

Evidence for a Several Earth-mass Planet in the Gliese 436 System

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Collaborators

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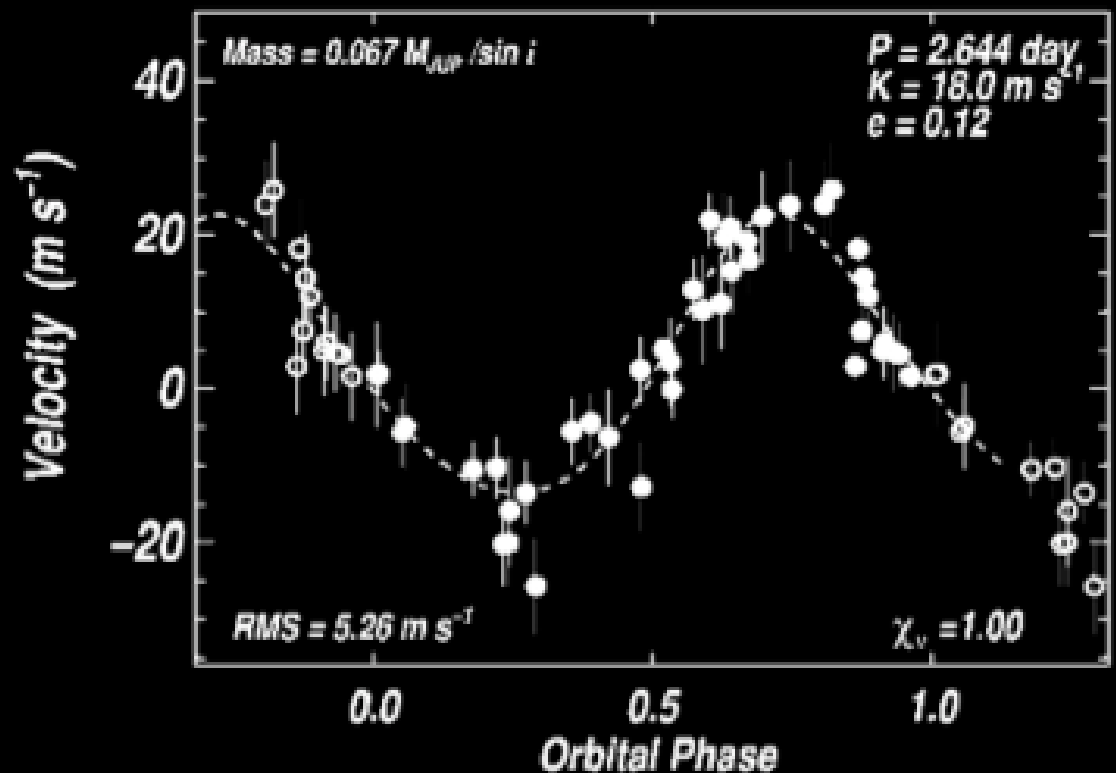
