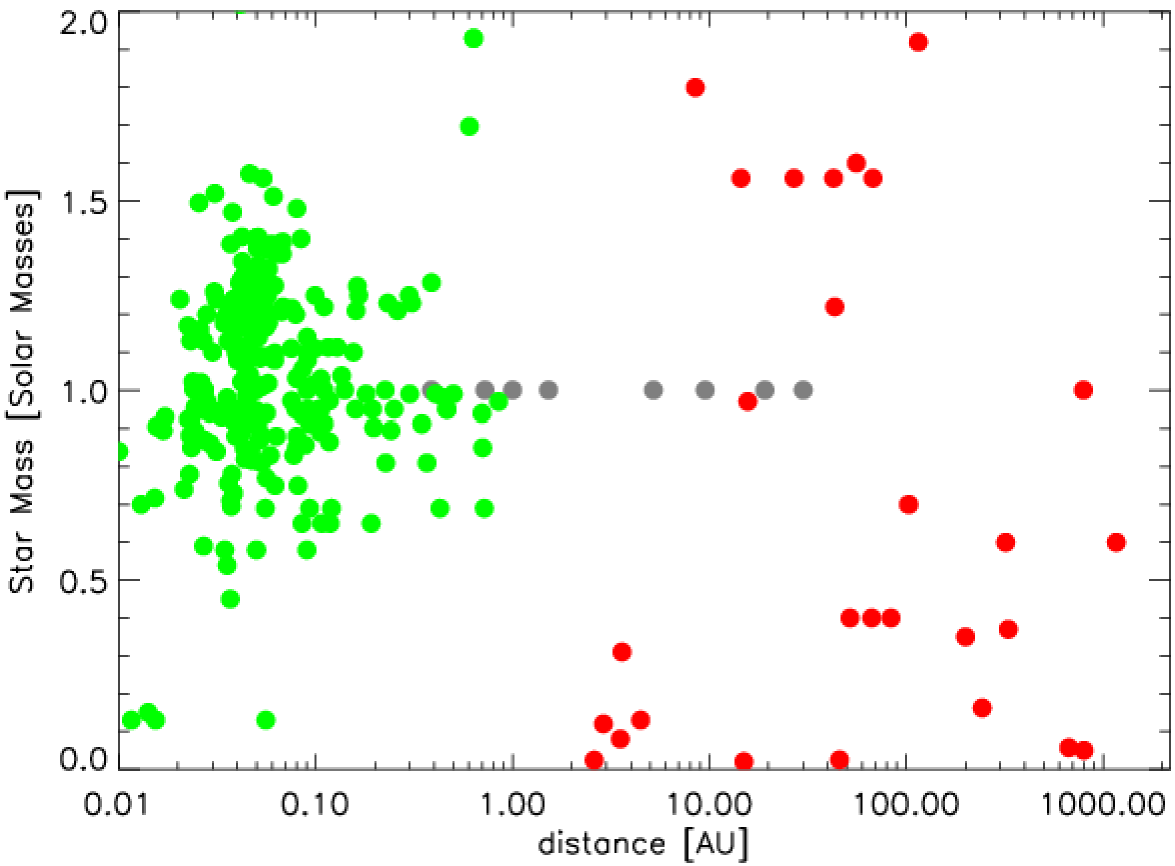


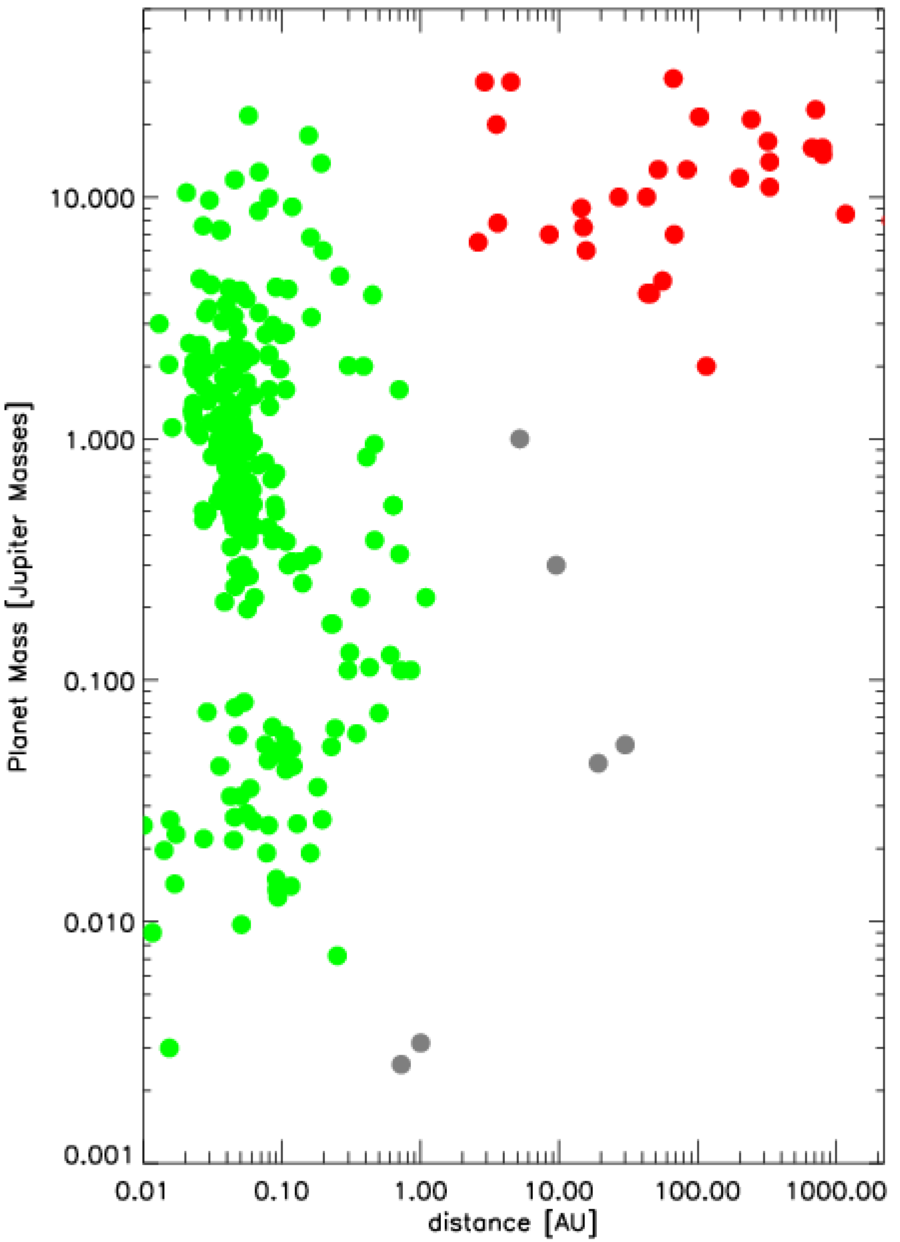
Planets detected by transit



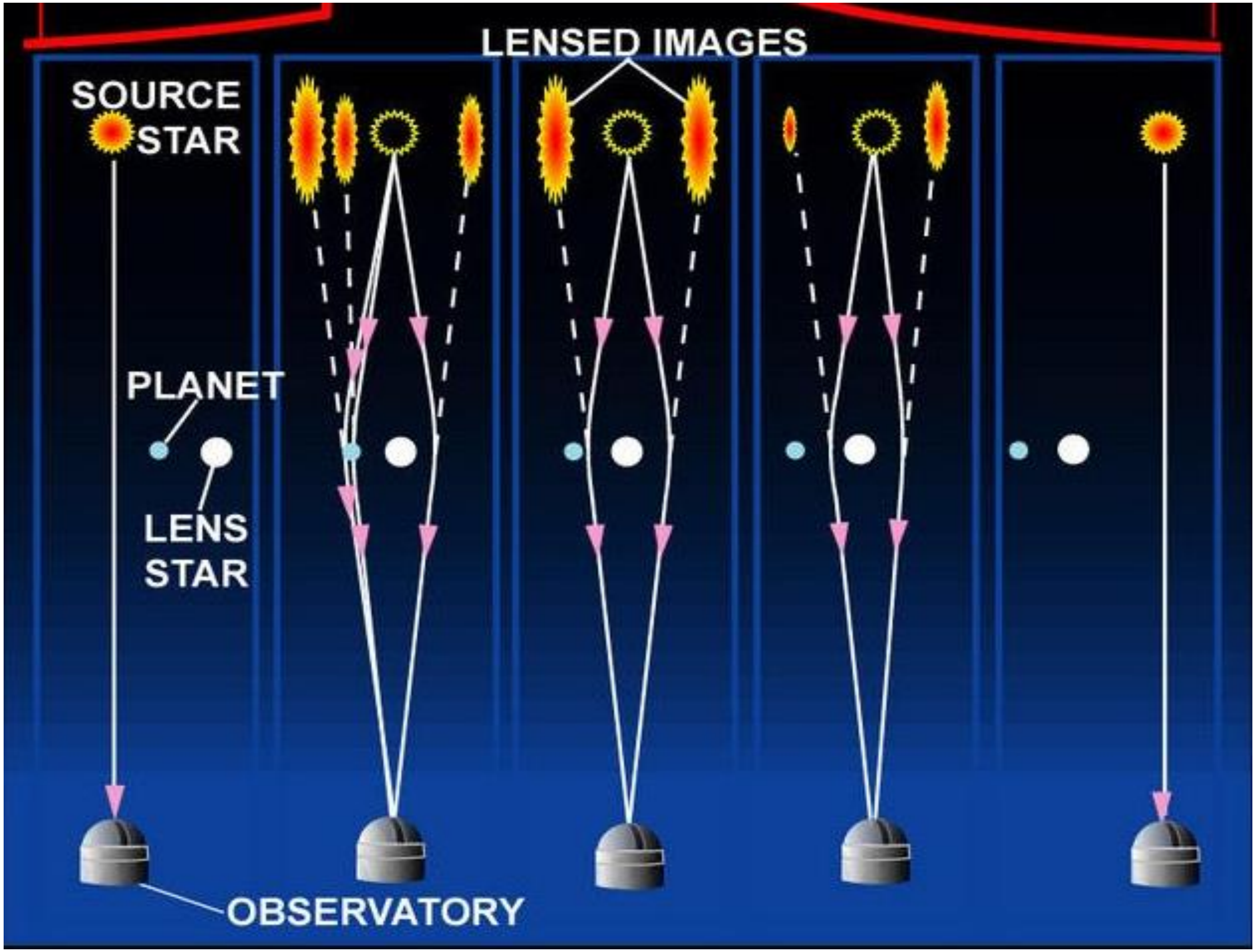


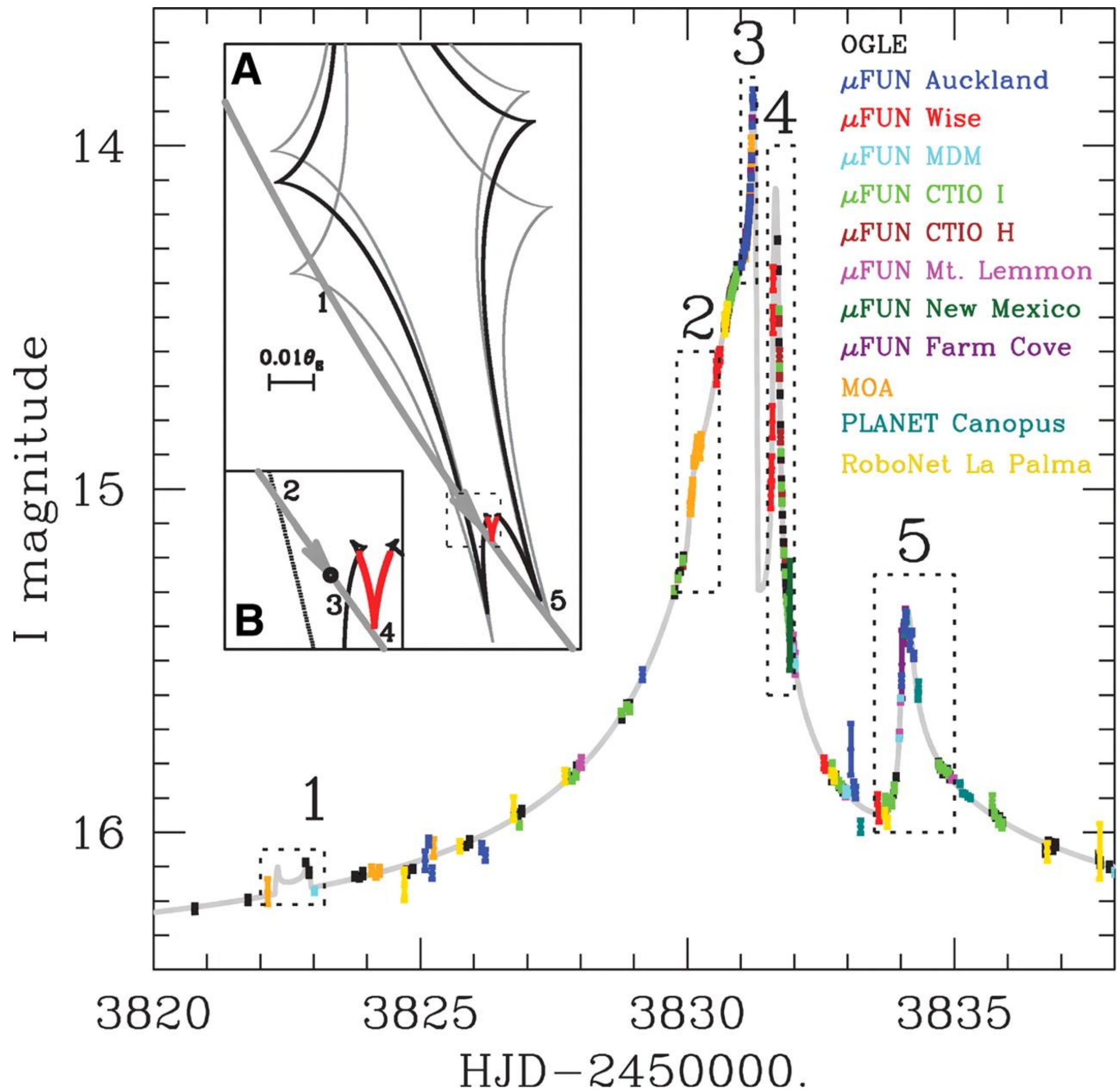
Planets detected by transit





Microlensing

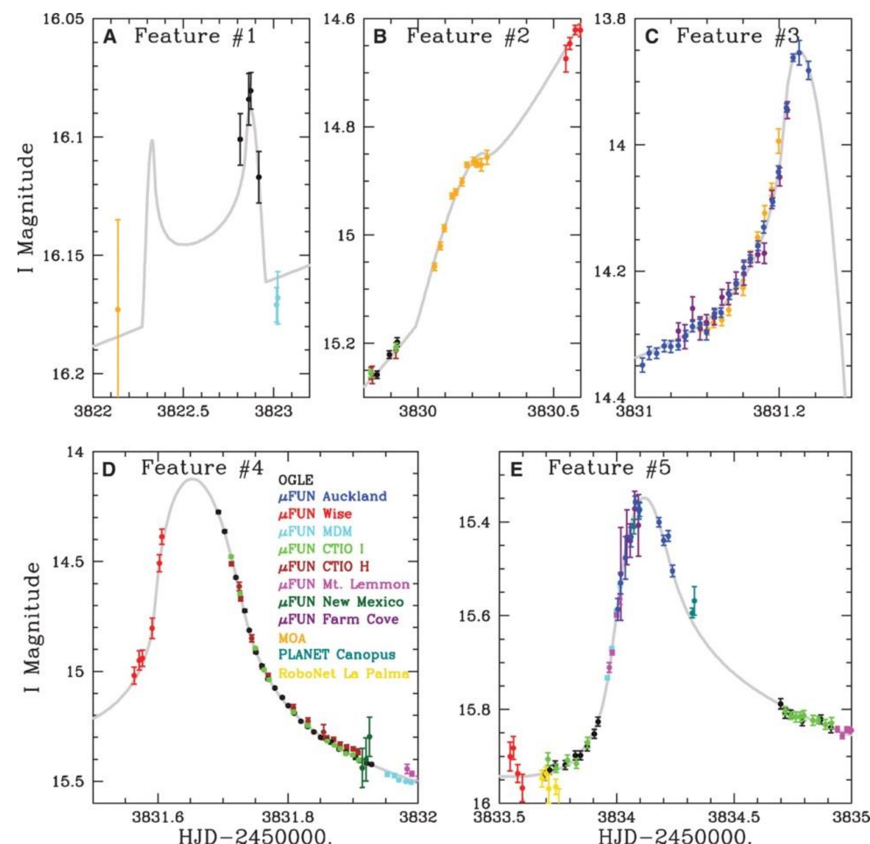




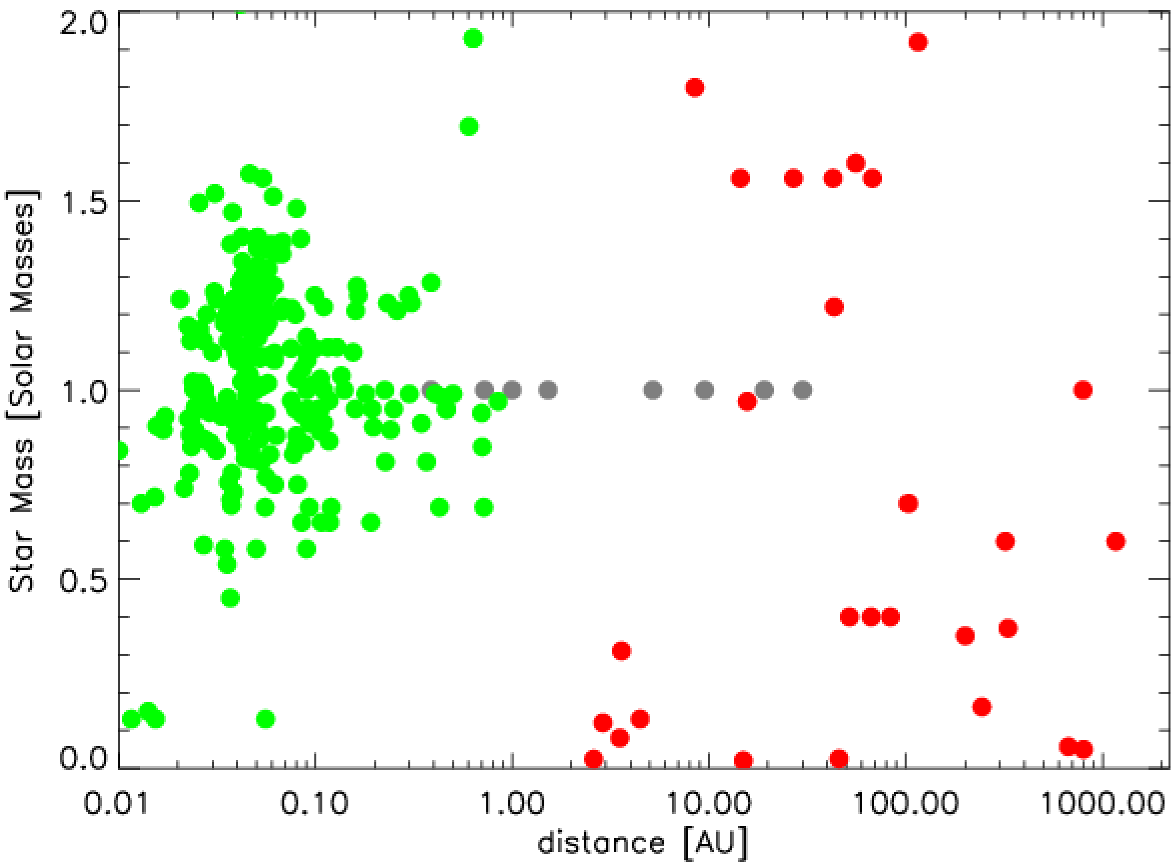
Discovery of a Jupiter/Saturn Analog with Gravitational Microlensing

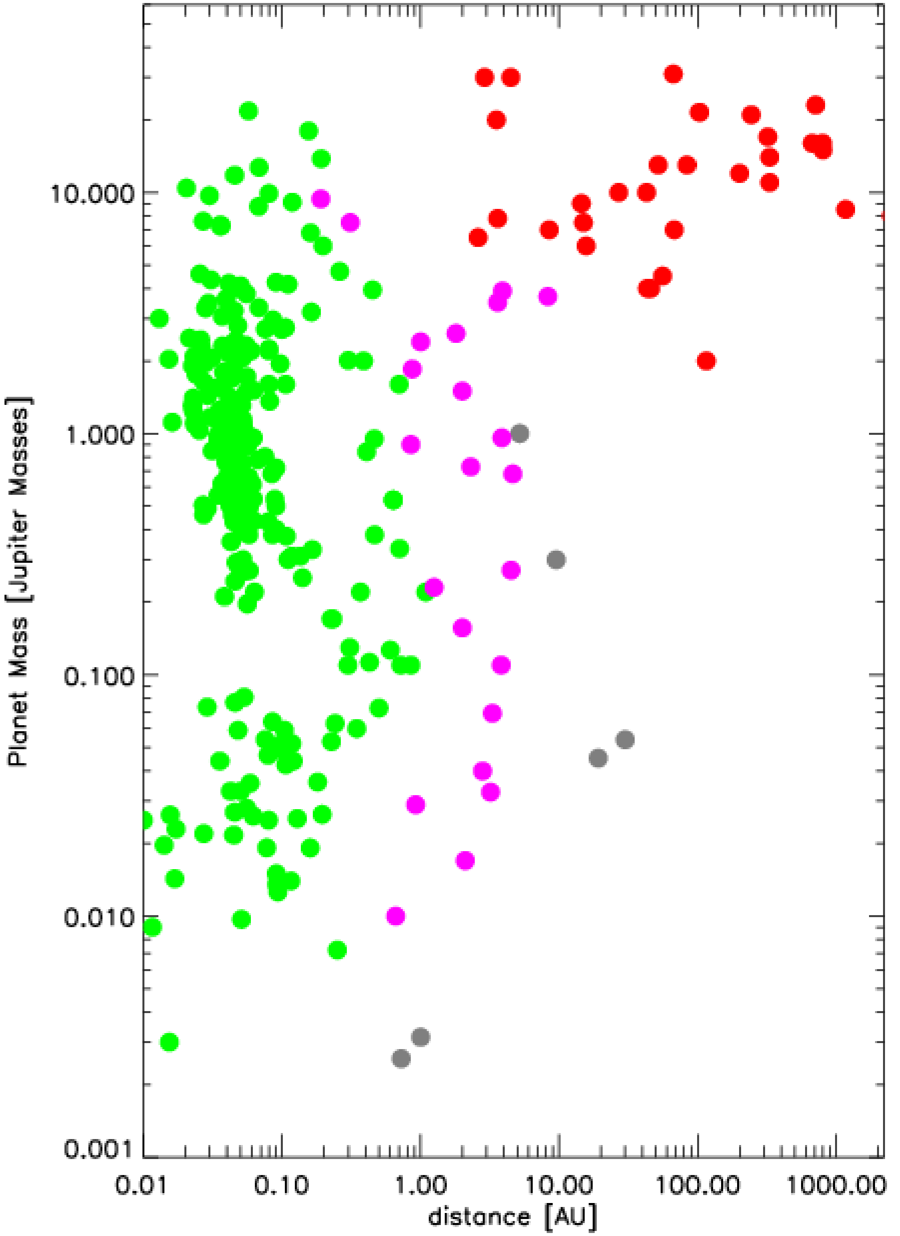
B. S. Gaudi,[1*] D. P. Bennett,[2] A. Udalski,[3] A. Gould,[1] G. W. Christie,[4] D. Maoz,[5] S. Dong,[1] J. McCormick,[6] M. K. Szymański,[3] P. J. Tristram,[7] S. Nikolaev,[8] B. Paczyński,[9]† M. Kubiak,[3] G. Pietrzyński,[3,10] I. Soszyński,[3] O. Szewczyk,[3] K. Ulaczyk,[3] Ł. Wyrzykowski,[3,11] (The OGLE Collaboration); D. L. DePoy,[1] C. Han,[12] S. Kaspi,[5] C.-U. Lee,[13] F. Mallia,[14] T. Natusch,[4] R. W. Pogge,[1] B.-G. Park,[13] (The μFUN Collaboration); F. Abe,[15] I. A. Bond,[16] C. S. Botzler,[17] A. Fukui,[15] J. B. Hearnshaw,[18] Y. Itow,[15] K. Kamiya,[15] A. V. Korpela,[19] P. M. Kilmartin,[7] W. Lin,[16] K. Masuda,[15] Y. Matsubara,[15] M. Motomura,[15] Y. Muraki,[20] S. Nakamura,[15] T. Okumura,[15] K. Ohnishi,[21] N. J. Rattenbury,[22] T. Sako,[15] To. Saito,[23] S. Sato,[24] L. Skuljan,[16] D. J. Sullivan,[19] T. Sumi,[15] W. L. Sweatman,[16] P. C. M. Yock,[17] (The MOA Collaboration); M. D. Albrow,[18] A. Allan,[25] J.-P. Beaulieu,[26] M. J. Burgdorf,[27] K. H. Cook,[8] C. Coutures,[26] M. Dominik,[28] S. Dieters,[29] P. Fouqué,[30] J. Greenhill,[29] K. Horne,[28] I. Steele,[27] Y. Tsapras,[27] (From the PLANET and RoboNet Collaborations); B. Chaboyer,[31] A. Crocker,[32] S. Frank,[1] B. Macintosh[8]

Searches for extrasolar planets have uncovered an astonishing diversity of planetary systems, yet the frequency of solar system analogs remains unknown. The gravitational microlensing planet search method is potentially sensitive to multiple-planet systems containing analogs of all the solar system planets except Mercury. We report the detection of a multiple-planet system with microlensing. We identify two planets with masses of ~0.71 and ~0.27 times the mass of Jupiter and orbital separations of ~2.3 and ~4.6 astronomical units orbiting a primary star of mass ~0.50 solar mass at a distance of ~1.5 kiloparsecs. This system resembles a scaled version of our solar system in that the mass ratio, separation ratio, and equilibrium temperatures of the planets are similar to those of Jupiter and Saturn. These planets could not have been detected with other techniques; their discovery from only six confirmed microlensing planet detections suggests that solar system analogs may be common.

