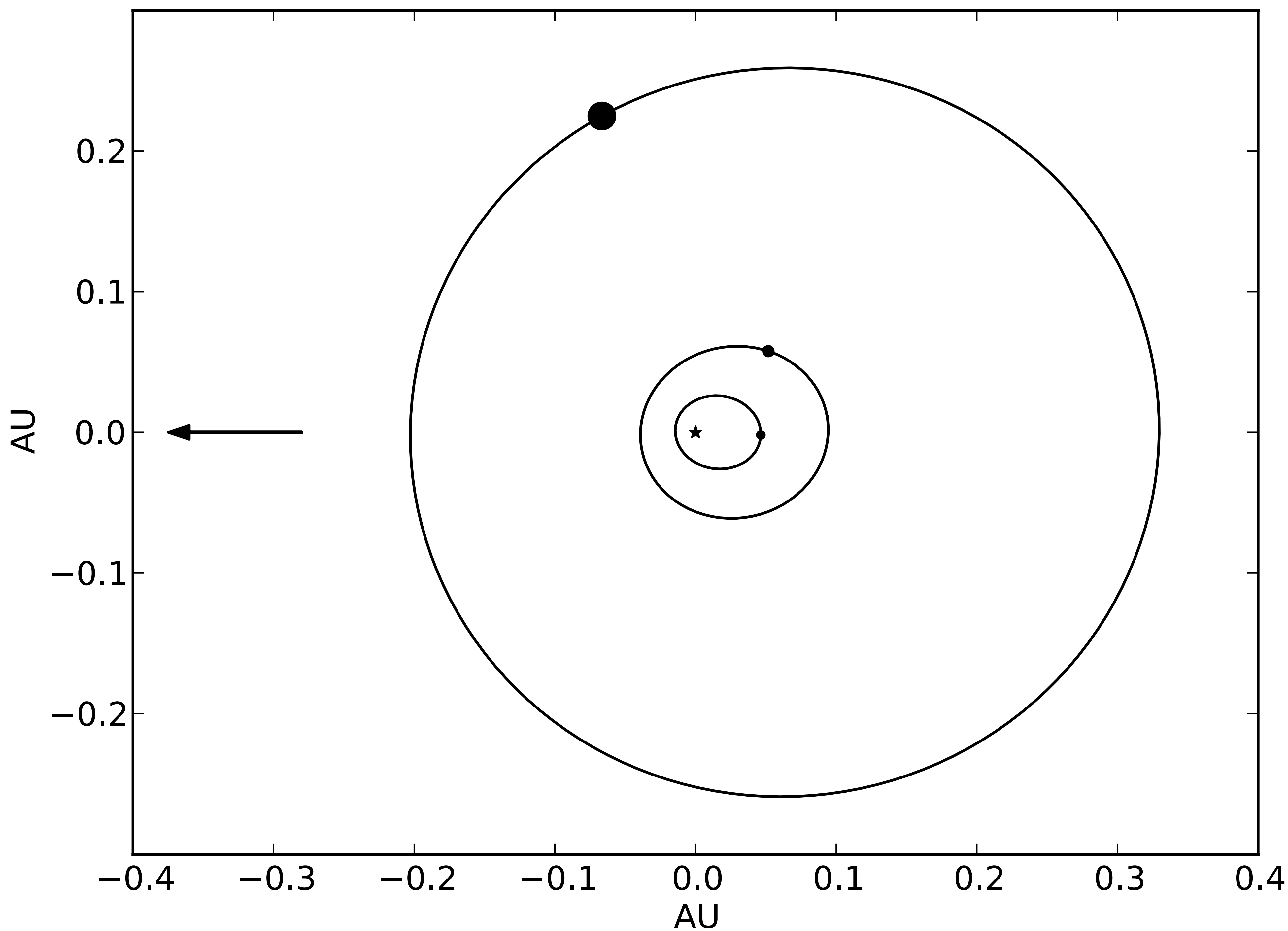
KOI-676

An active star with two transiting planets and a third possible candidate detected with TTV

Panagiotis Ioannidis
Hamburg Observatory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AU
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0.3
0.4
AU

OUTLINE

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- KOI - 676, a Kepler mission system with 2 planetary candidates

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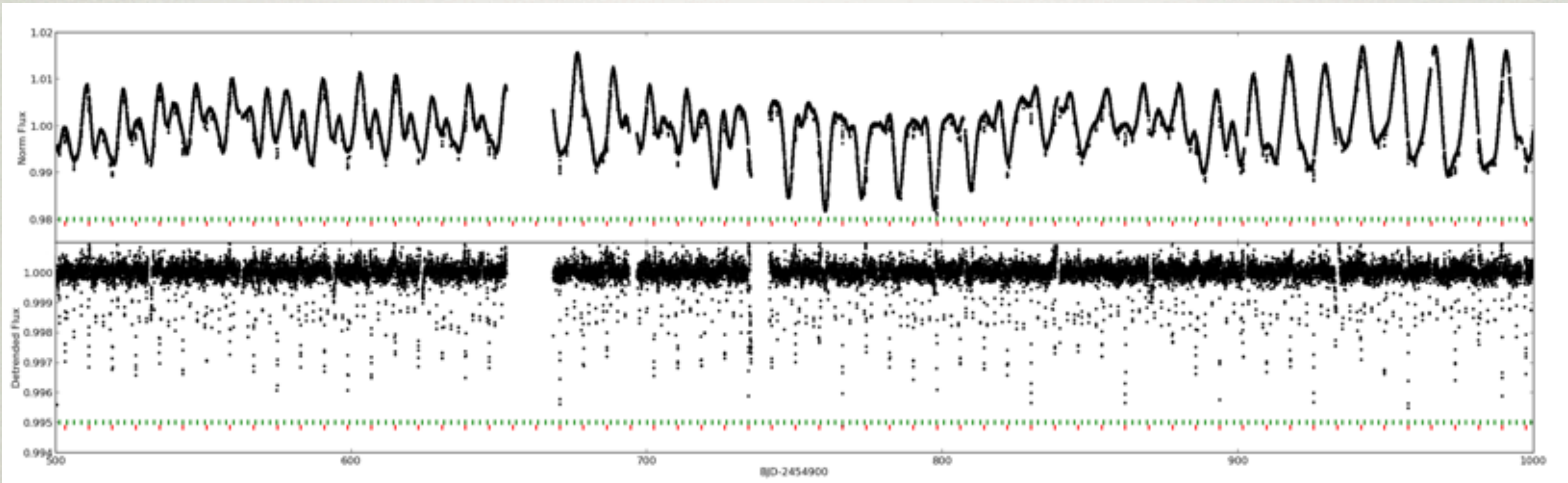
- Conclusions

KOI-676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1.02
1.01
1.00
0.99
0.98
Detrended Flux
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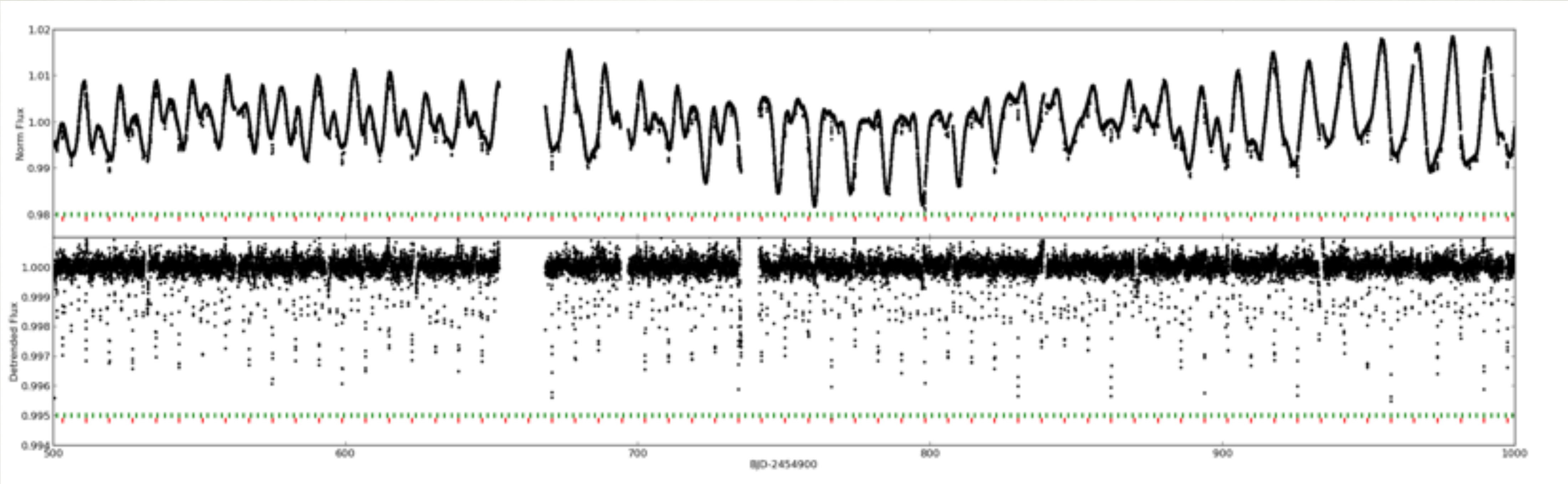
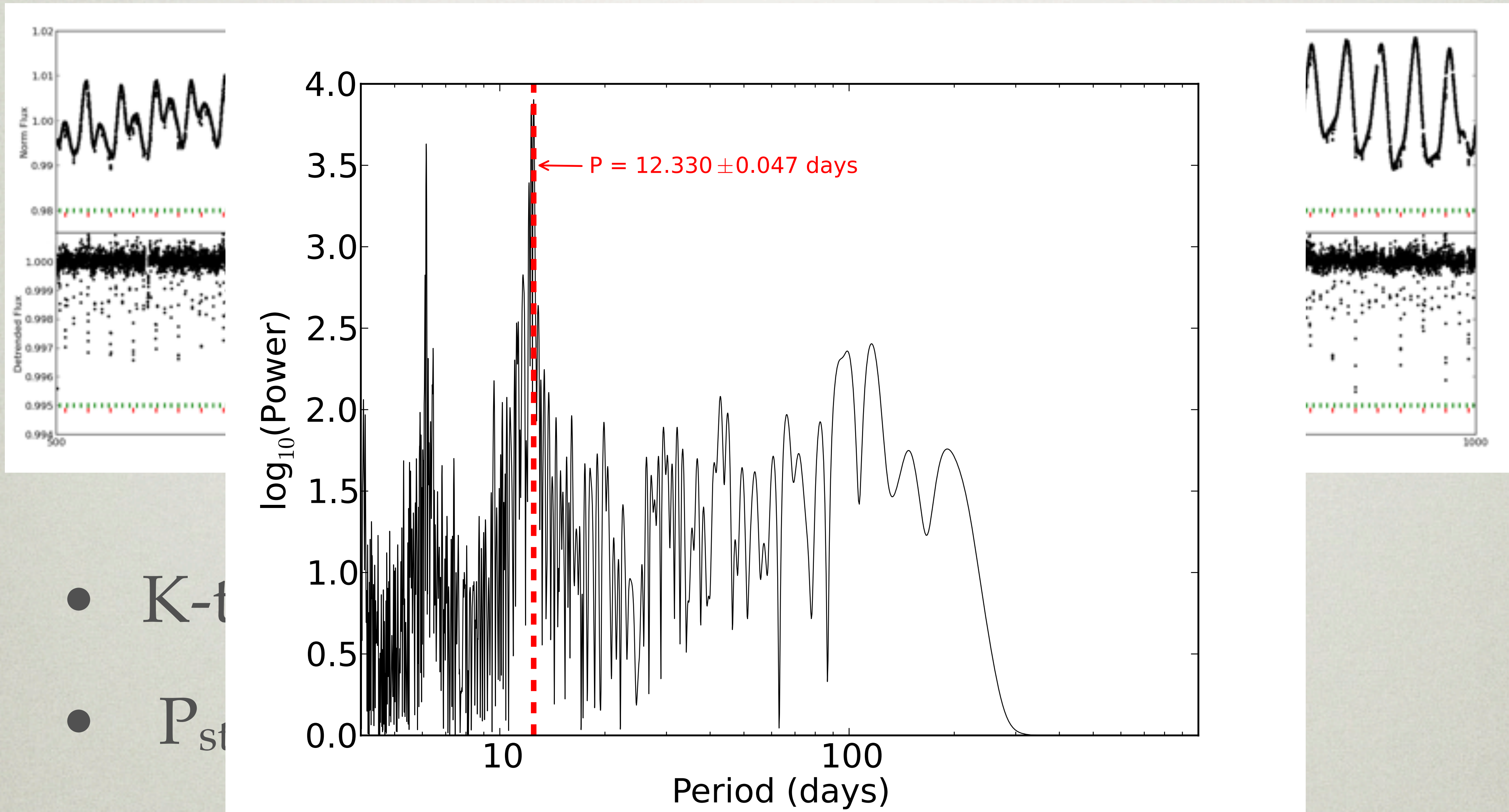
1000
BJD-2454900