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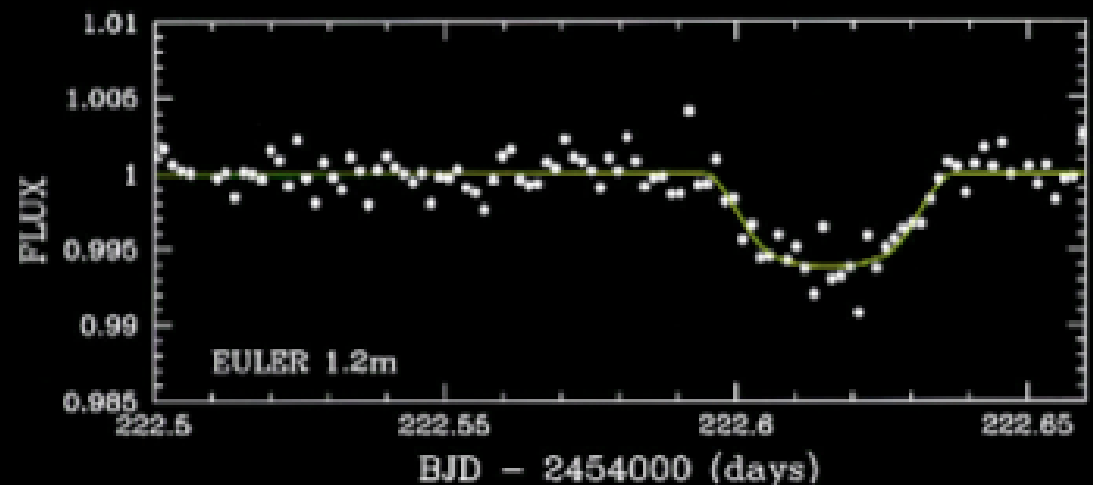
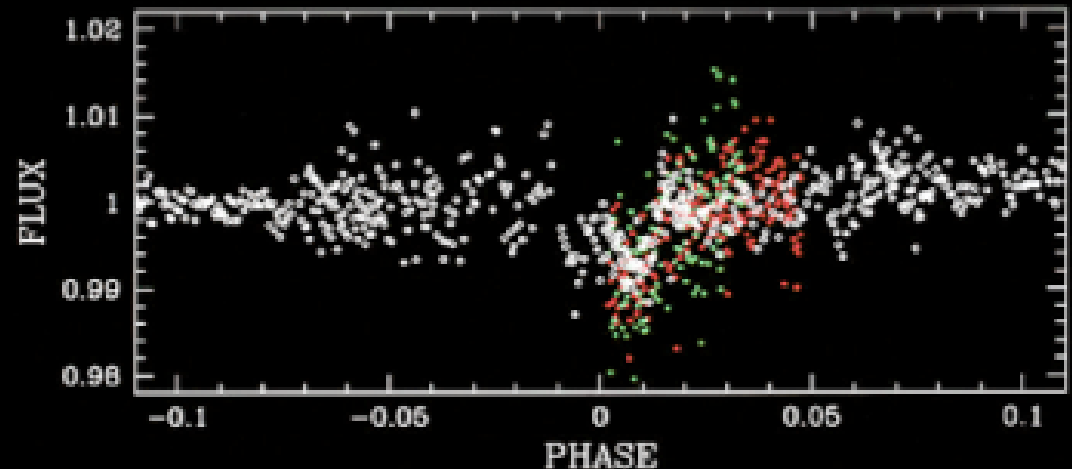
Detection of Gliese 436b (Butler et al. 2004)