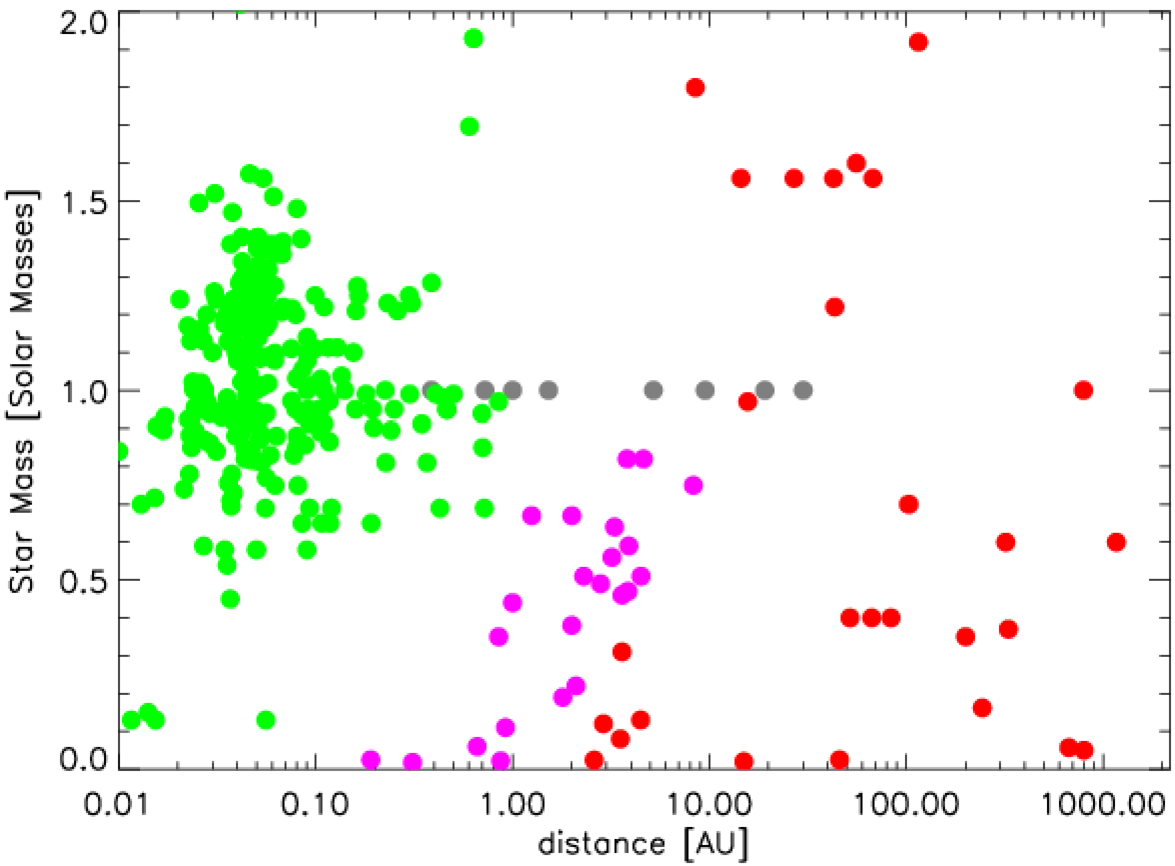


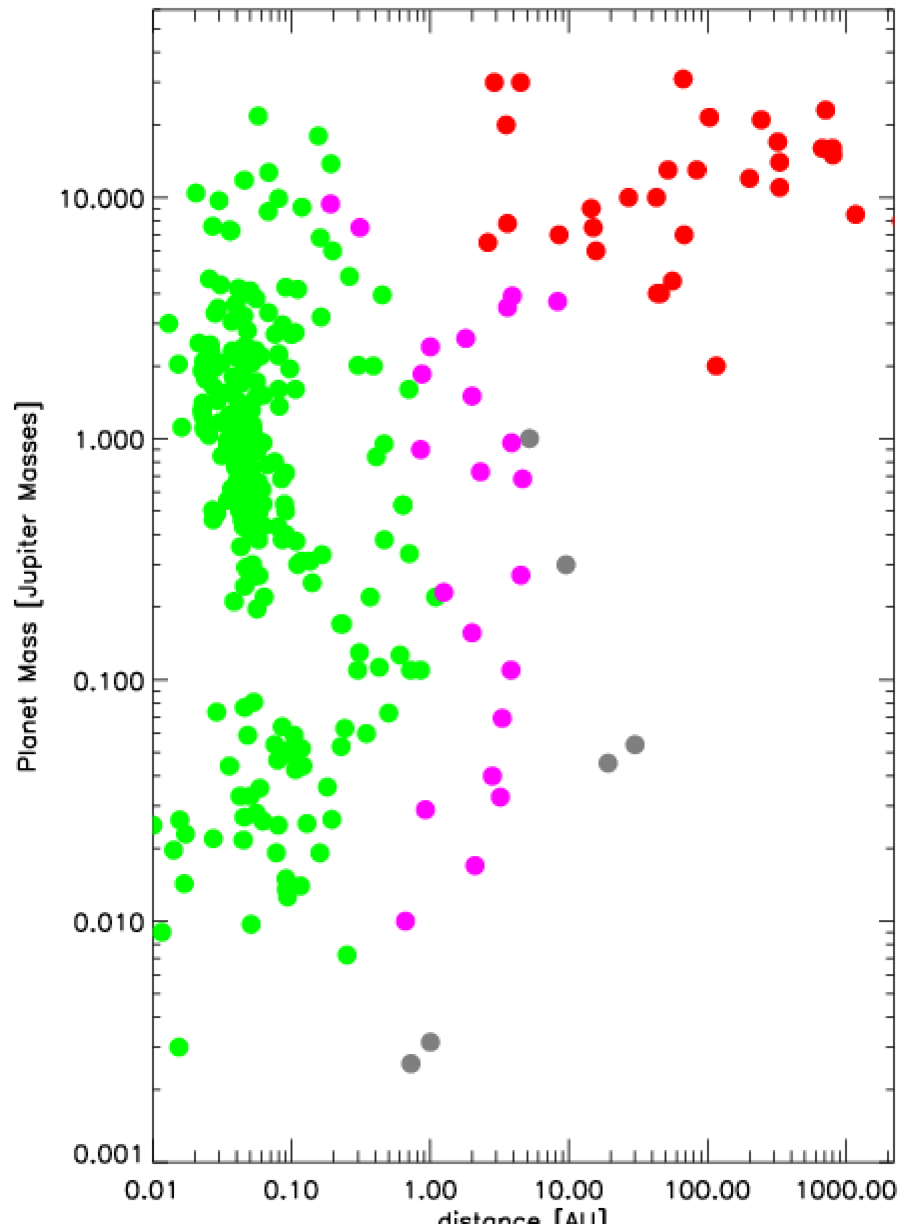
Planets detected by micro-lensing



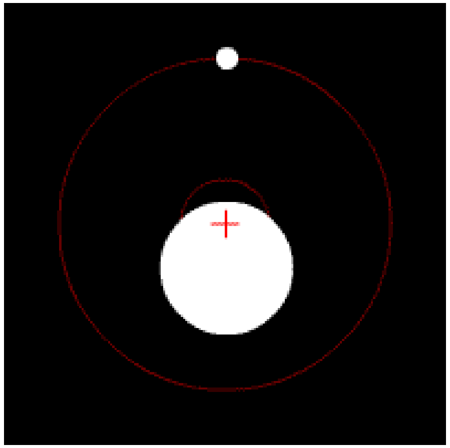


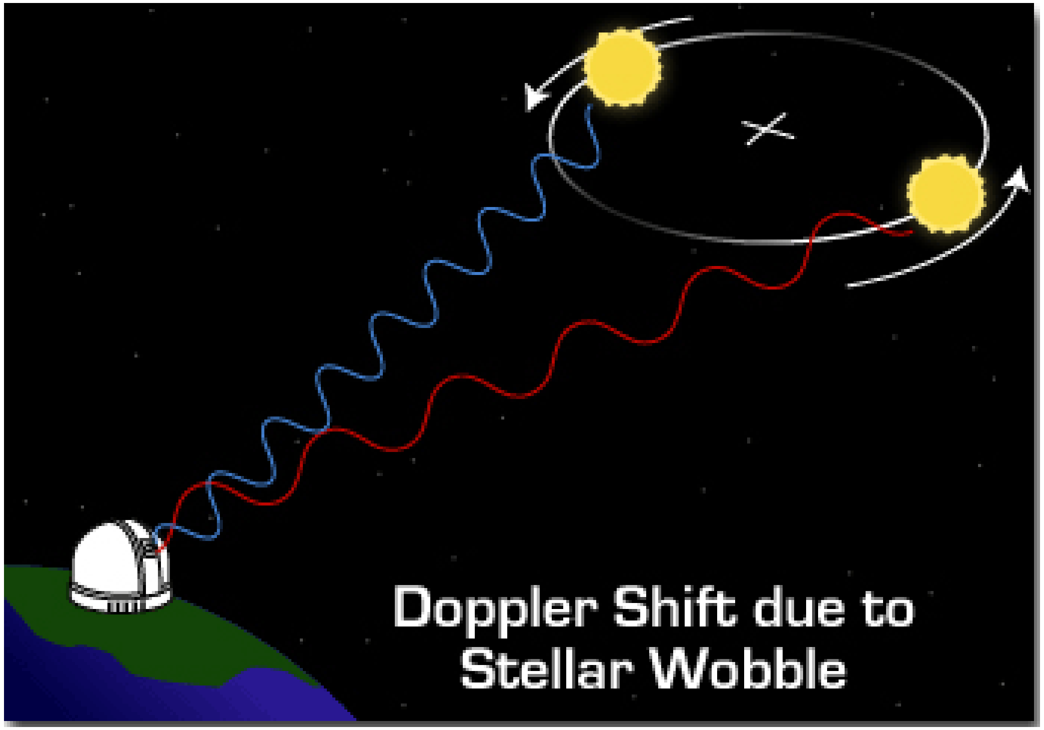
Planets detected by micro-lensing

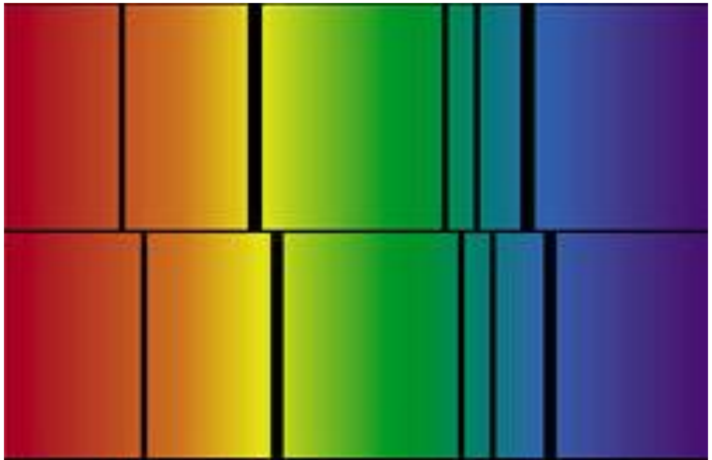