KOI-676



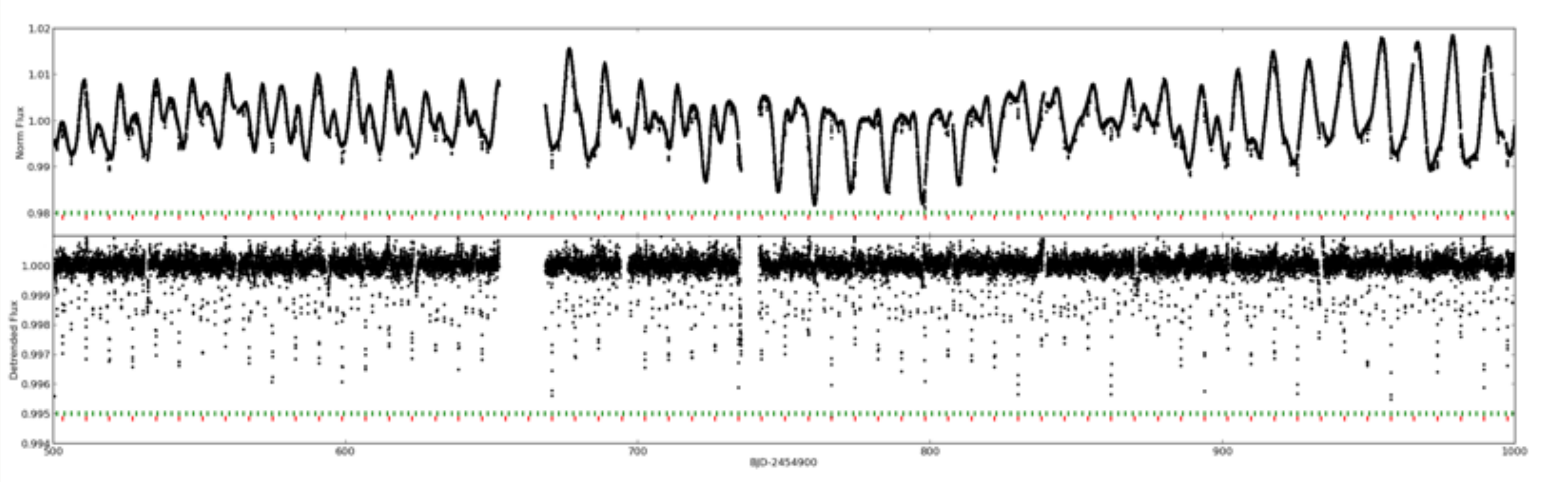
- K-type active star

KOI-676



- K-t
- P_{st}

KOI-676



- K-type active star
- P_{star} ~ 12.3 days
- age ~350 Myrs (Barnes et al. 2007)

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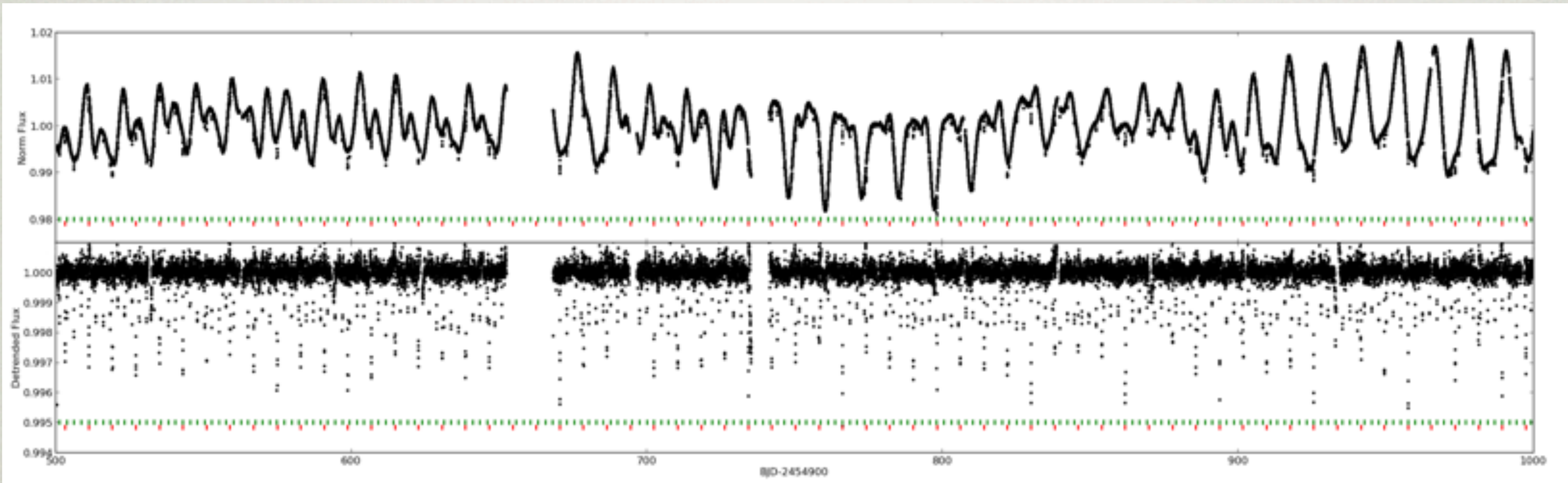

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- age ~350 Myrs (Barnes et al. 2007)
- 2 candidates with Neptune-like radii