- Gliese 436 - Red Dwarf, 33 light-years from us.
- Planet found in 2004: Gliese 436b
 - Orbital Period of 2.6441 days
 - 1.2 times the mass of Neptune (23 times the mass of Earth)
 - 30 times closer to its star than Earth is to the Sun
 - Significantly Eccentric Orbit
 - **No transit found in 2004**



3 years later... A Transit!

- Amateur and professional astronomers find transit in 2007.
- Radius of planet found to be about that of Neptune's, or four times the Earth's.
- First planet found to transit a Red dwarf

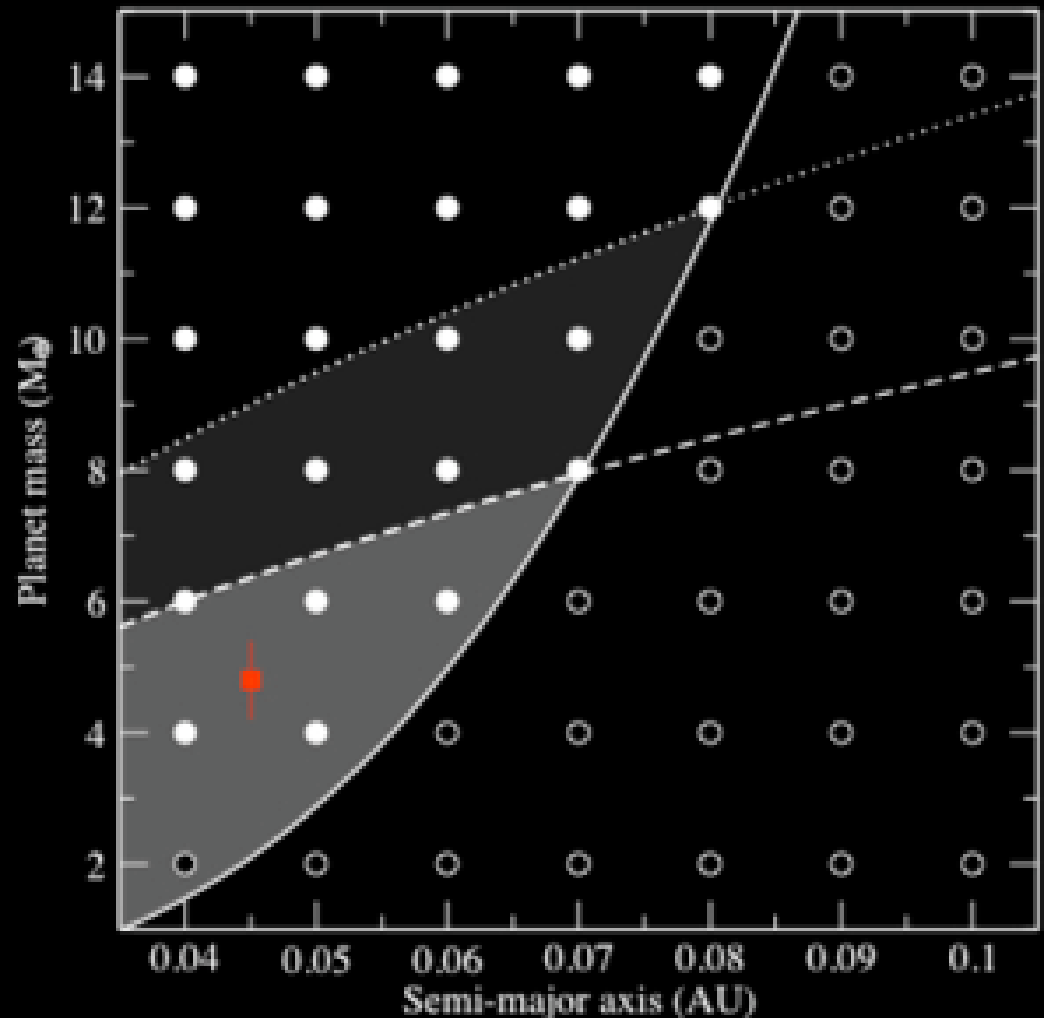


Hmm...That's Odd...