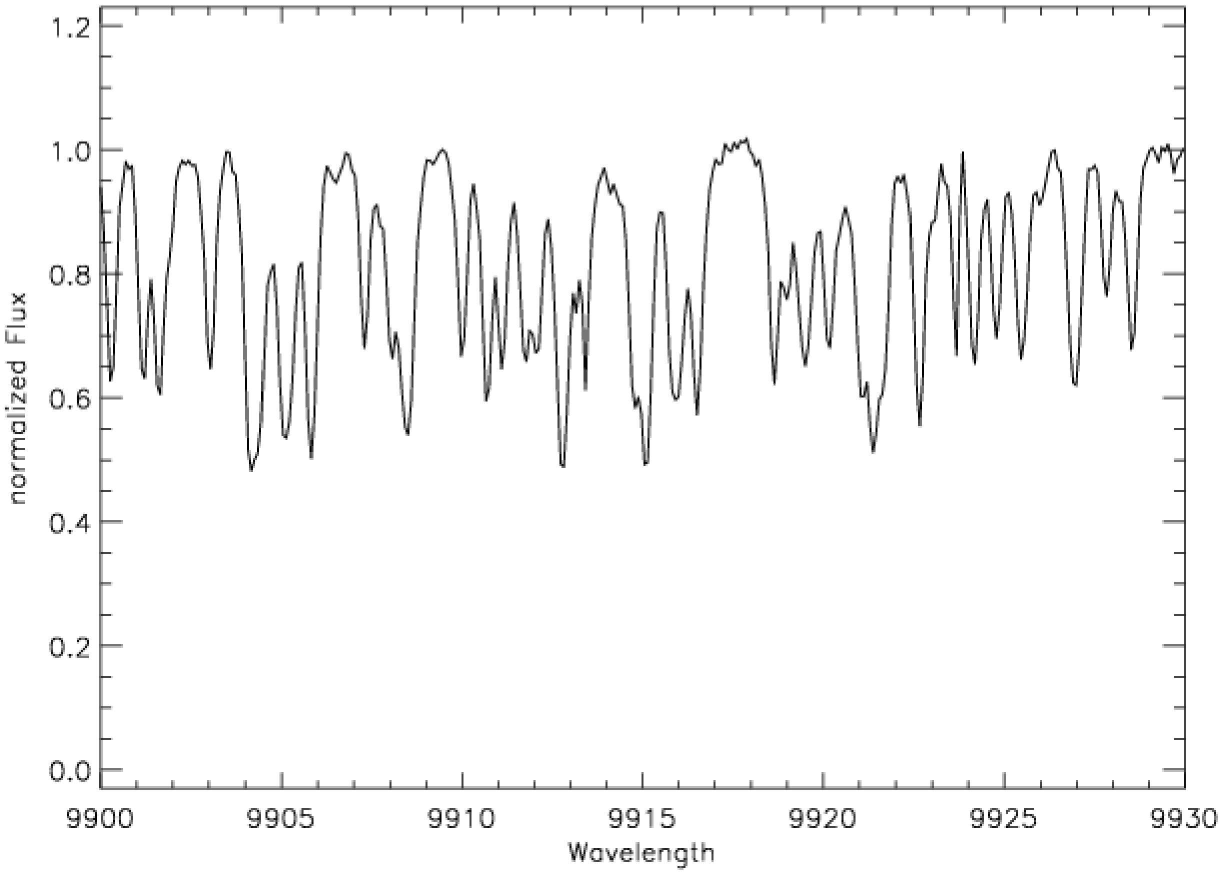
Radial velocities



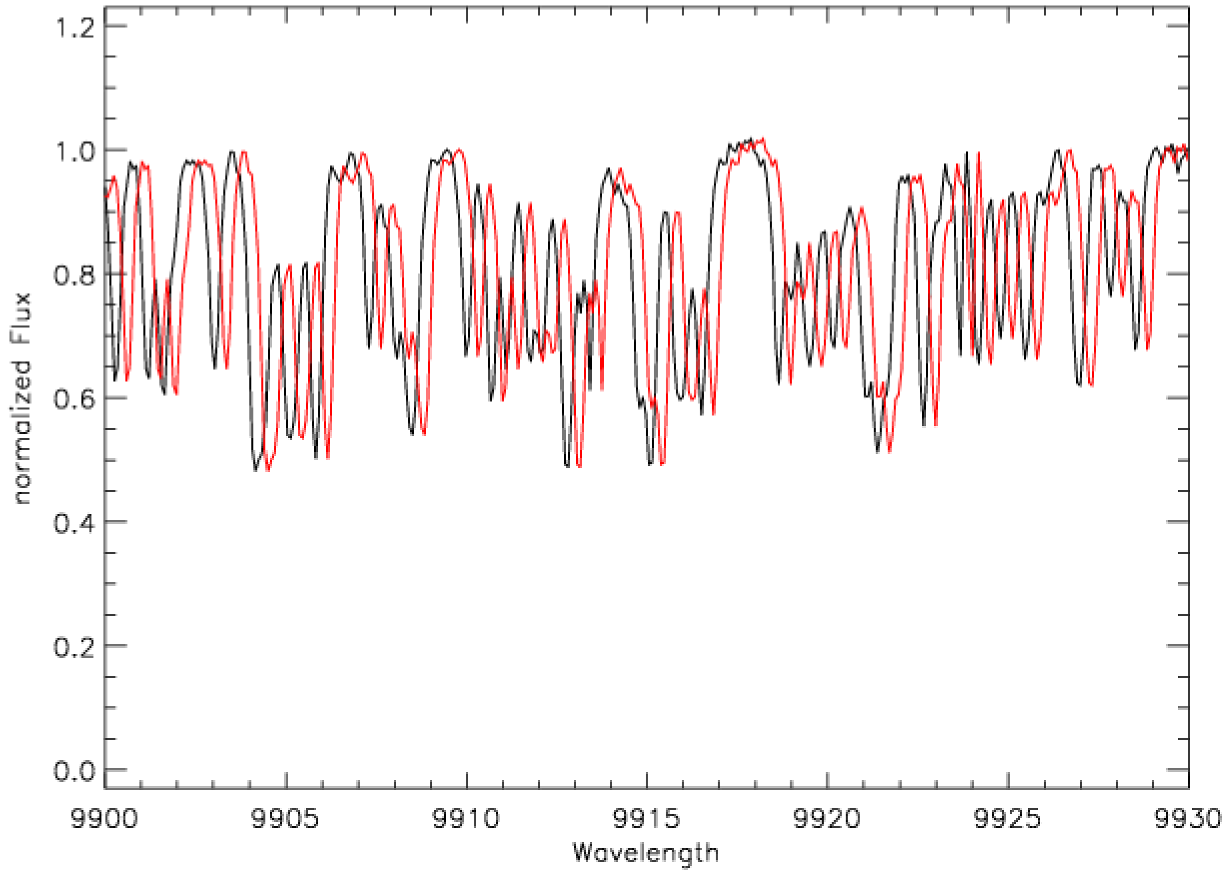




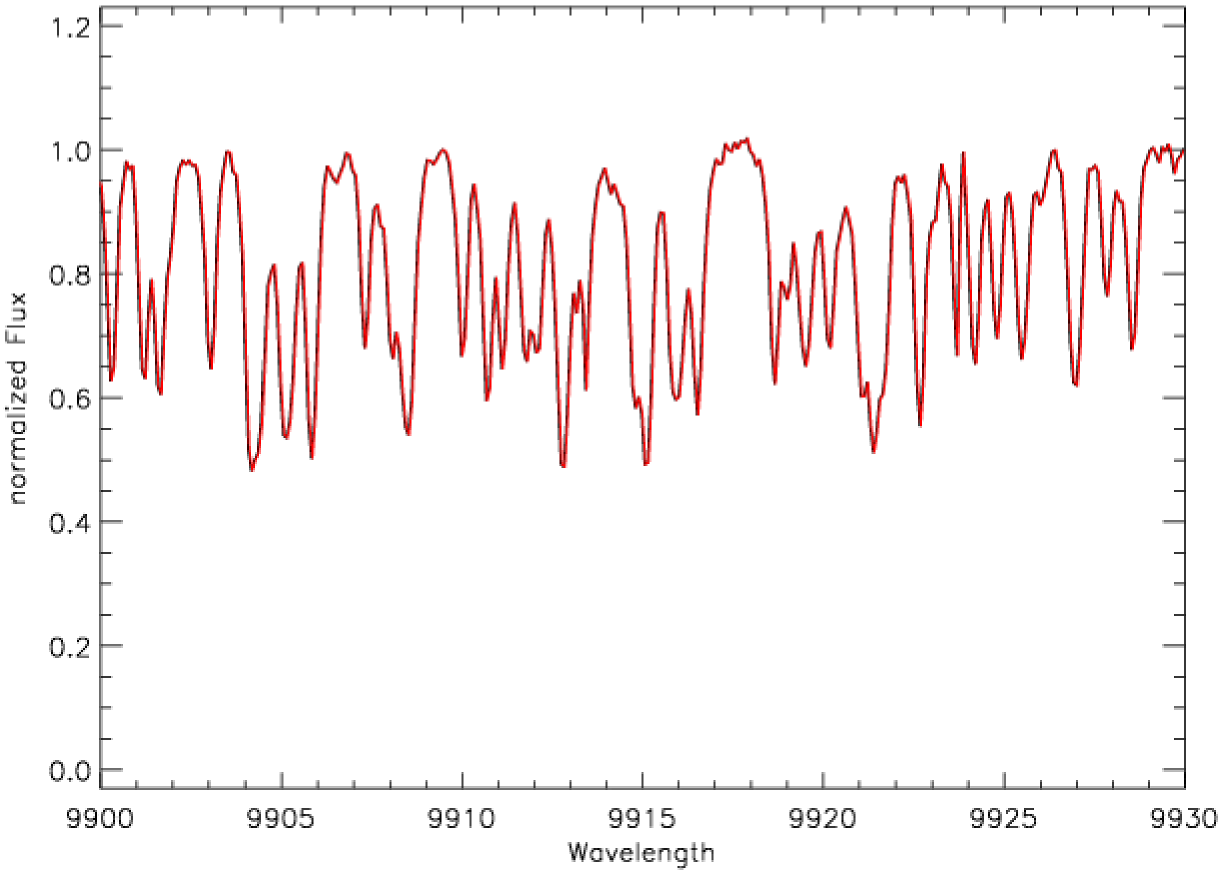
single spectrum



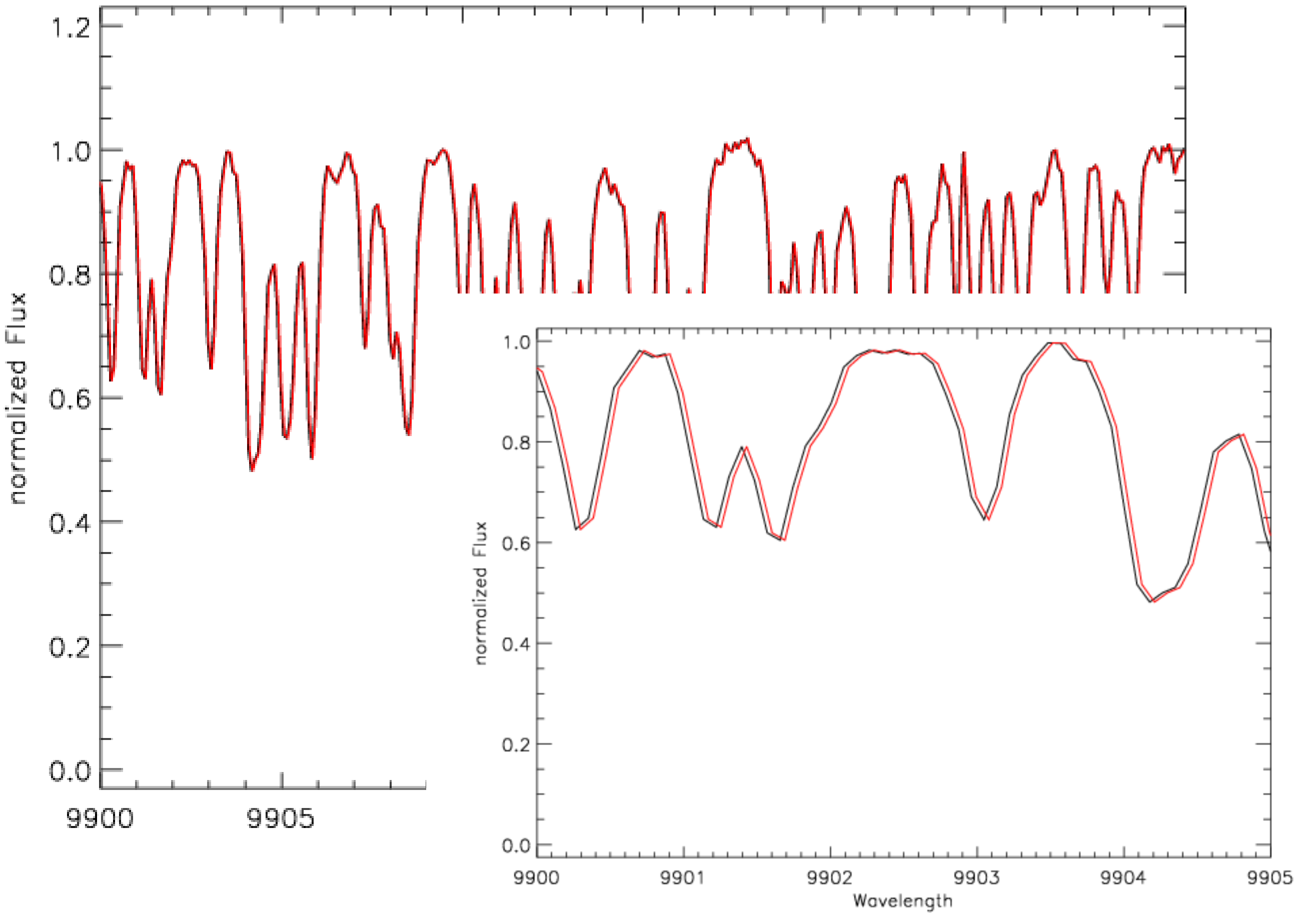
Doppler shift v_{rad}=10 km/s



Doppler shift v_{rad}=1 km/s

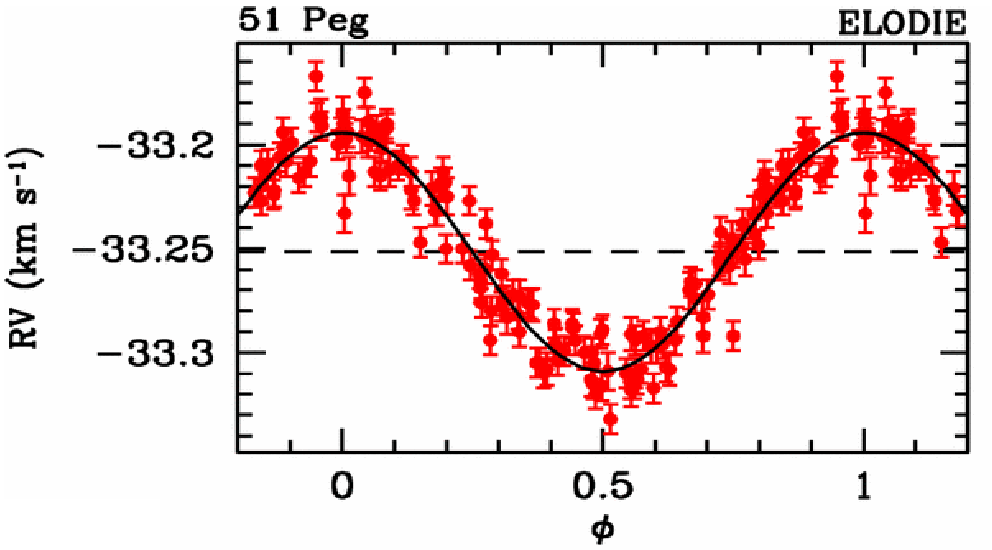