Planetary Transits

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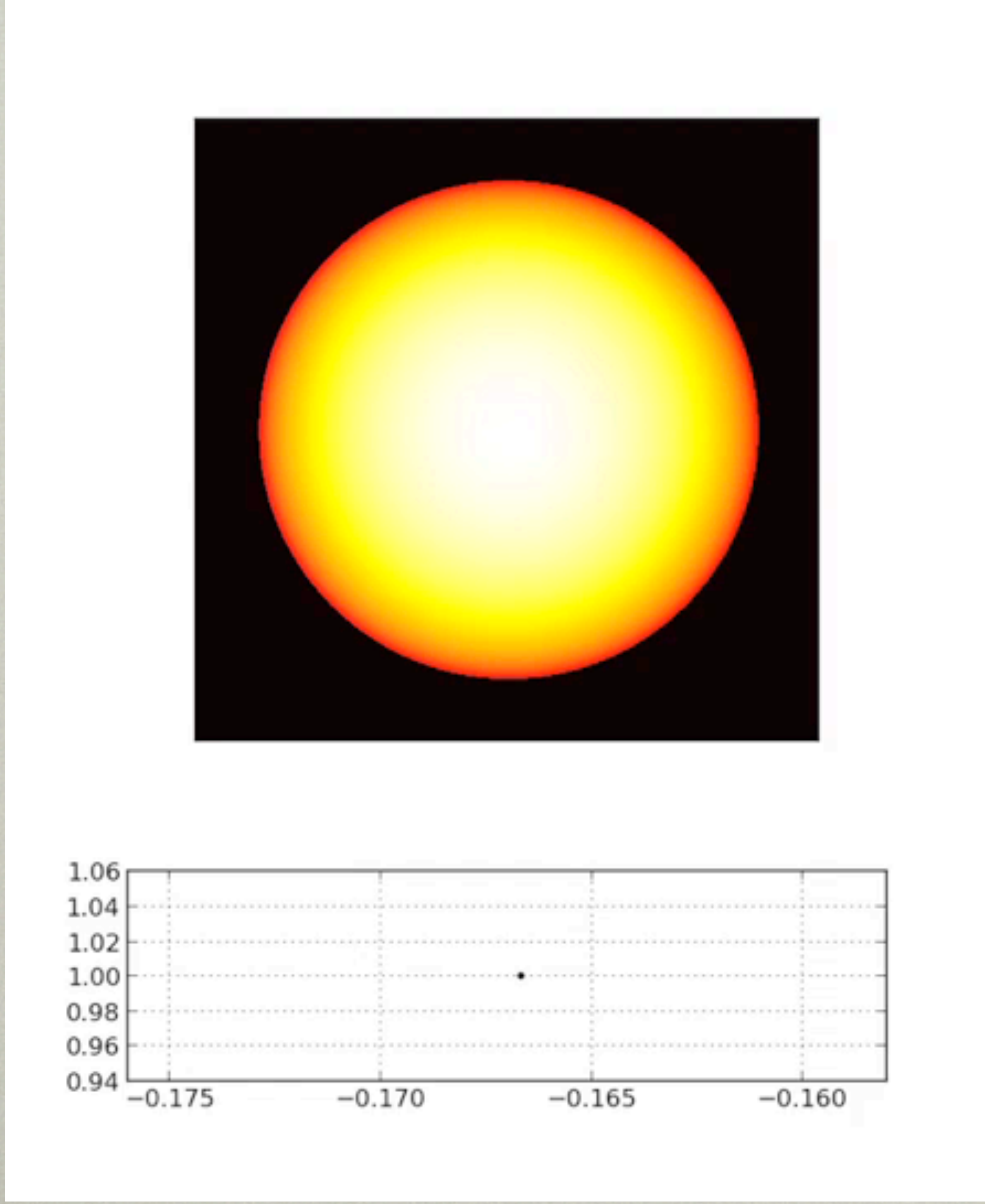
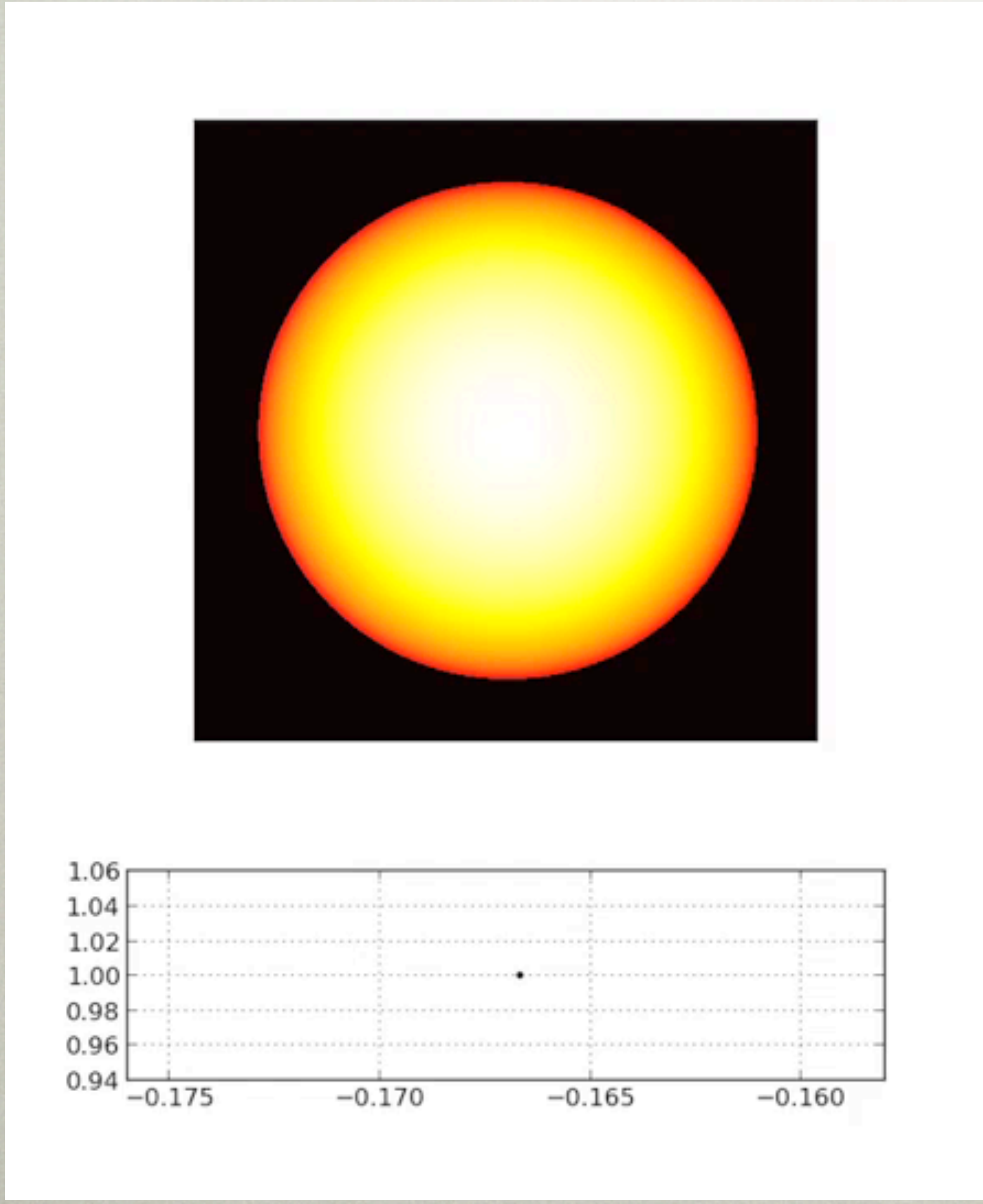