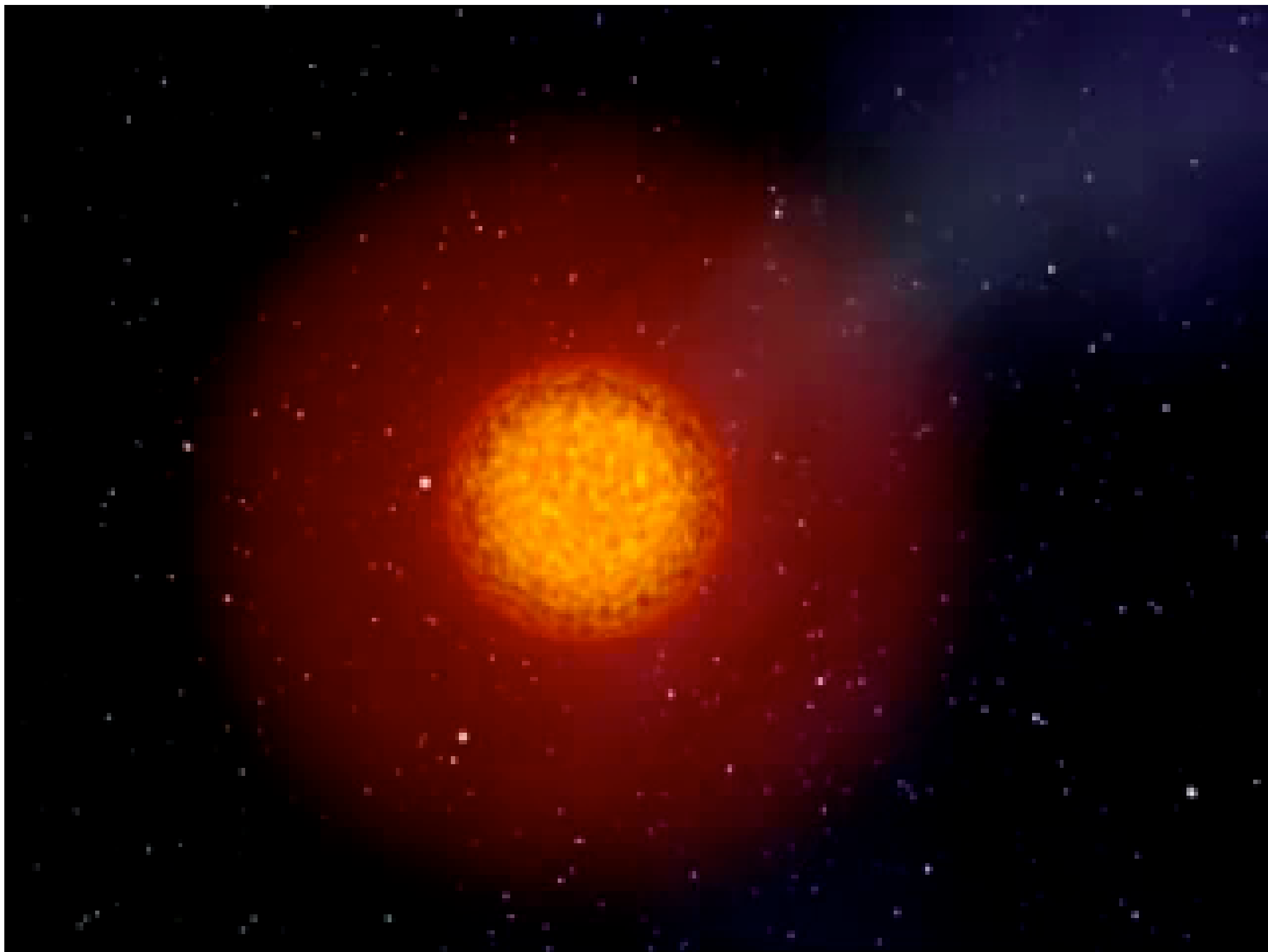
- We see a transit when we didn't see one before.
- The planet just barely crosses the bottom of the stellar disk.
- Given the high eccentricity of the orbit and tiny distance from star, it should not have been able to maintain its orbit for more than 100 million years, but the star is at least 6 billion years old.

Could there be another planet?