Doppler shift v_{rad}=1 km/s

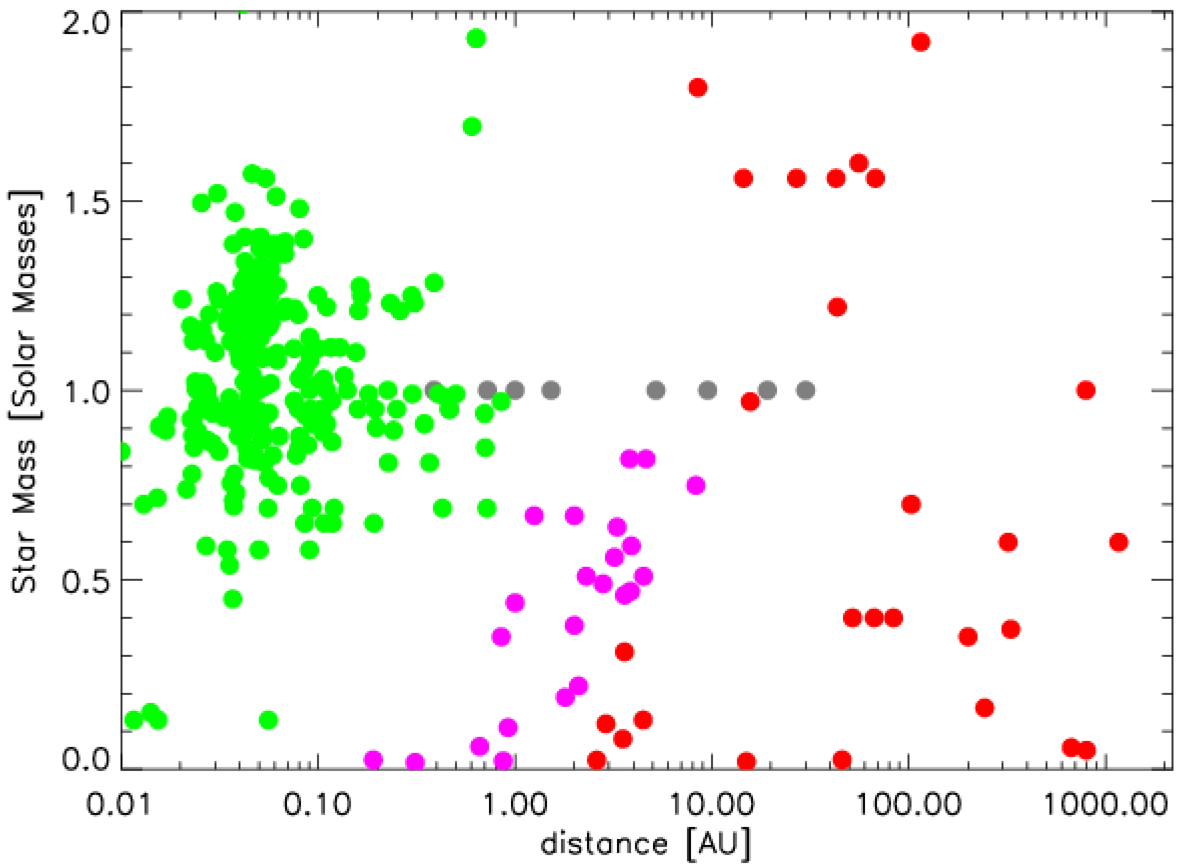


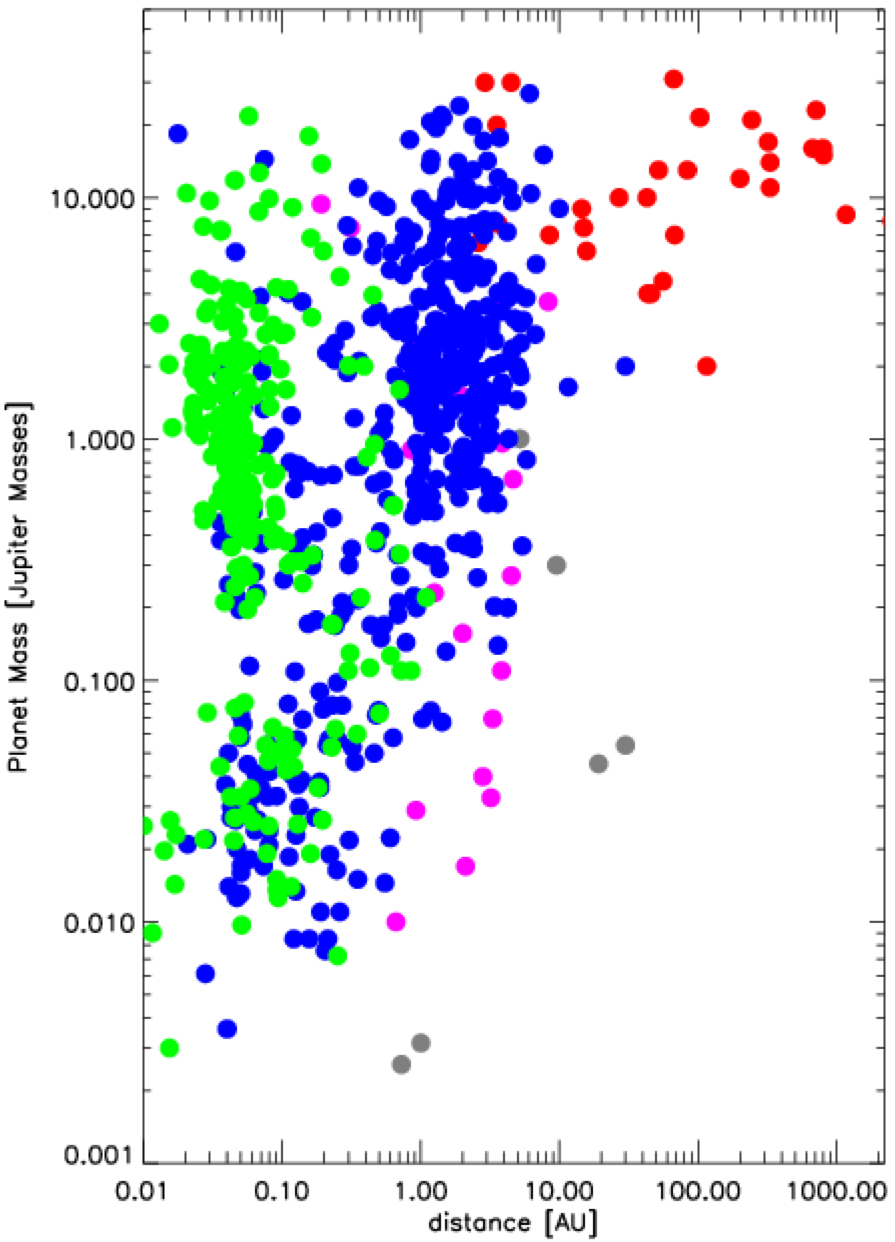
Precision today: ~1m/s

< 1/1000 pixel (!)

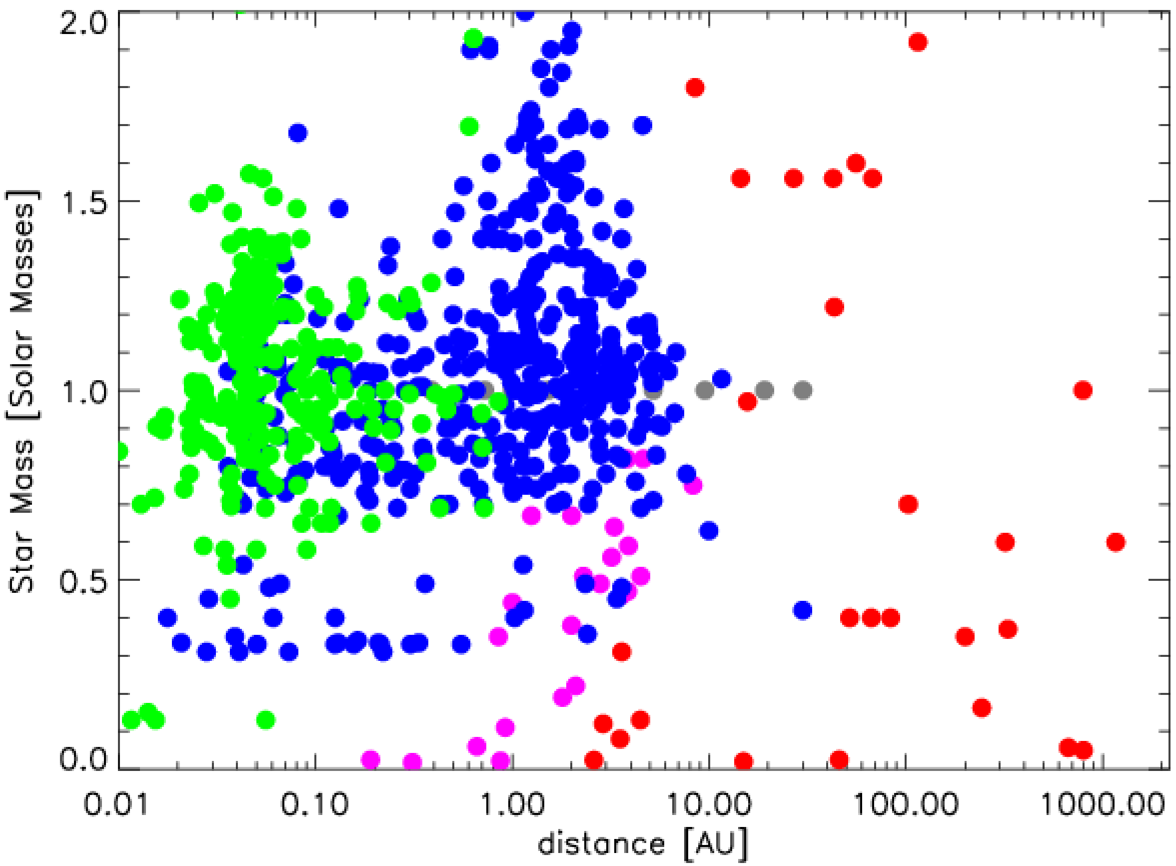


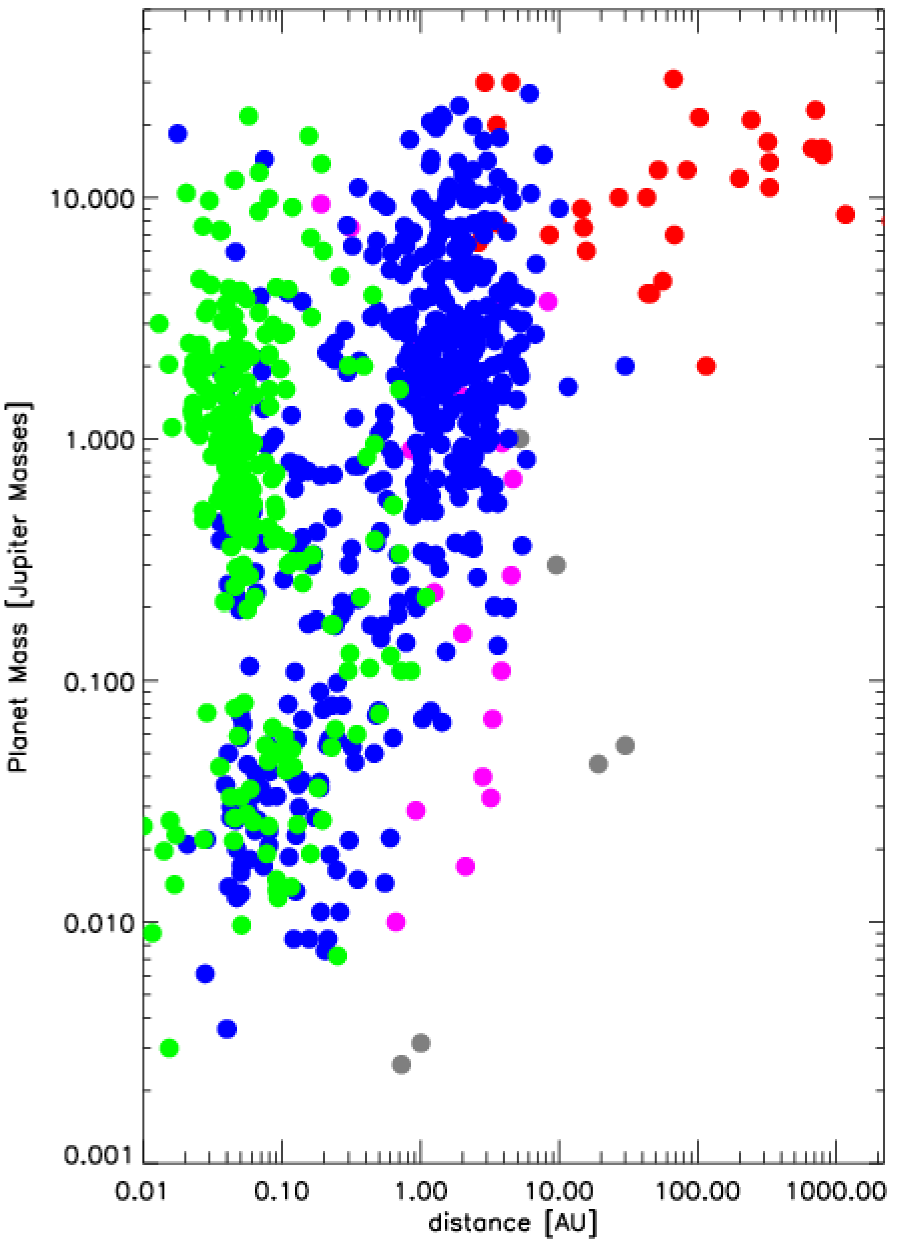
Planets detected using radial velocities