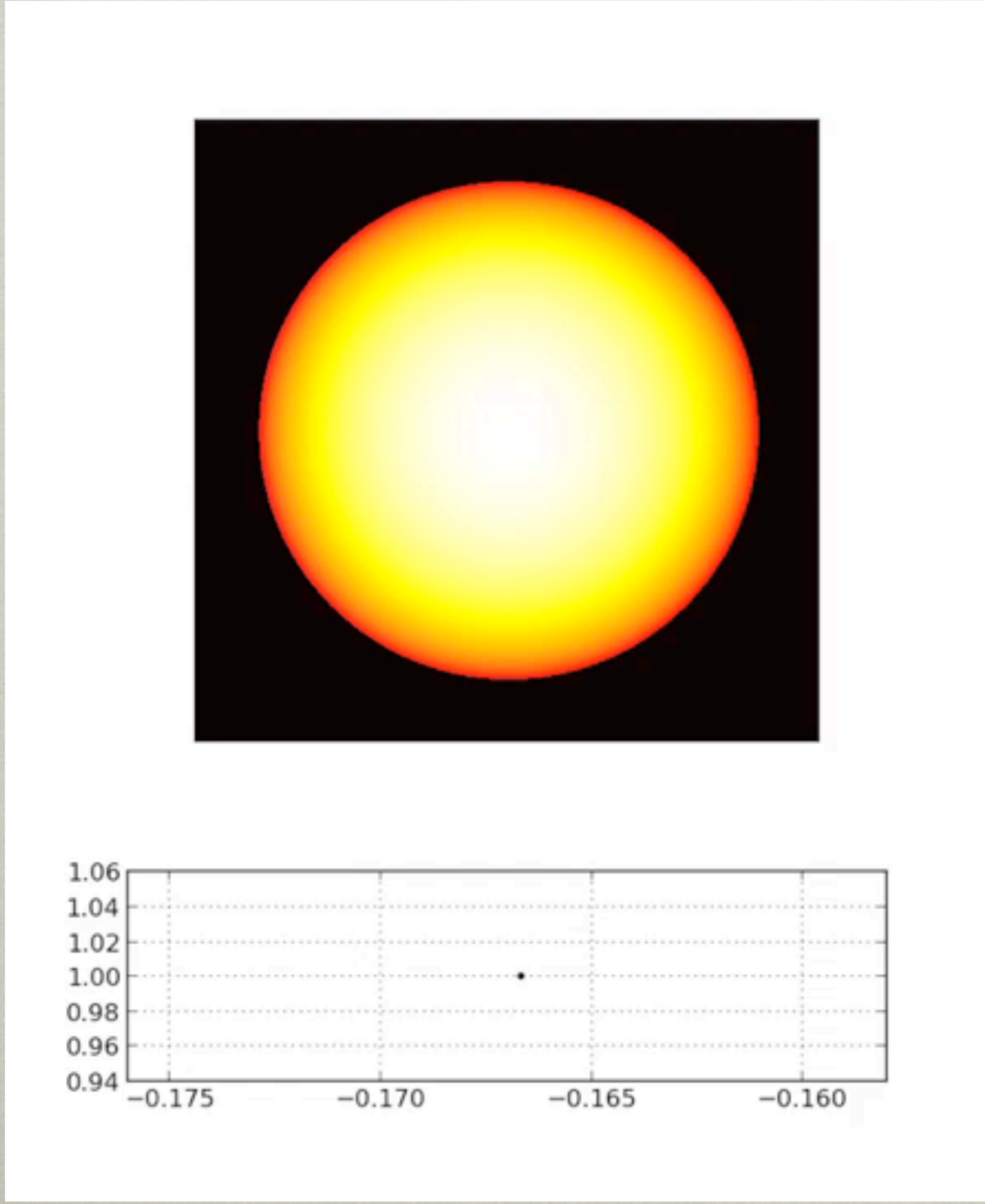
- Transit duration D

Planetary Transits



- Transit duration D
- α/R_{star}

Planetary Transits



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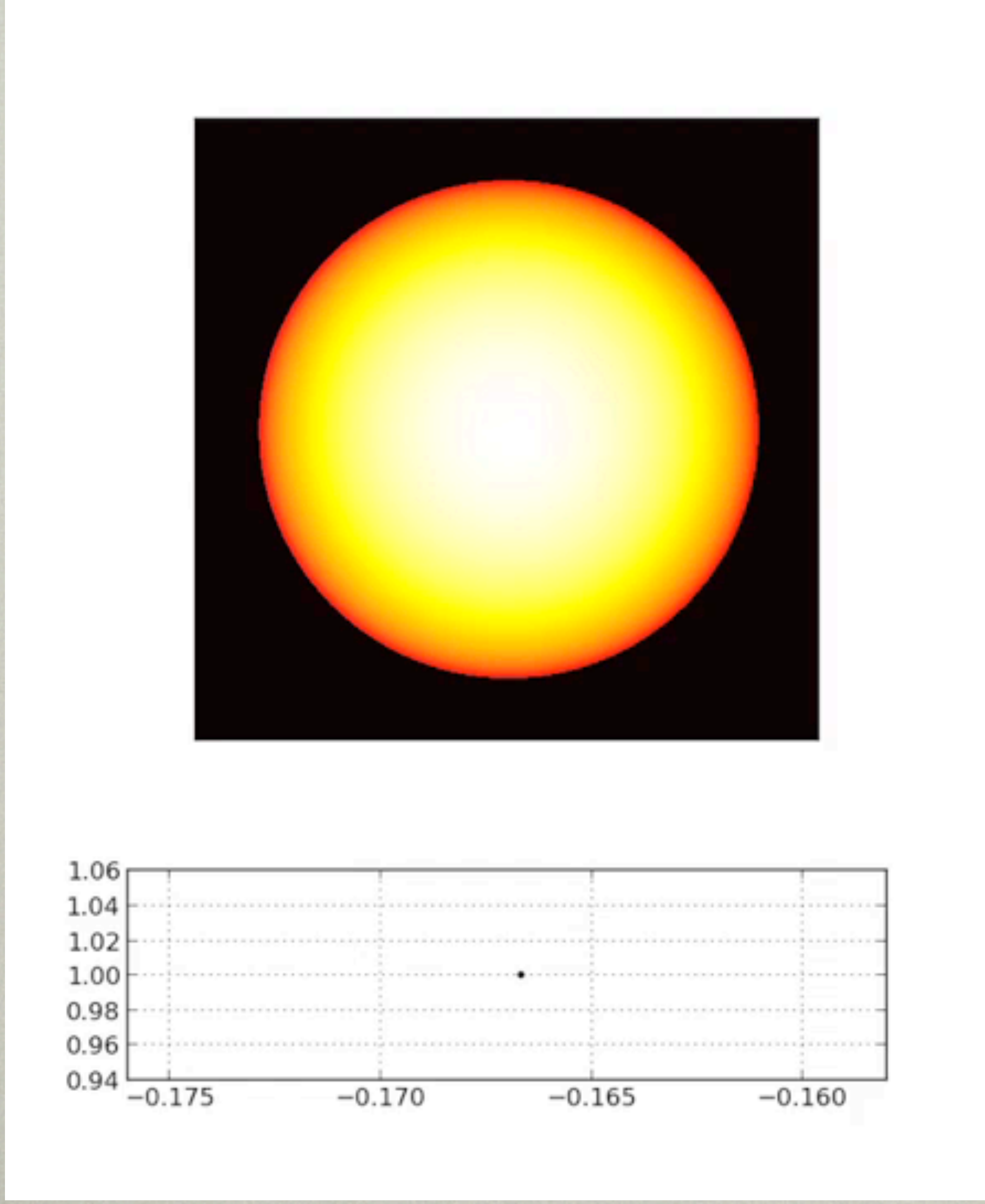
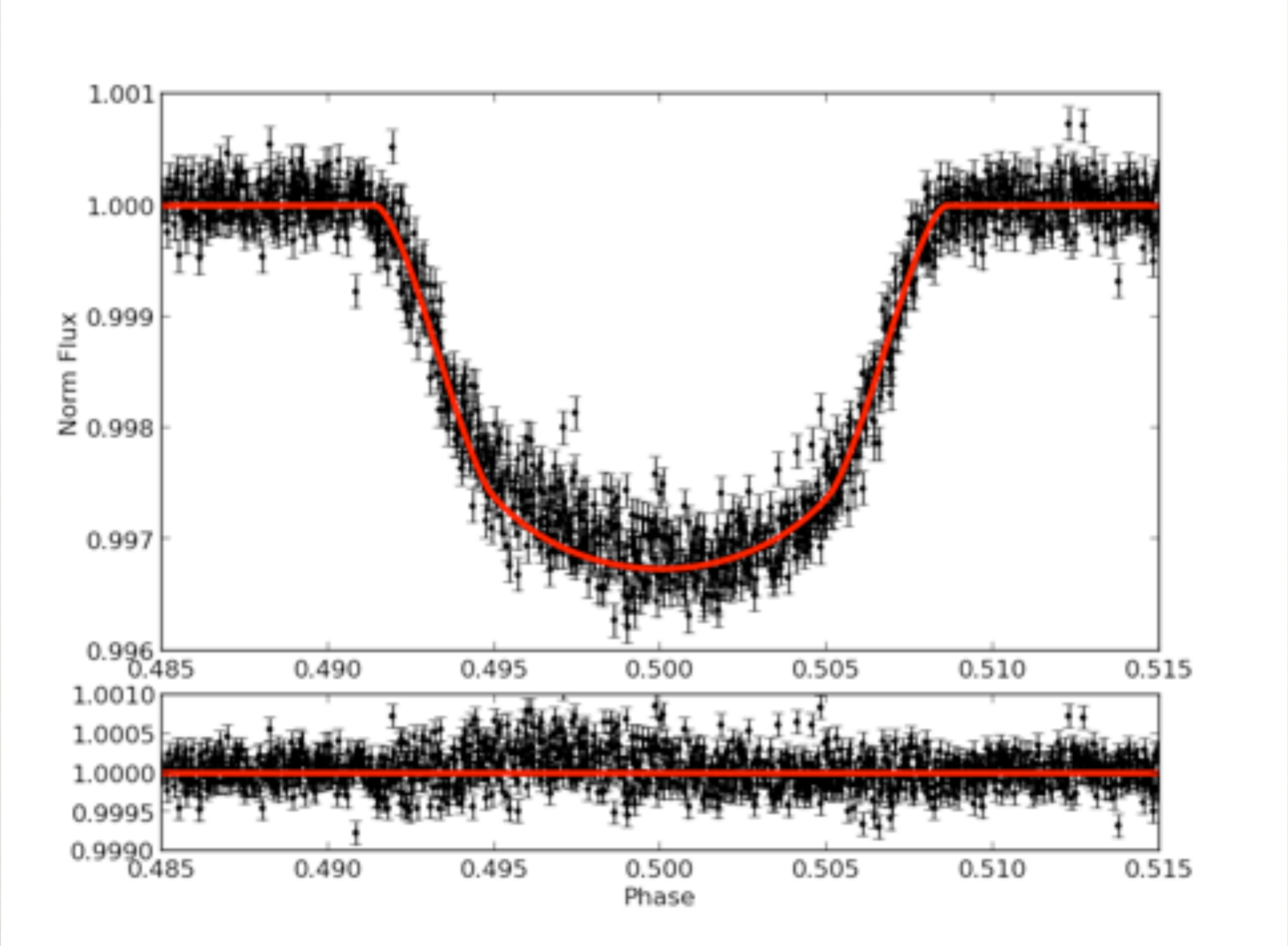
- R_p / R_{star}