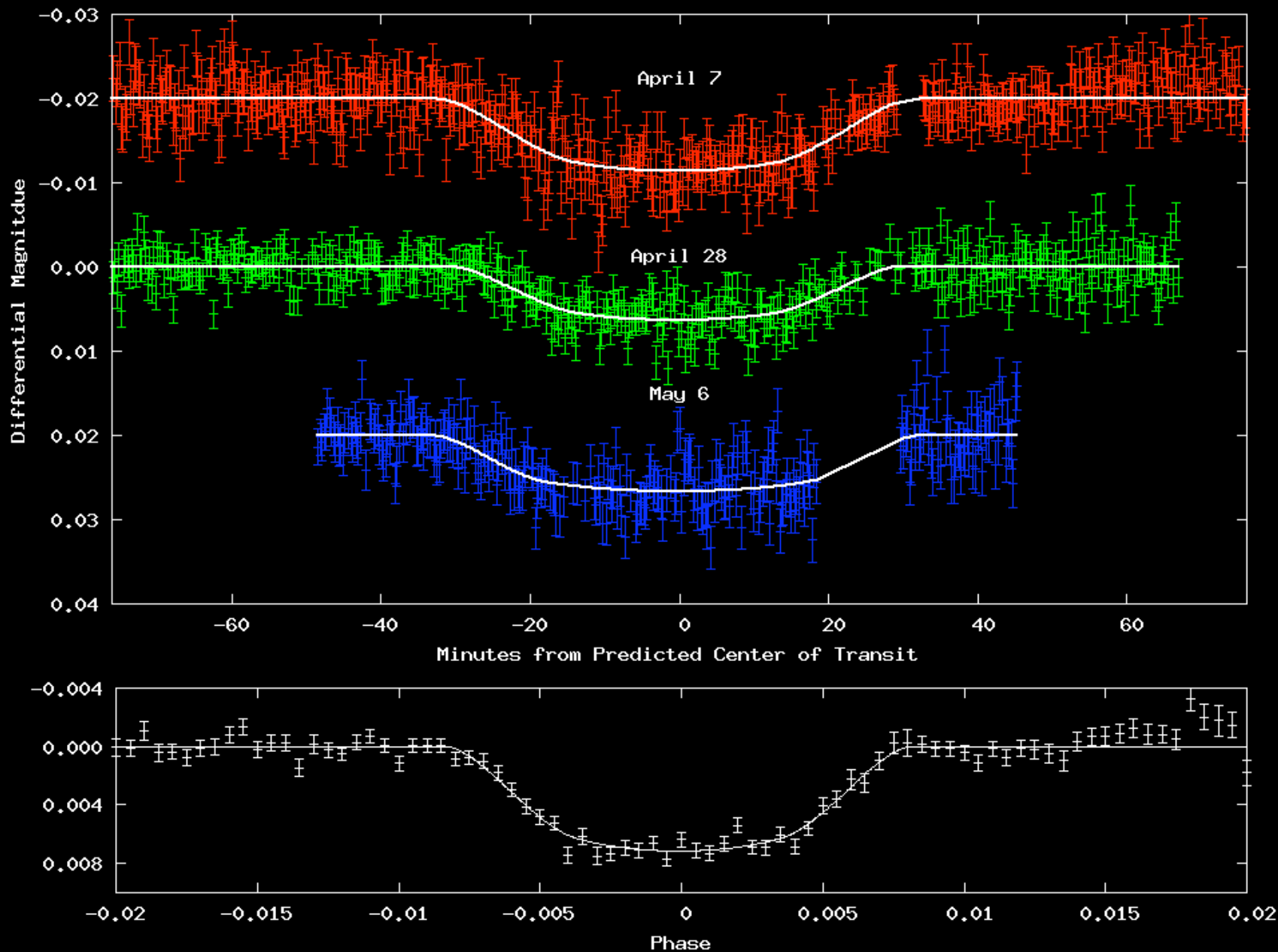
- A second planet could be changing the inclination of the transiting planet over time.
- Would have to be also close-in and around several Earth-masses.
- **We can search for these variations!**



(Ribas et al. 2008a)