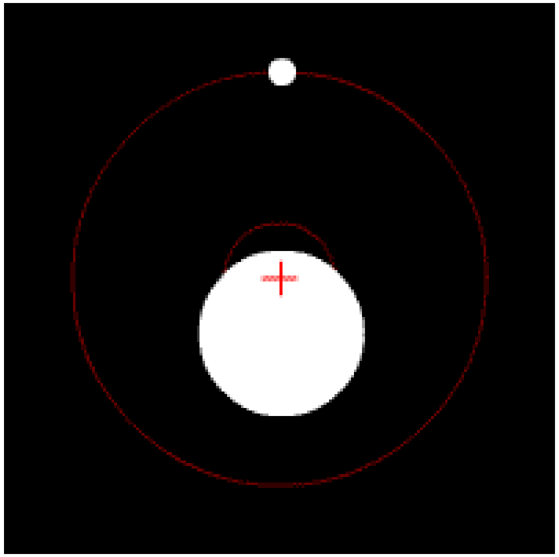


Planets detected using radial velocities

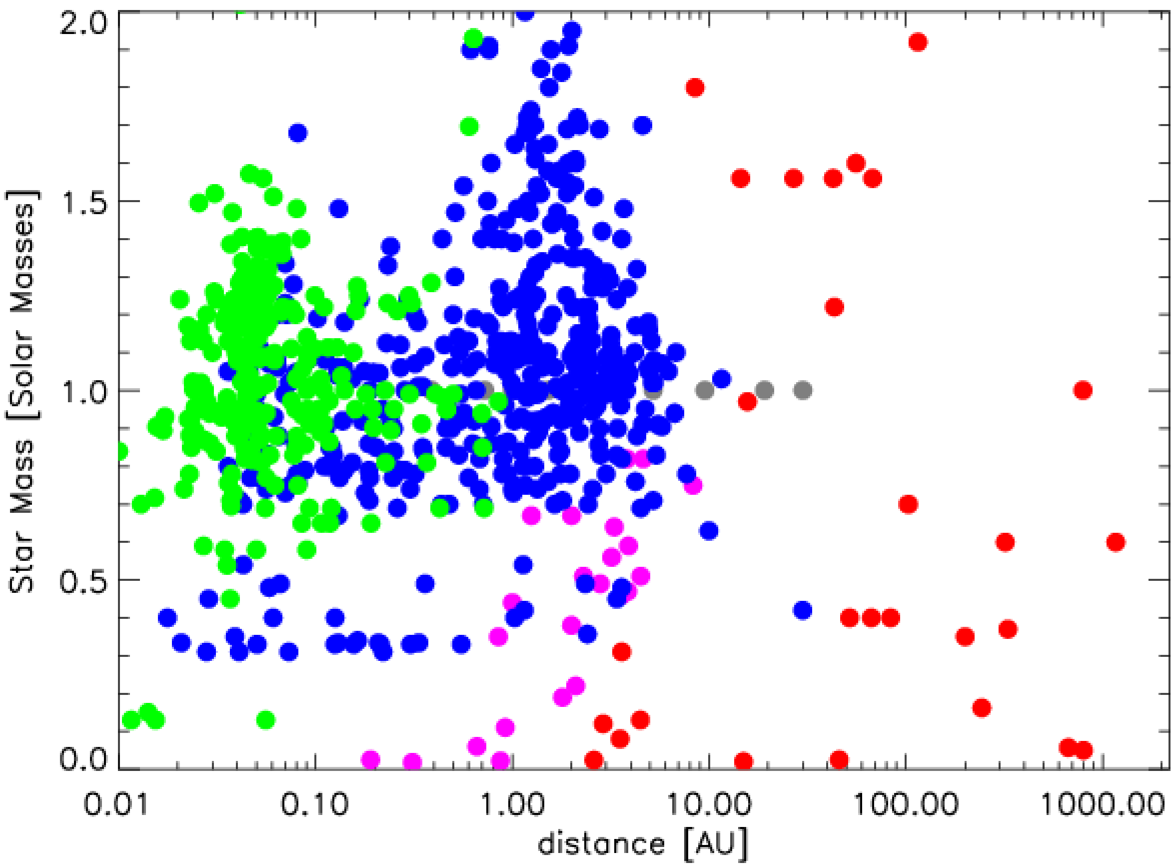


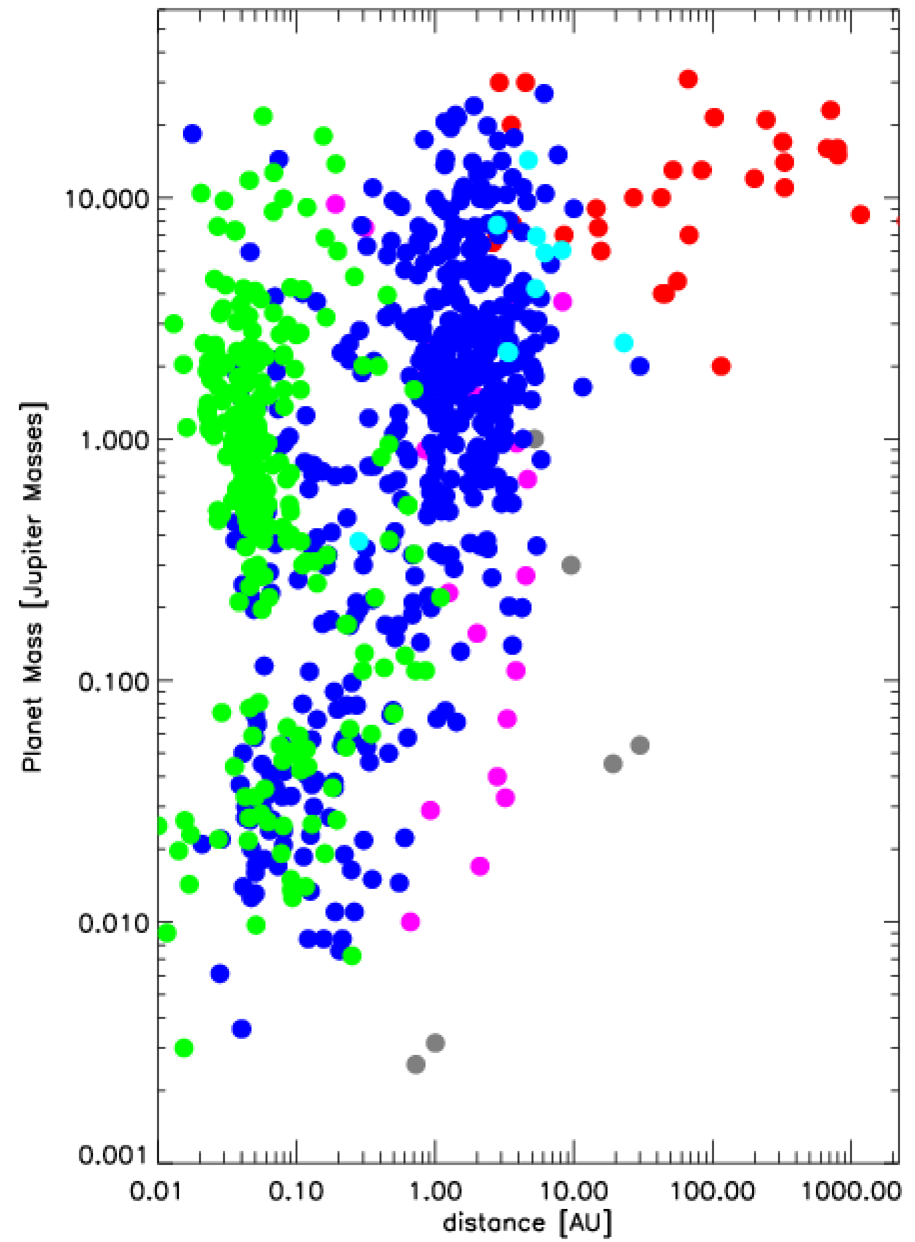


Transit timing

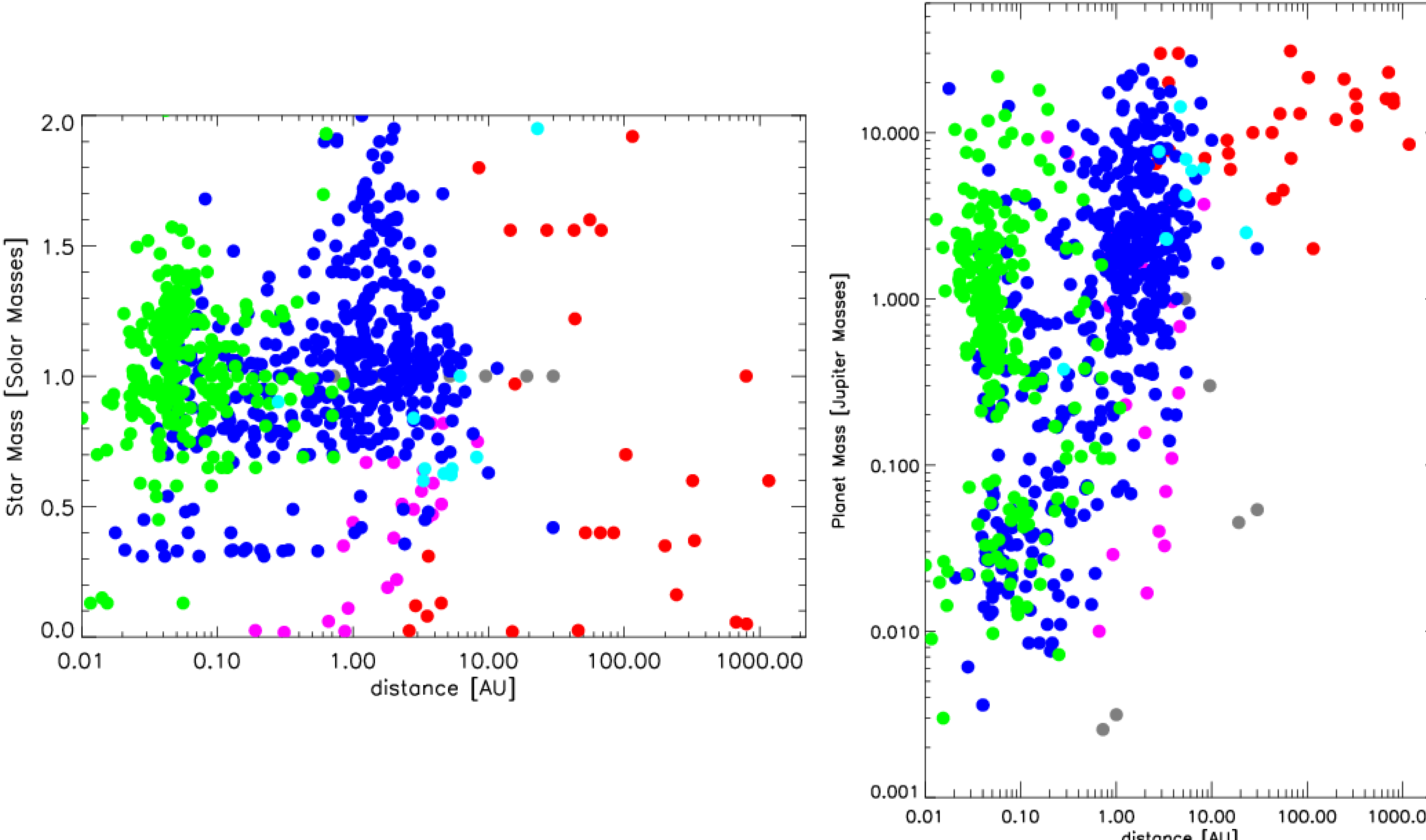


Planets detected with transit timing