Planetary Transits

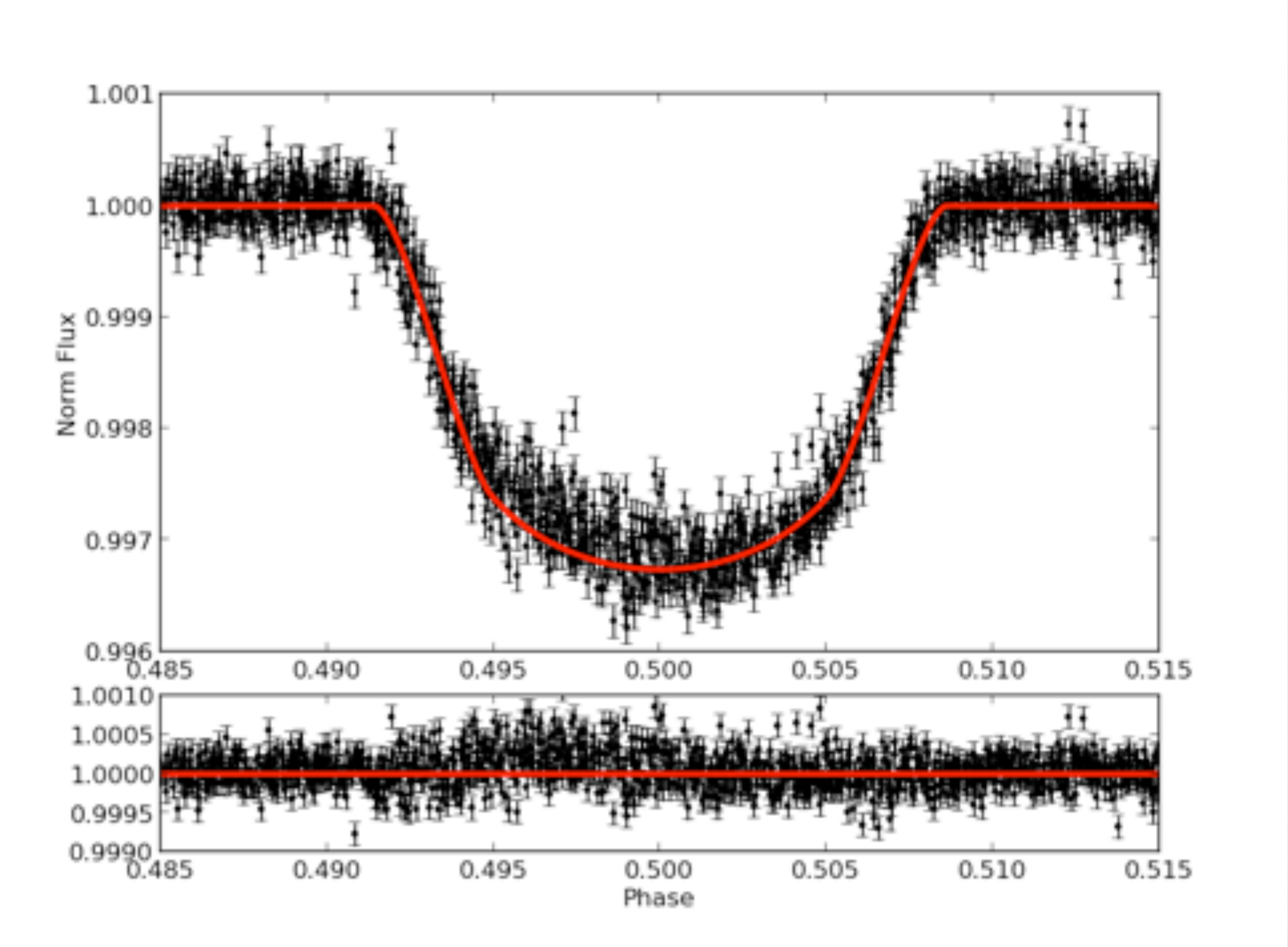


- Transit duration D
- α/R_{star}
- R_p/R_{star}
- Impact parameter b

Transit KOI-676.01

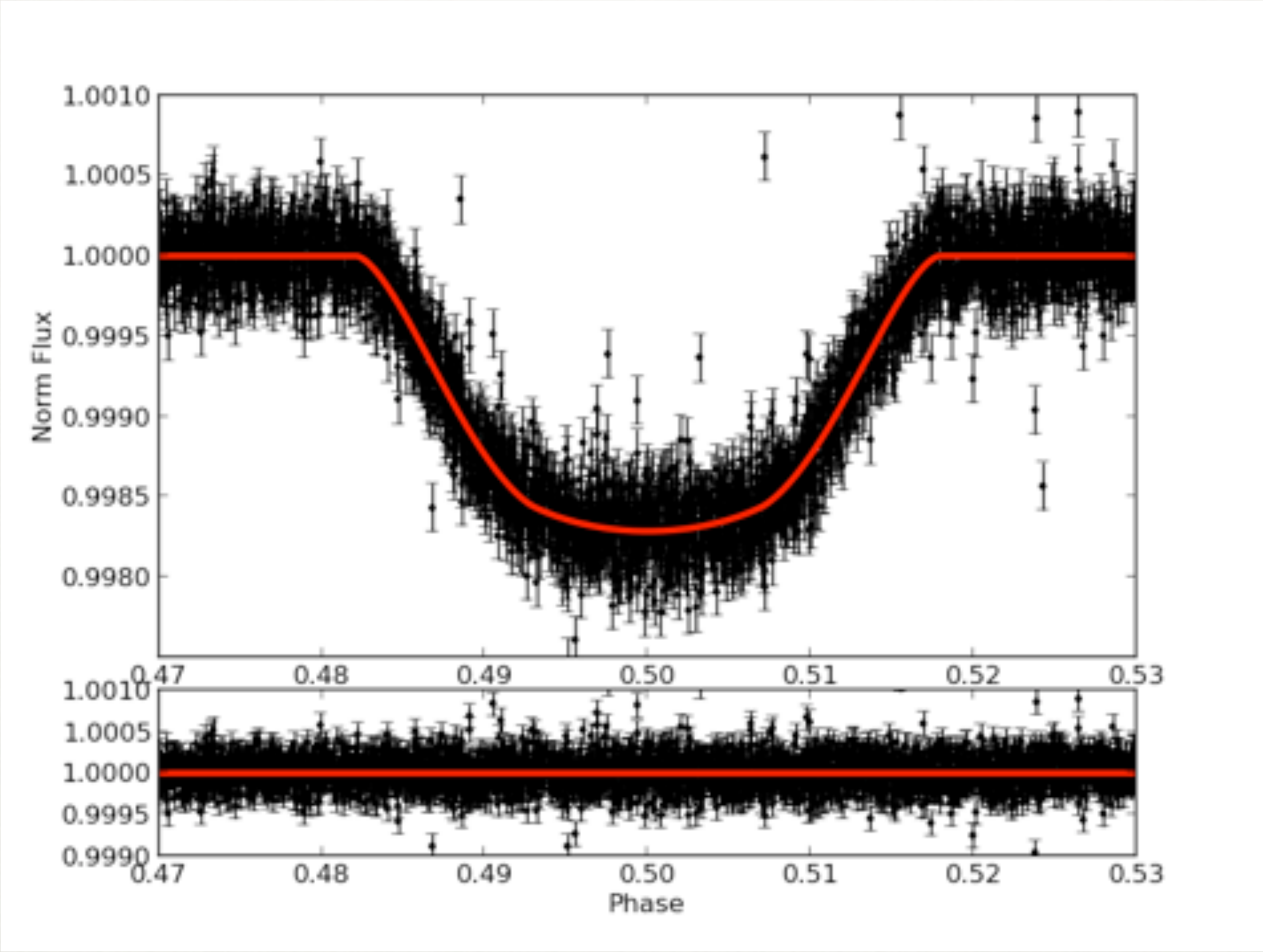


Transit KOI-676.01

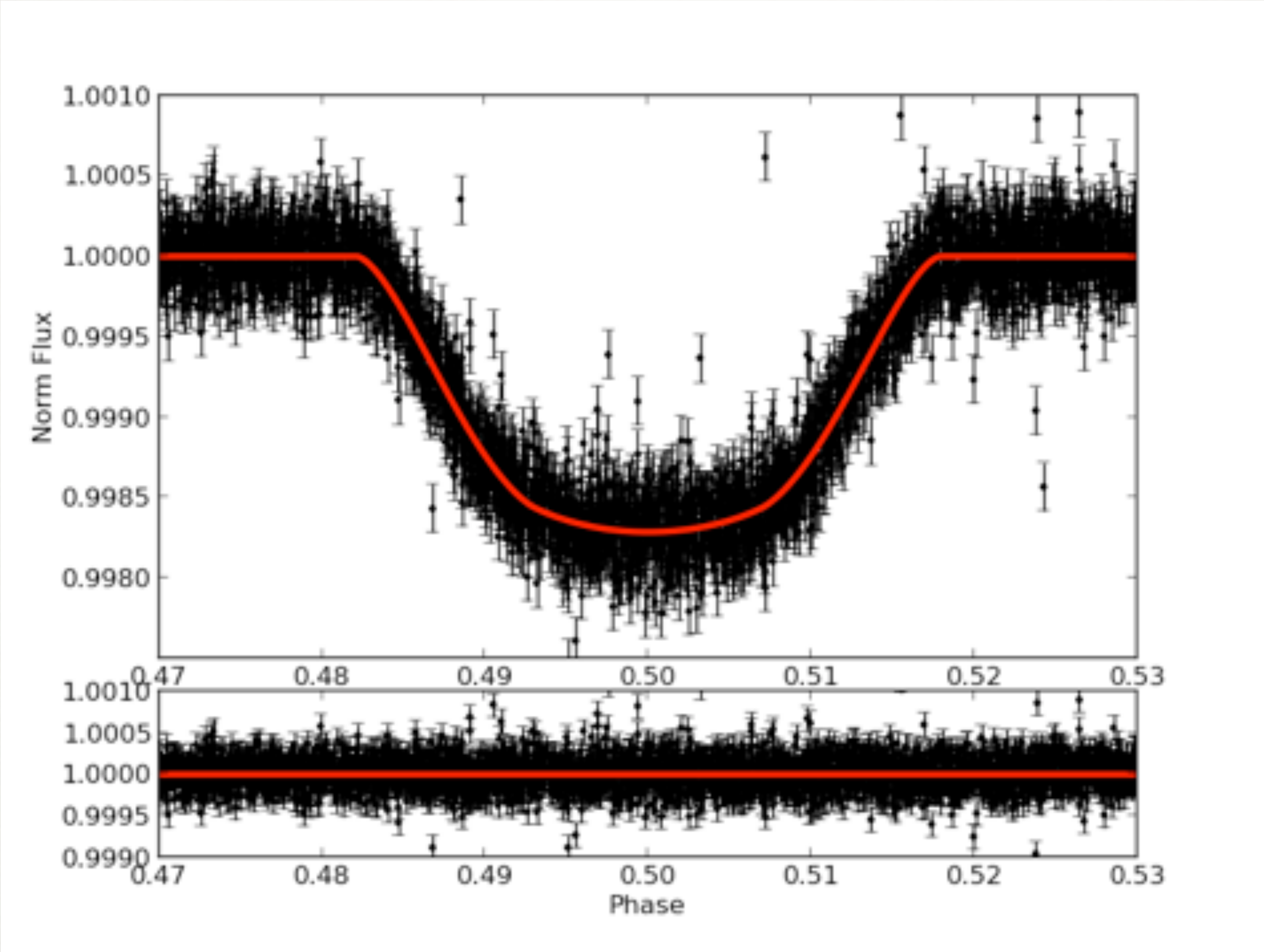


- $P = 7.9725 \pm 0.0014$
- $b = 0.861 \pm 0.065$
- $D = 0.1371 \pm 0.0199$ days
- $r/R_{star} = 0.06 \pm 3.07e\text{-}4$

Transit
KOI-676.02



Transit
KOI-676.02



- $P = 2.4532 \pm 0.0007$
- $b = 0.931 \pm 0.038$
- $D = 0.0857 \pm 0.0232$ days
- $r/R_{star} = 0.051 \pm 1.085e\text{-}4$

IRREGULARITIES

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Kepler's 3^{rd} law

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- $\varrho_o = 2.6\ g/cm^3$

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1. Third light assumption

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3. Ellipticity of the orbits