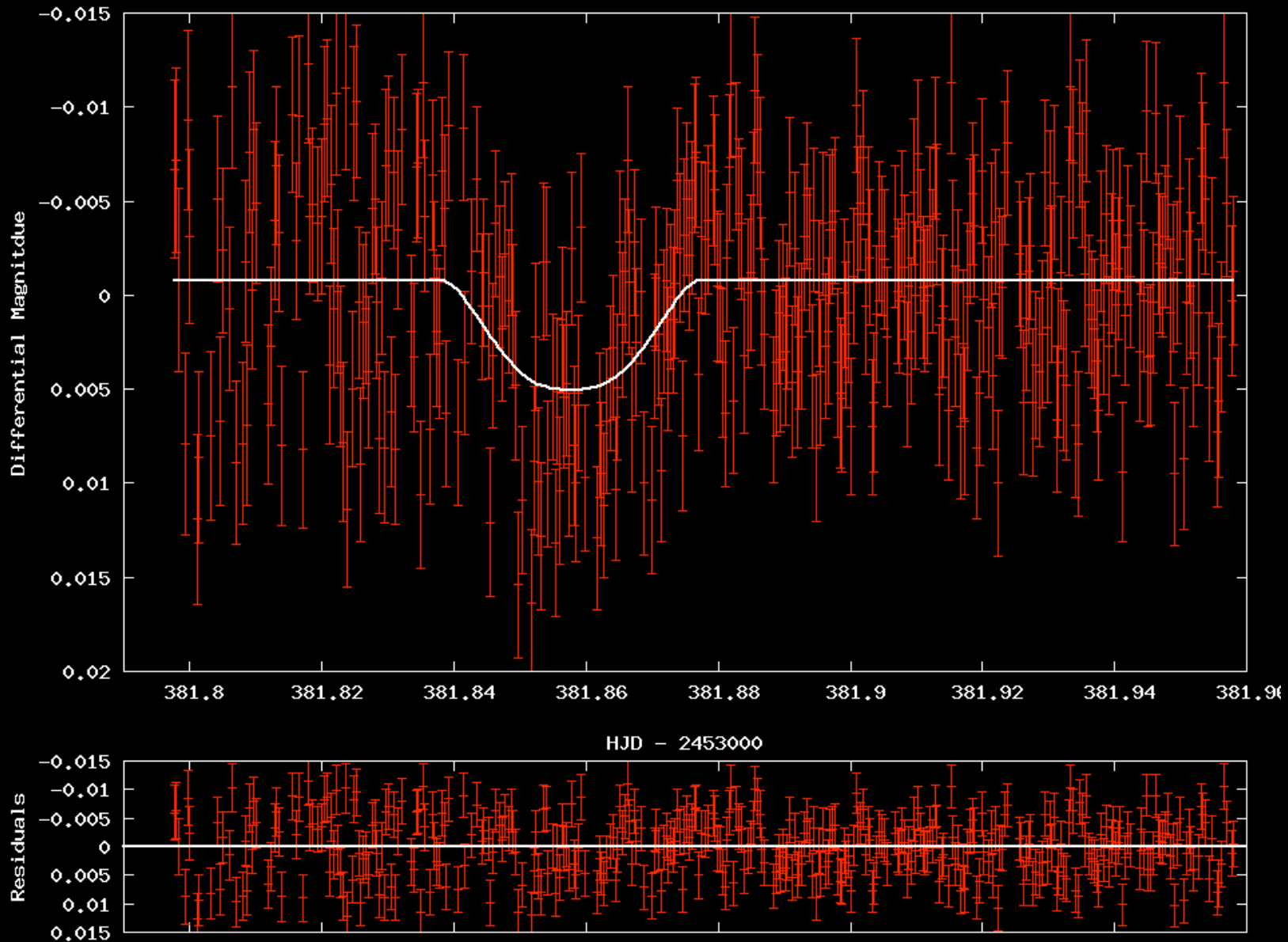


APO 3.5m Observations



NMSU 1-meter

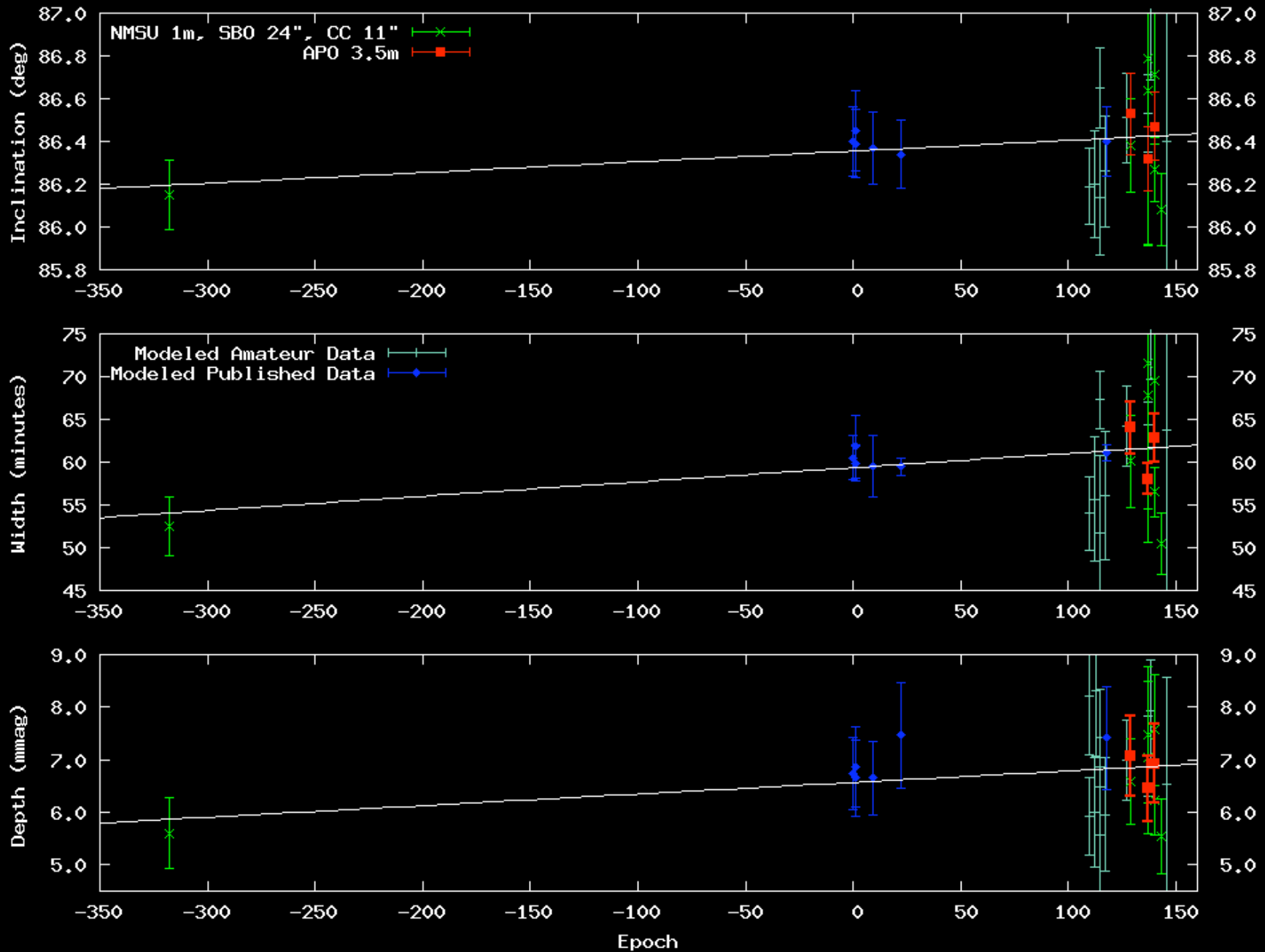
Automatically captured a transit in 2005!



Modeling

- In total had 28 transit curves, (16 professional, 12 amateur), with baseline of 3.3 years.
- Used the JKTEBOP code (Southworth 2008)
Well established for transiting planets.
- Solved for the time of central transit, inclination, and radius of the star and planet. (Able to then also get width and depth.)
- Did robust error analysis.