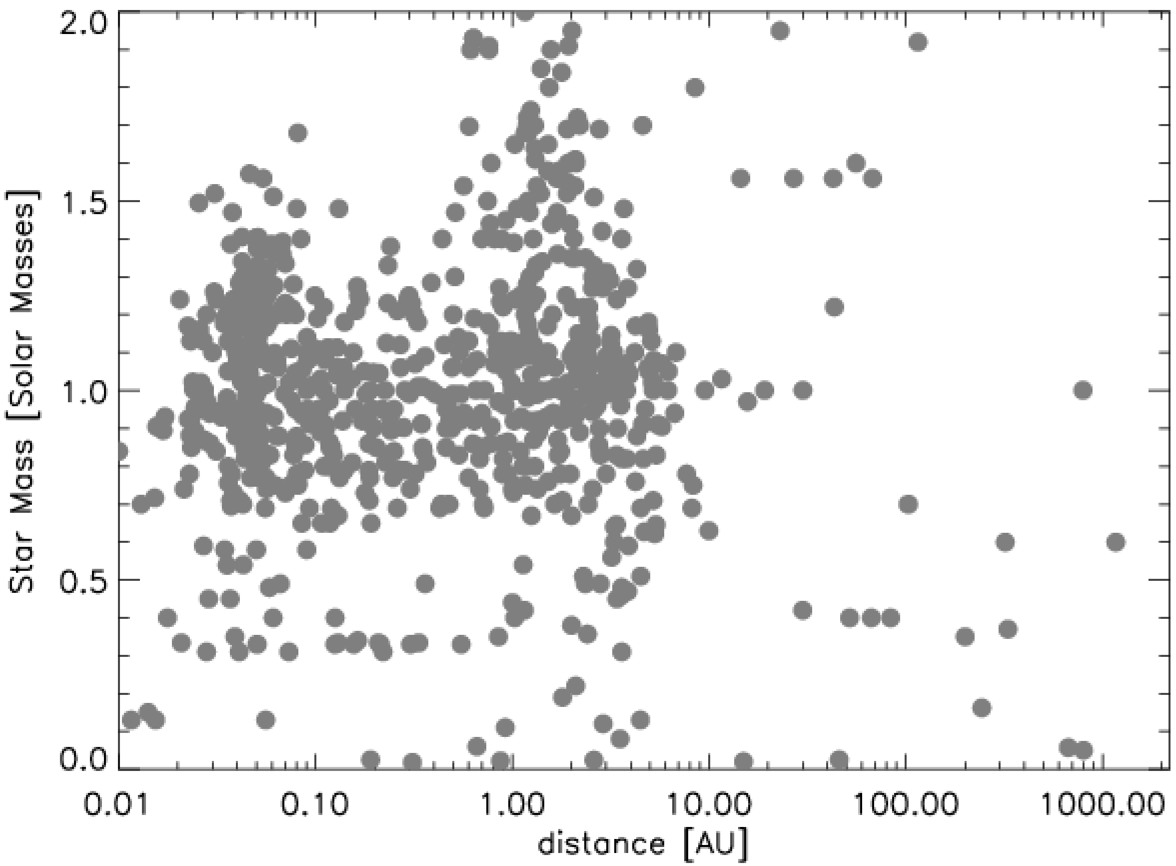


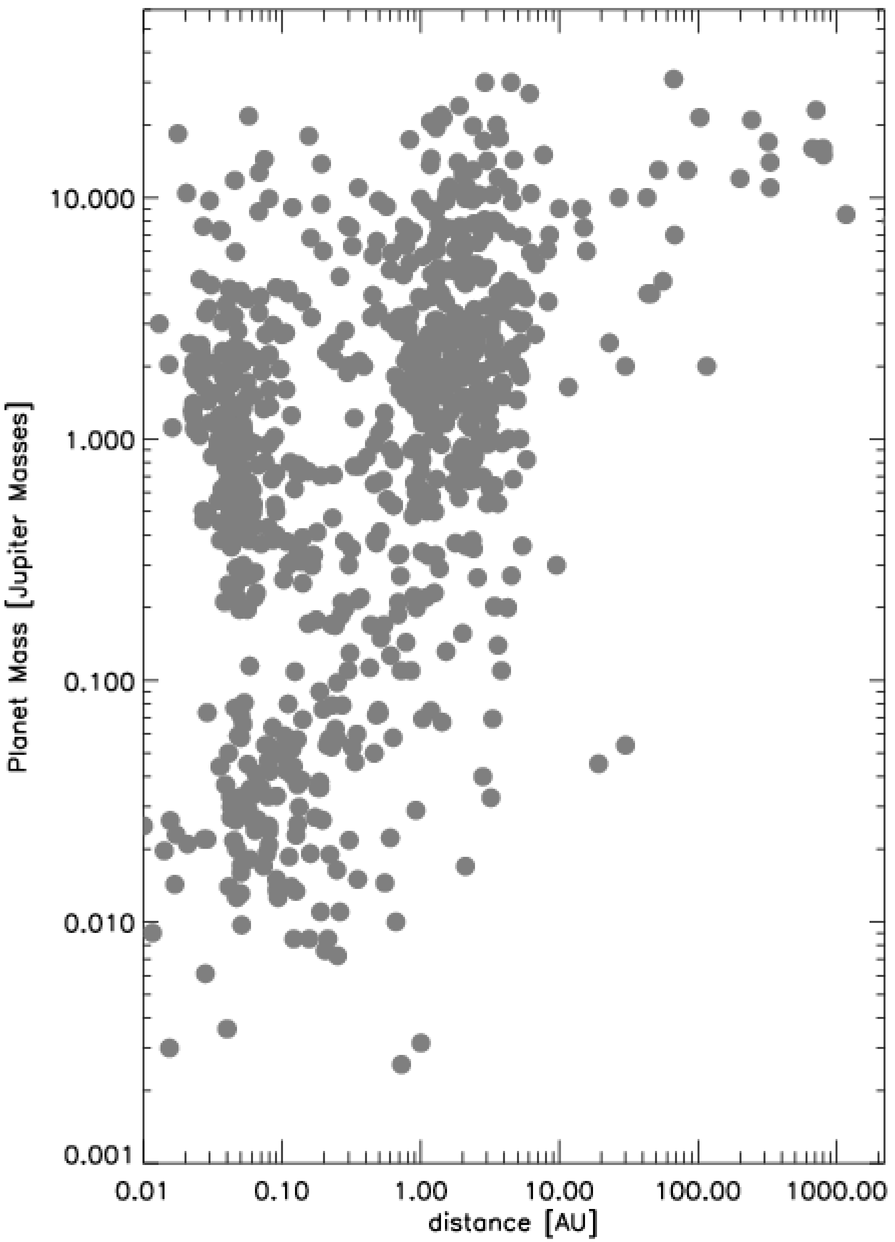


Planets detected with transit timing

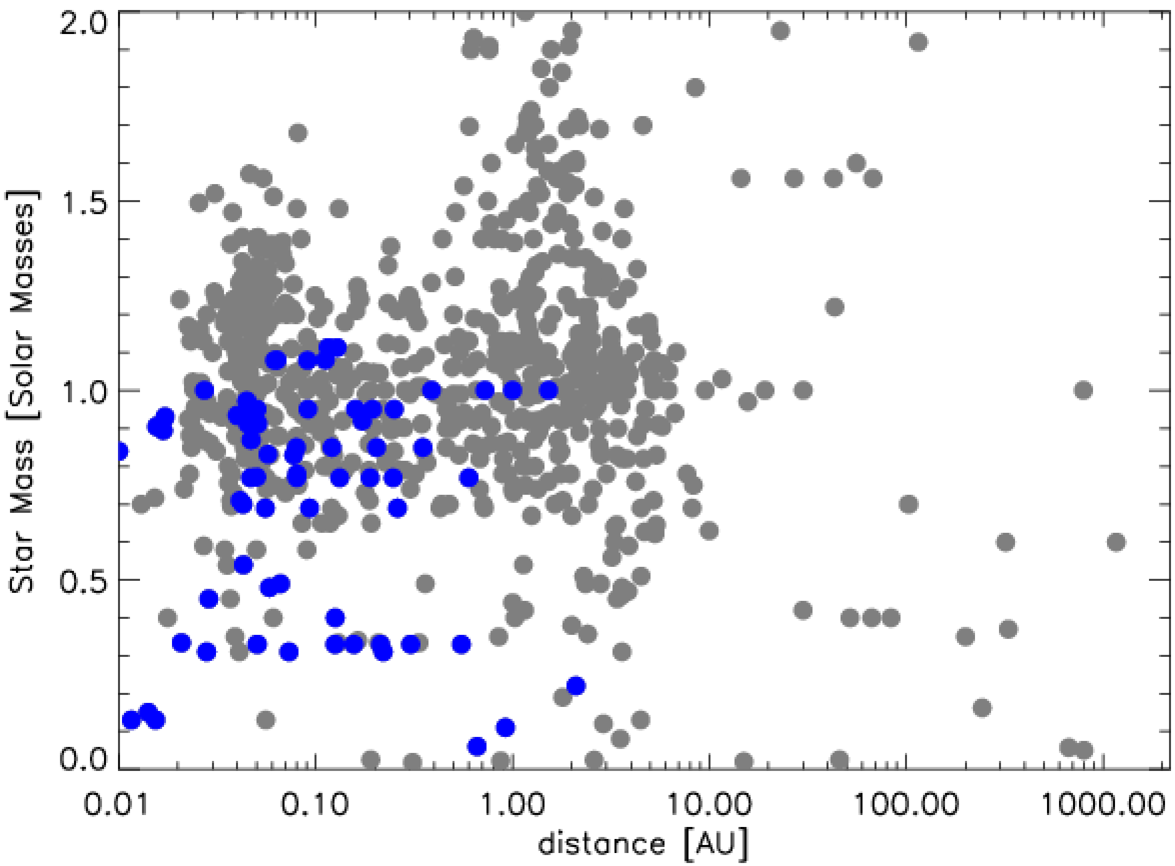


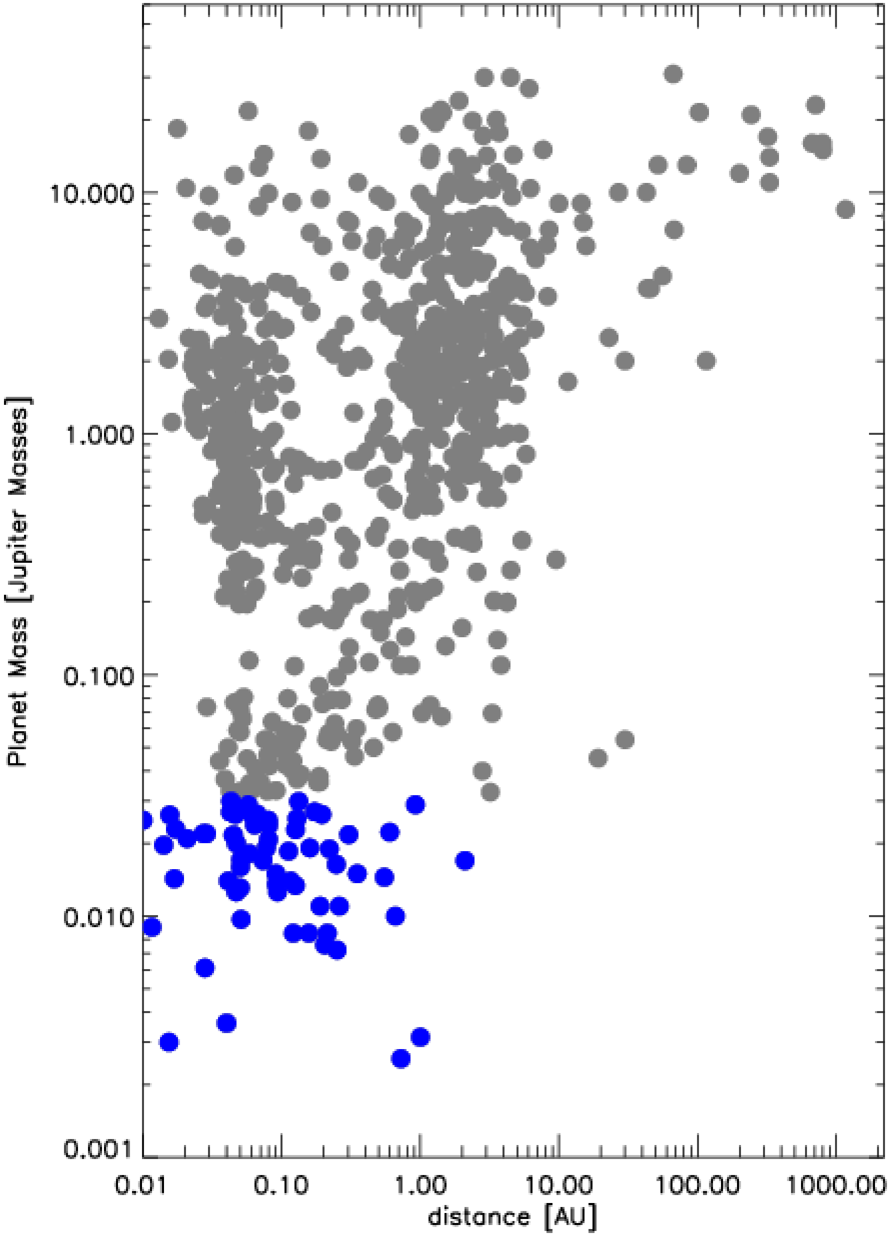
Habitability



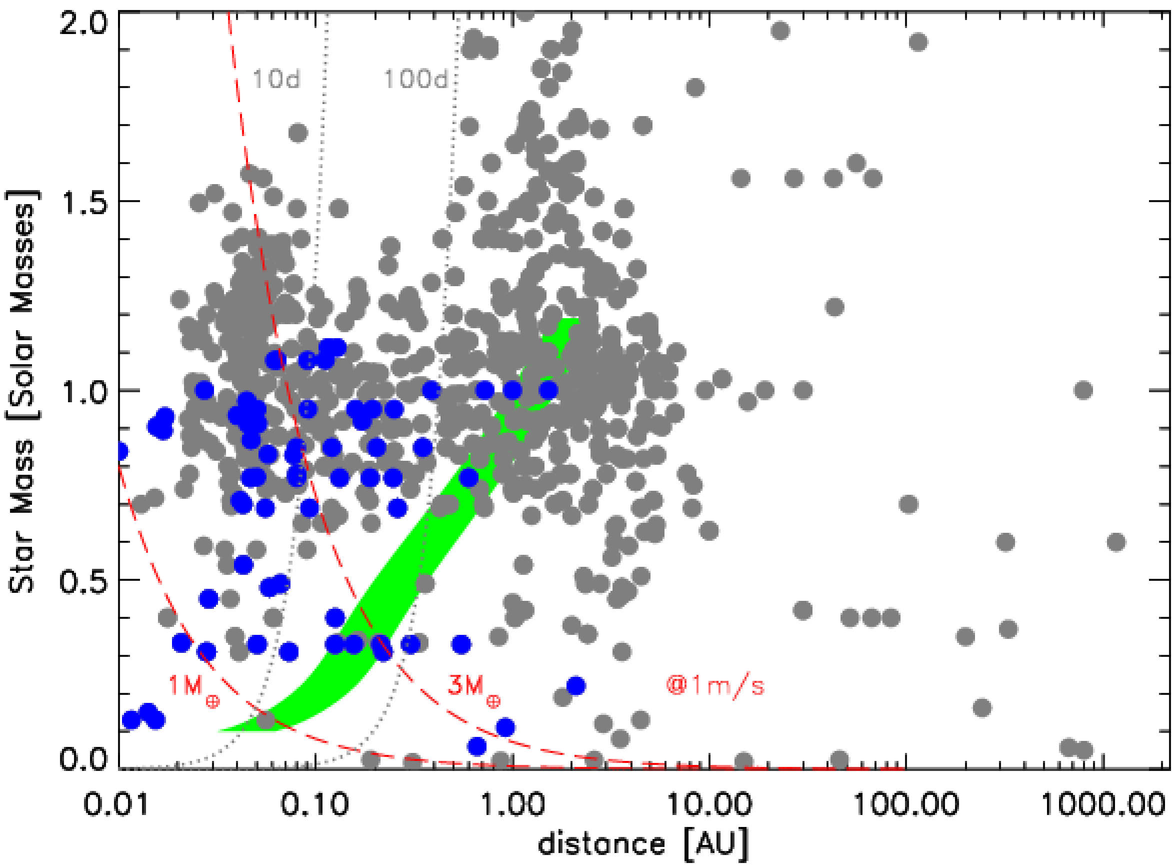


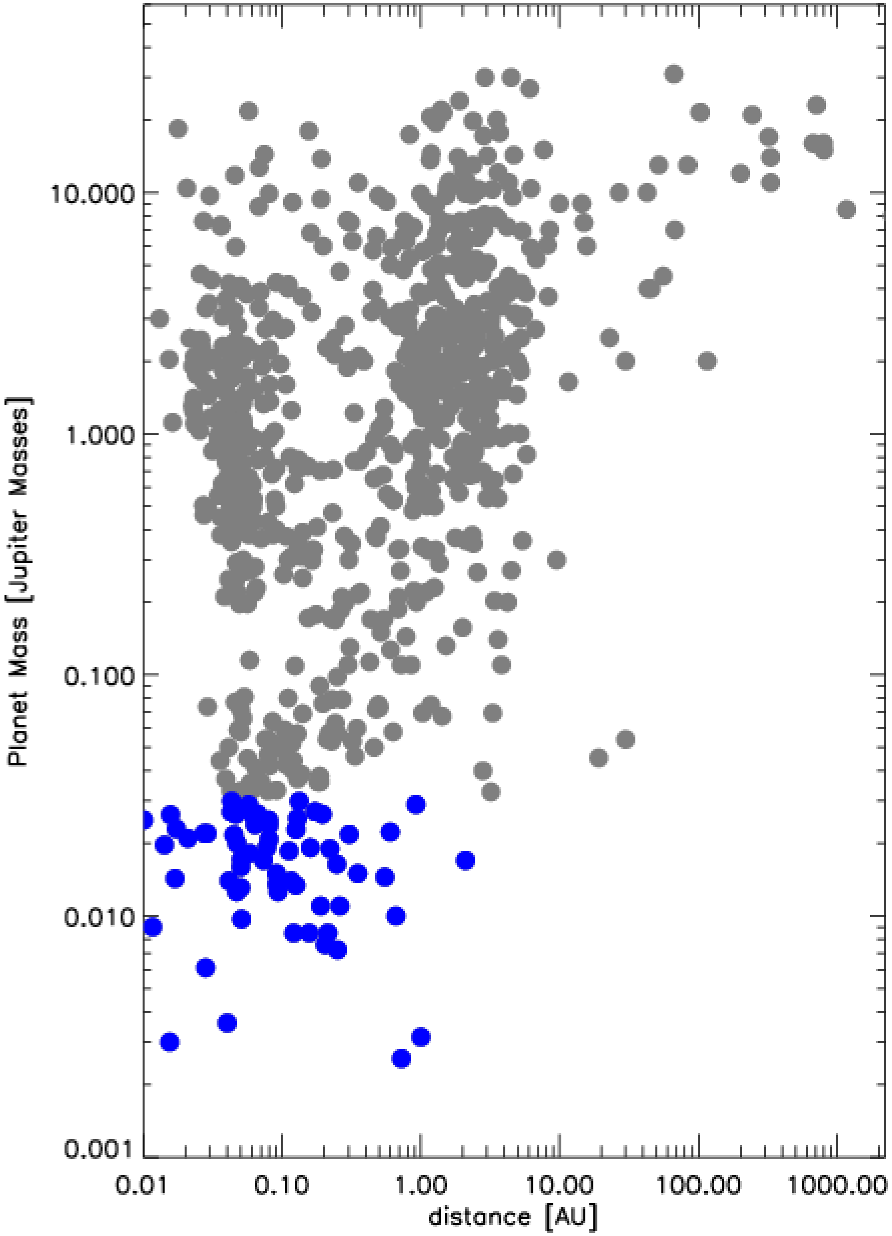