Third Light Scenario

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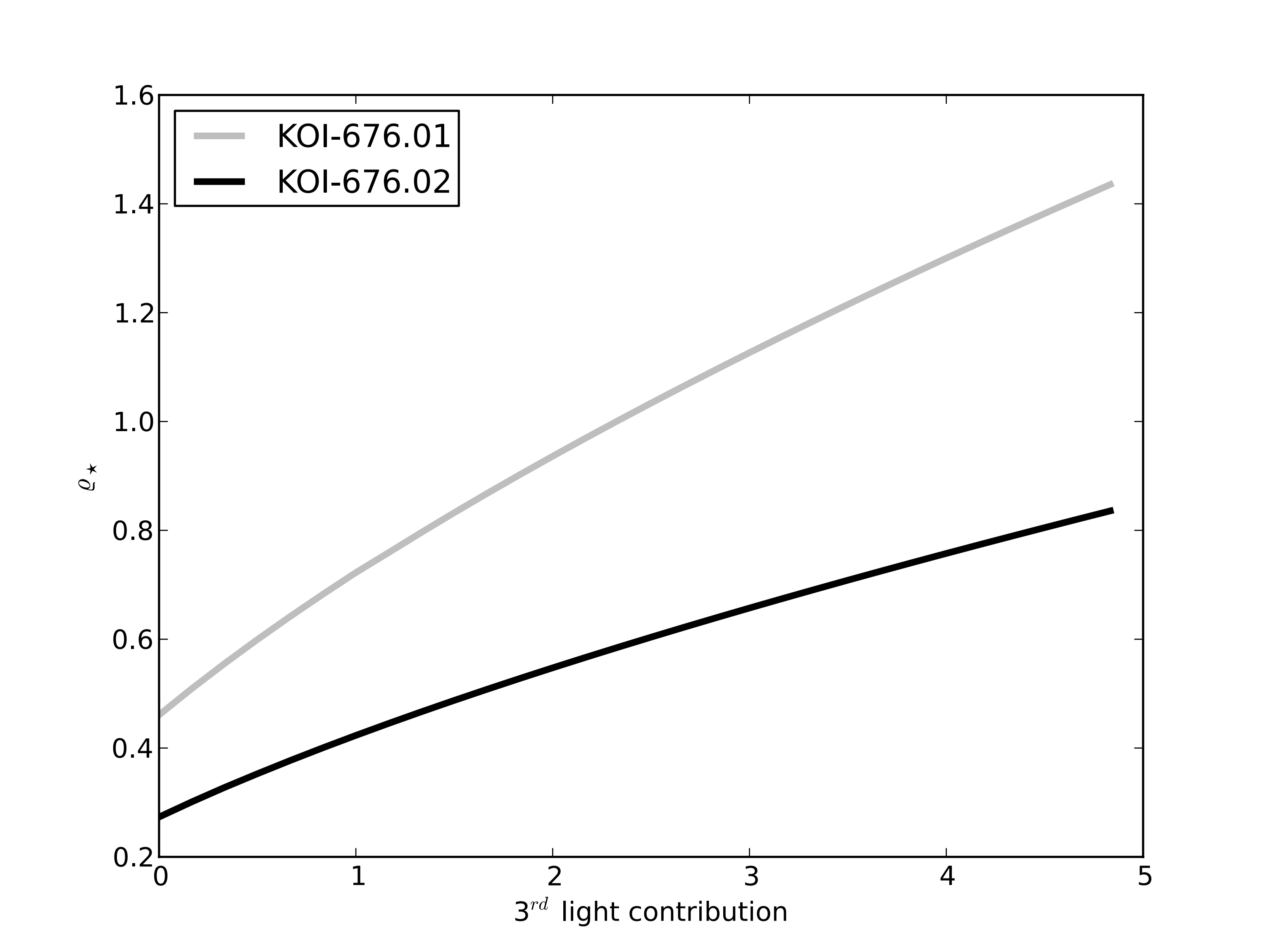
Third Light Scenario

Can[illegible]
expl[illegible] flux
due[illegible]



- Spec[illegible] [illegible]osite

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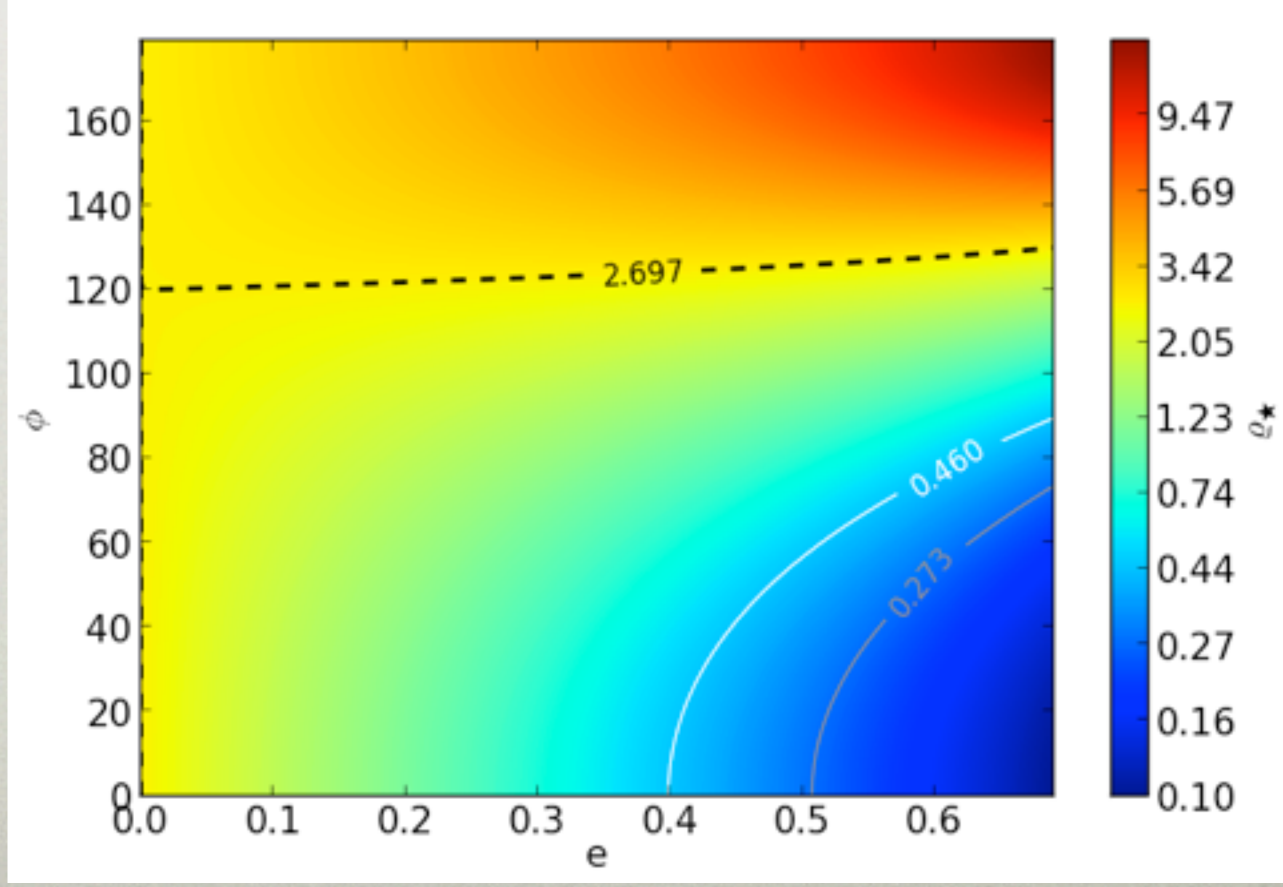
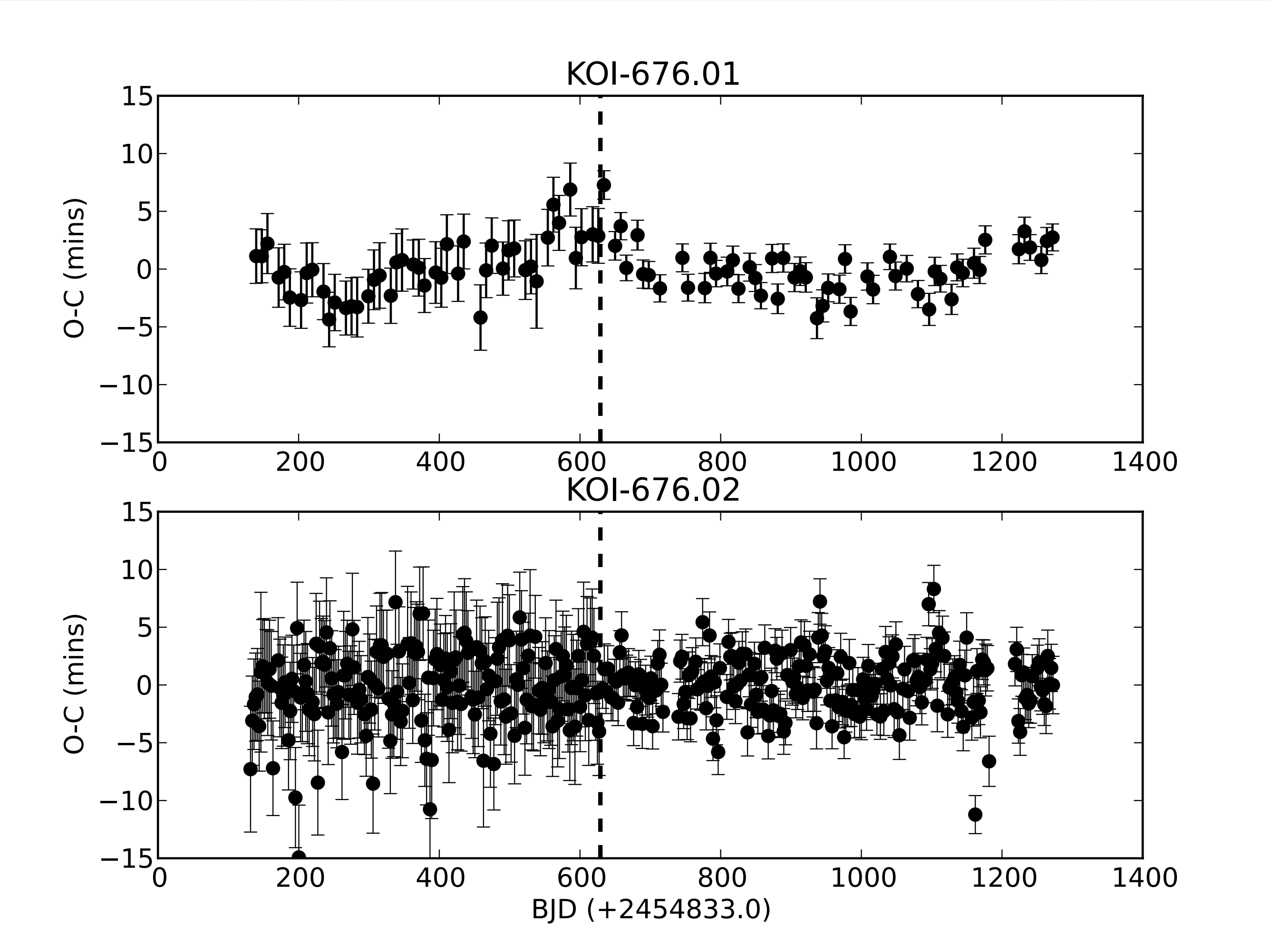