Parameter Variations

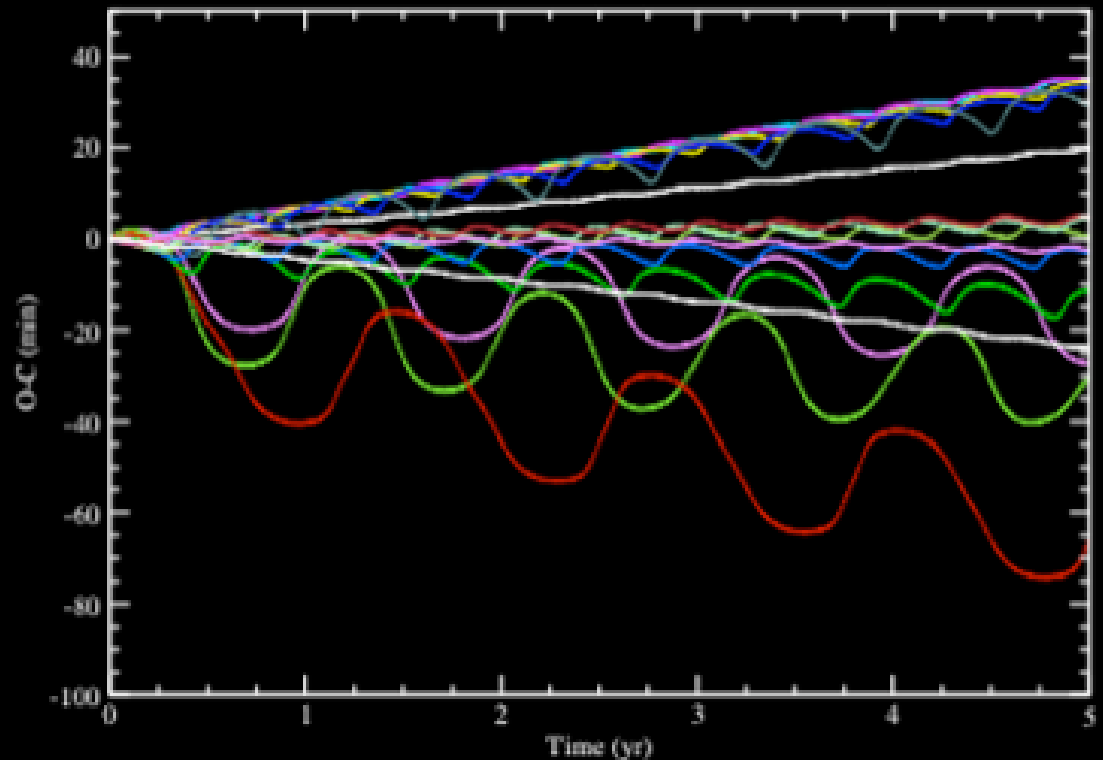


What We Found

- Increasing inclination, width, and depth of transit with statistical significance.
- The derived amount of inclination change of ~ 0.1 deg/yr can explain the lack of transit detection in 2004 and the detection of transits in 2005 through present.
- Evidence for a perturbing second planet, with a mass of less than 8 times that of Earth, also very close to the star.
- Would be first extrasolar planet detected via orbital perturbations to another planet.

How to Confirm and Narrow Planet Parameters

- Need more observations over several years to confirm trend.
- Need long baseline to see timing variations, which will ultimately nail down the parameters, but it could be anything!
(Ribas 2008b)



Questions?

References

Butler, R.P. et al. 2004, ApJ, 617

Gillon, M., et al. 2007, A&A, 472, L13

Ribas, I., Font-Ribera A., Beaulieu, J.-P. 2008a, ApJL, 677, L59

Ribas, I., Font-Ribera, A., Beaulieu, J.-P., Morales, J.C., & Garcia-Melendo, E. 2008b, to appear in the proceedings of IAU Symposium 253, arXiv:0807.0235

Southworth, J. 2008, MNRAS, 386