Habitability



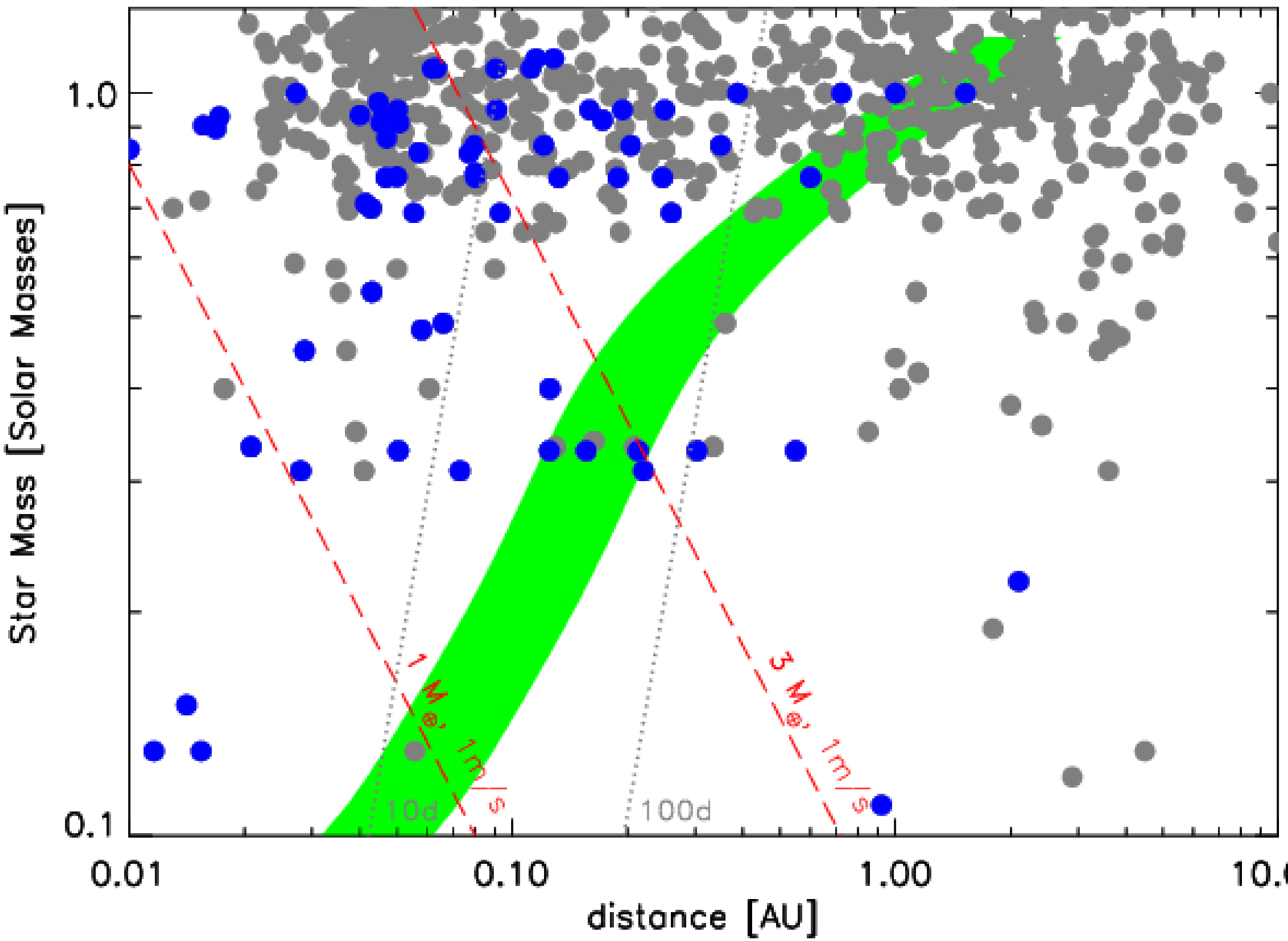


Habitability

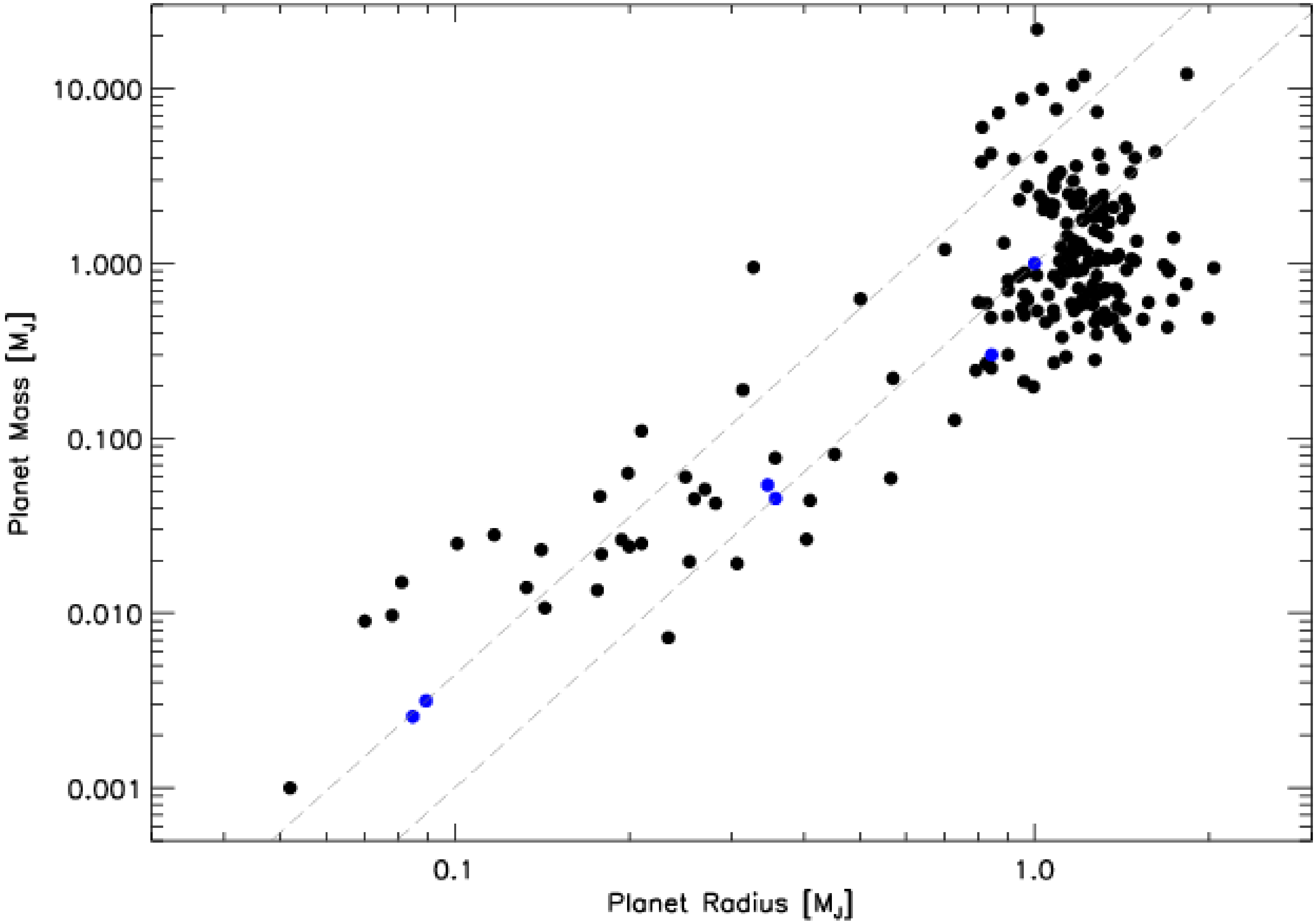




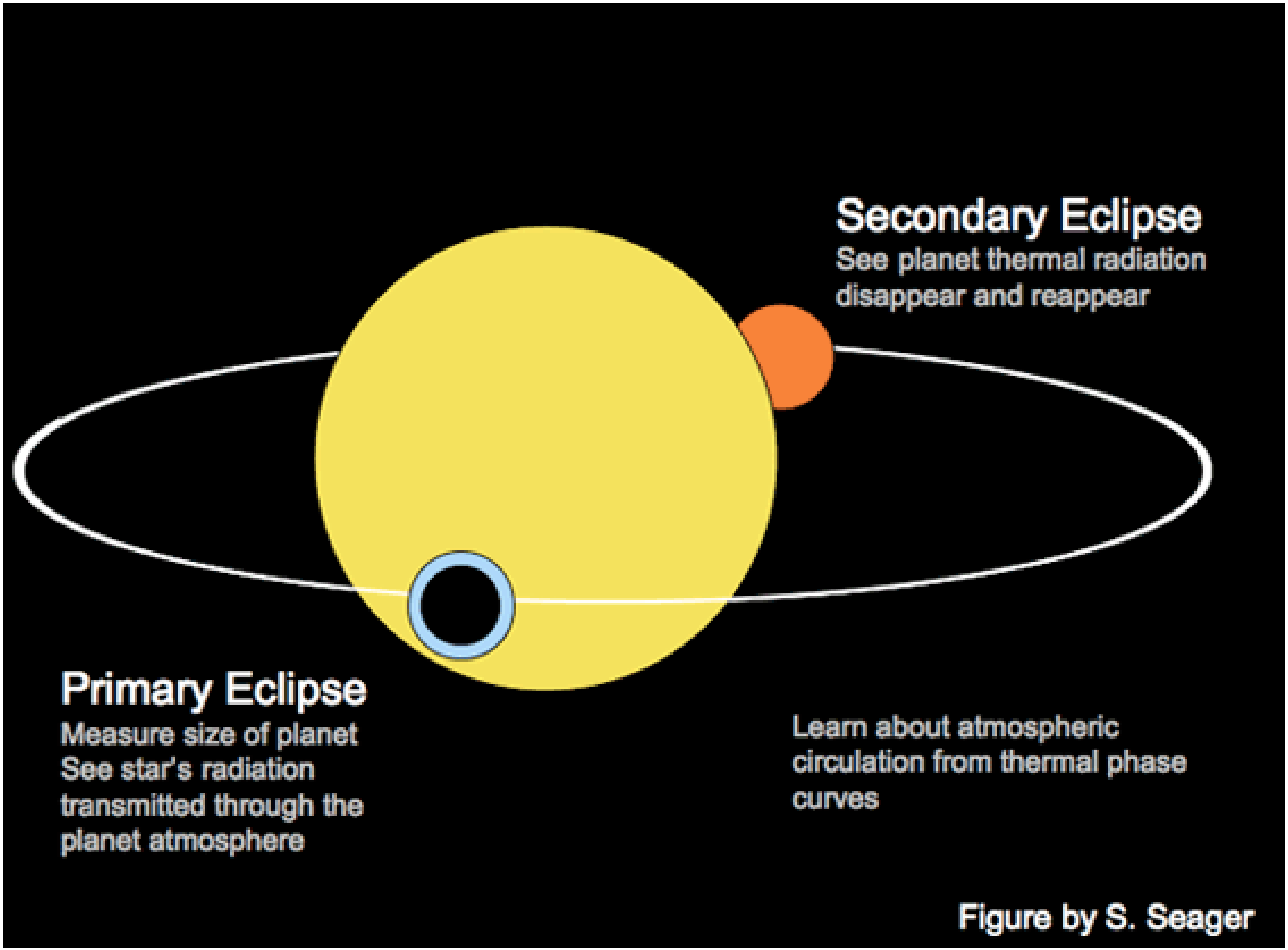
The case for M stars



Mass-Radius relation



Atmospheres of Exoplanets



Spectroscopy Candidates