TTV Analysis



- 2 planets in 4:13 period ratio.
- Not close to mean motion resonance.
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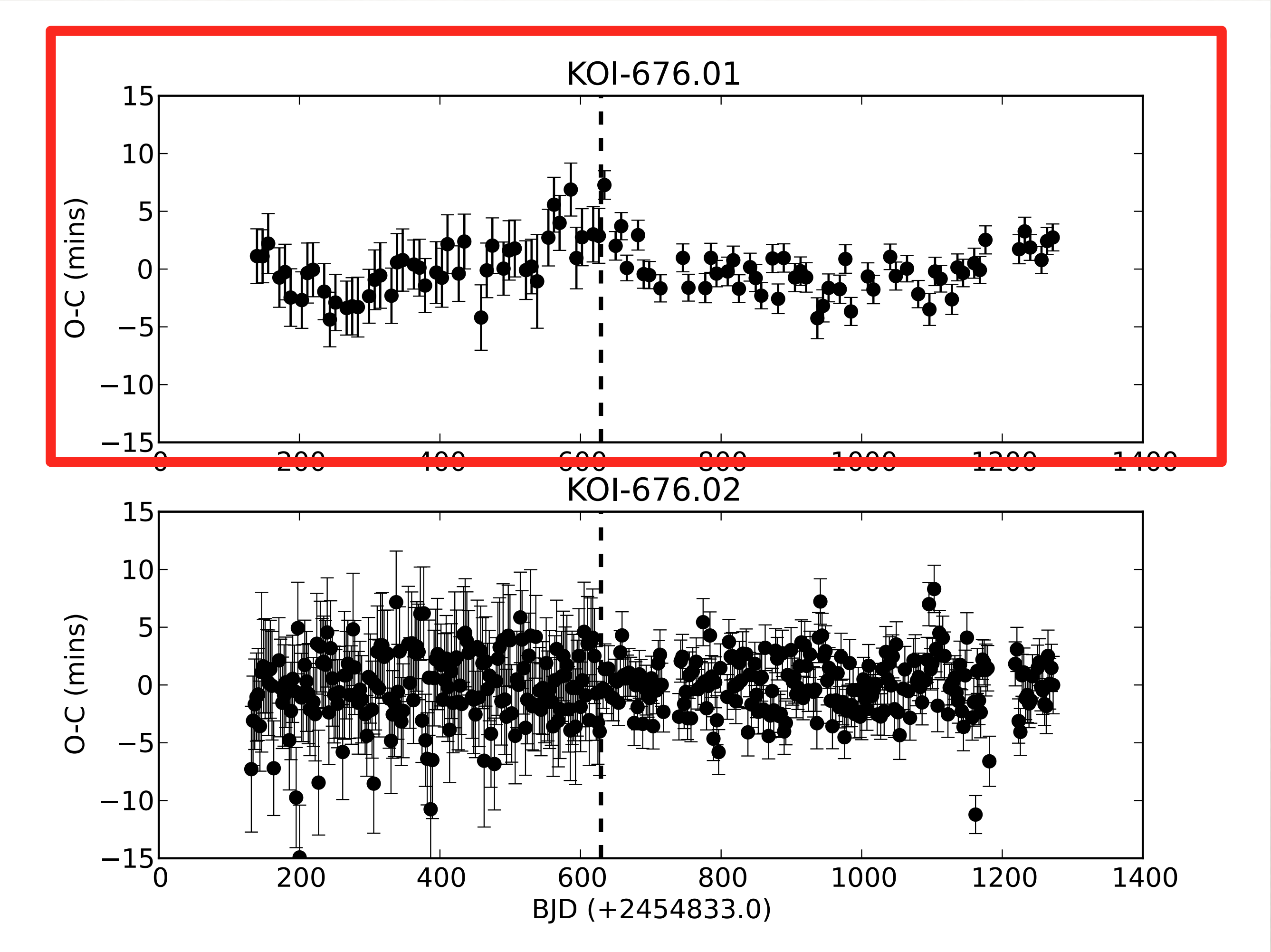

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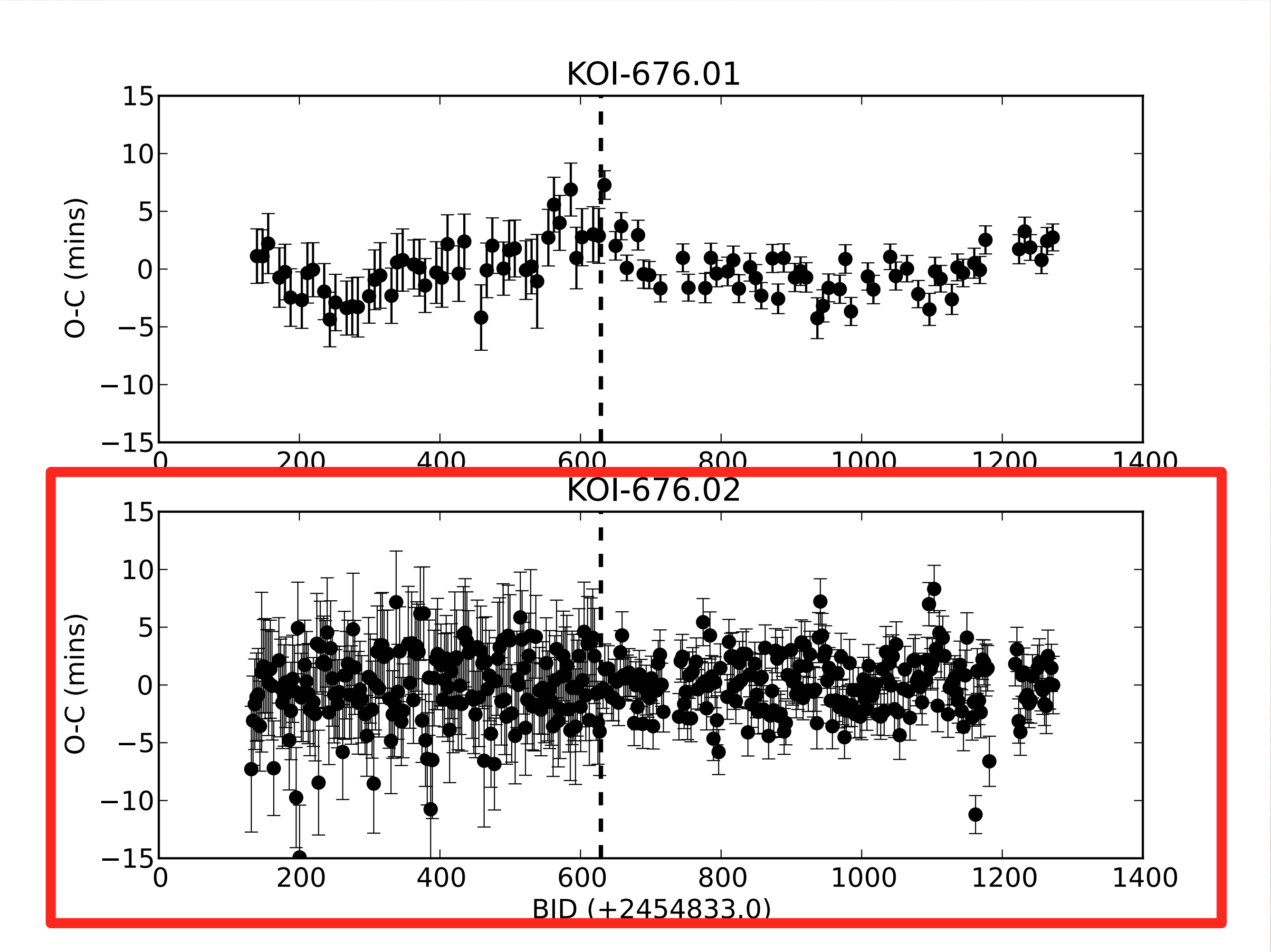

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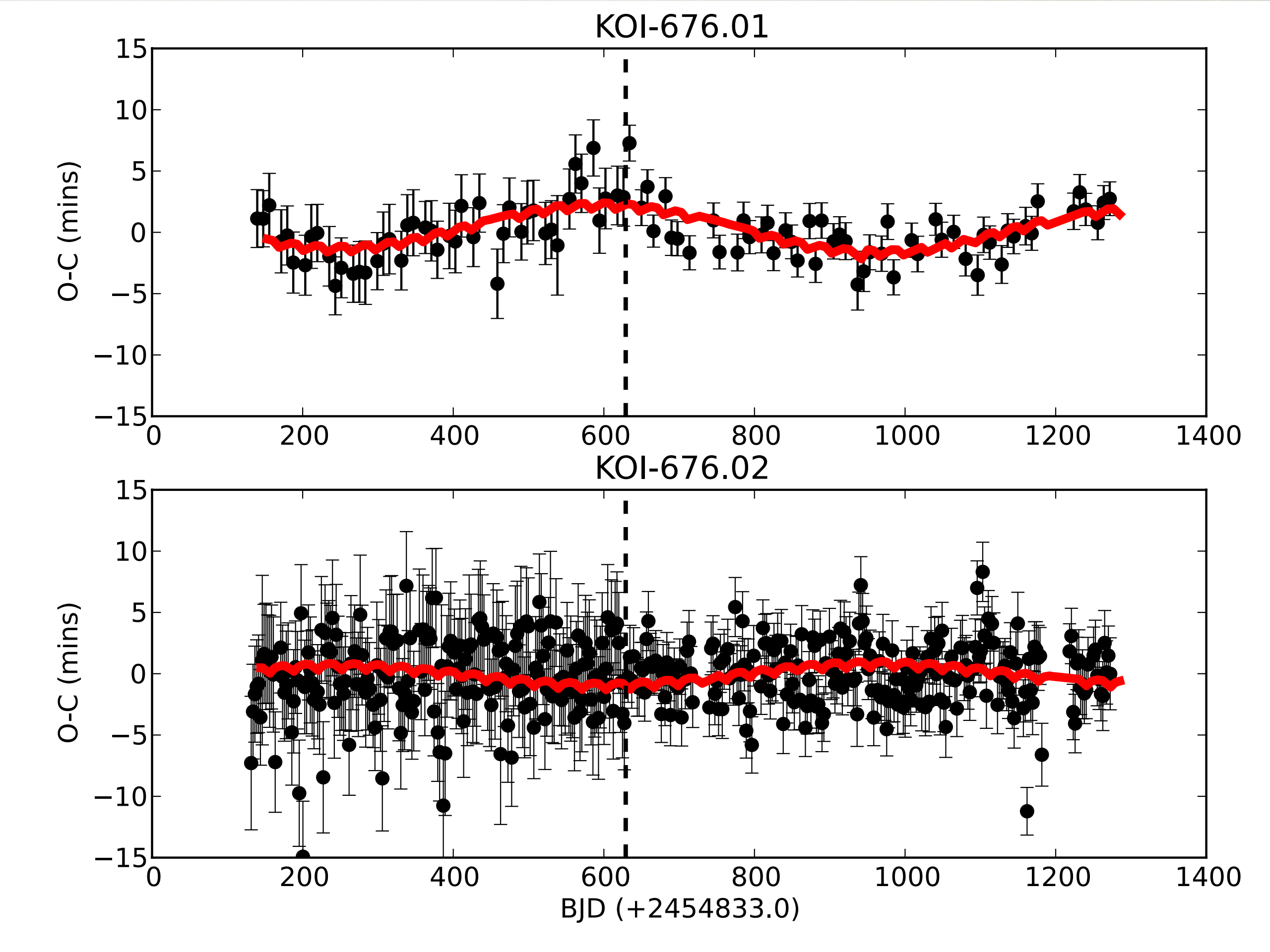

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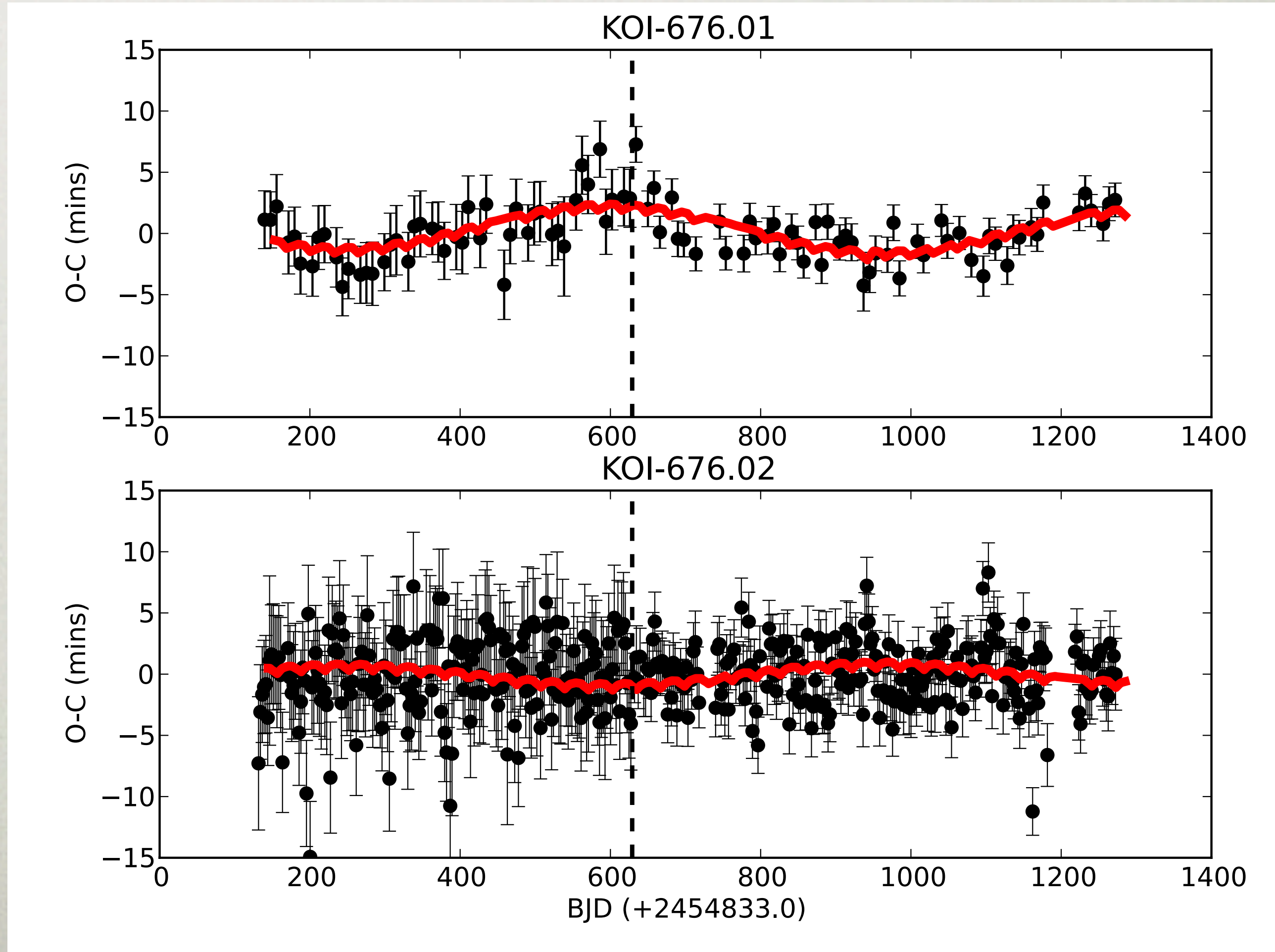

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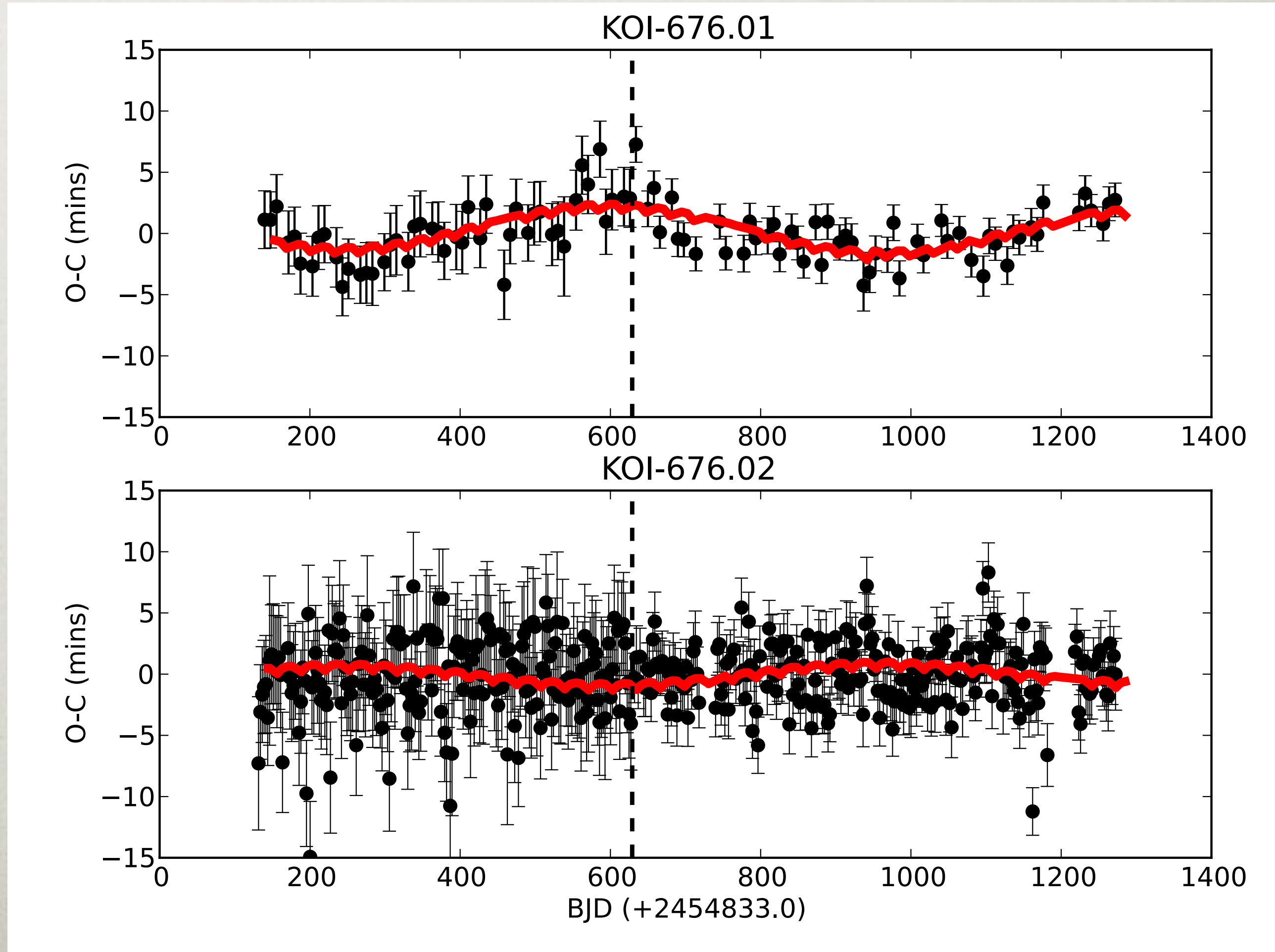
planet b variation

planet c variation



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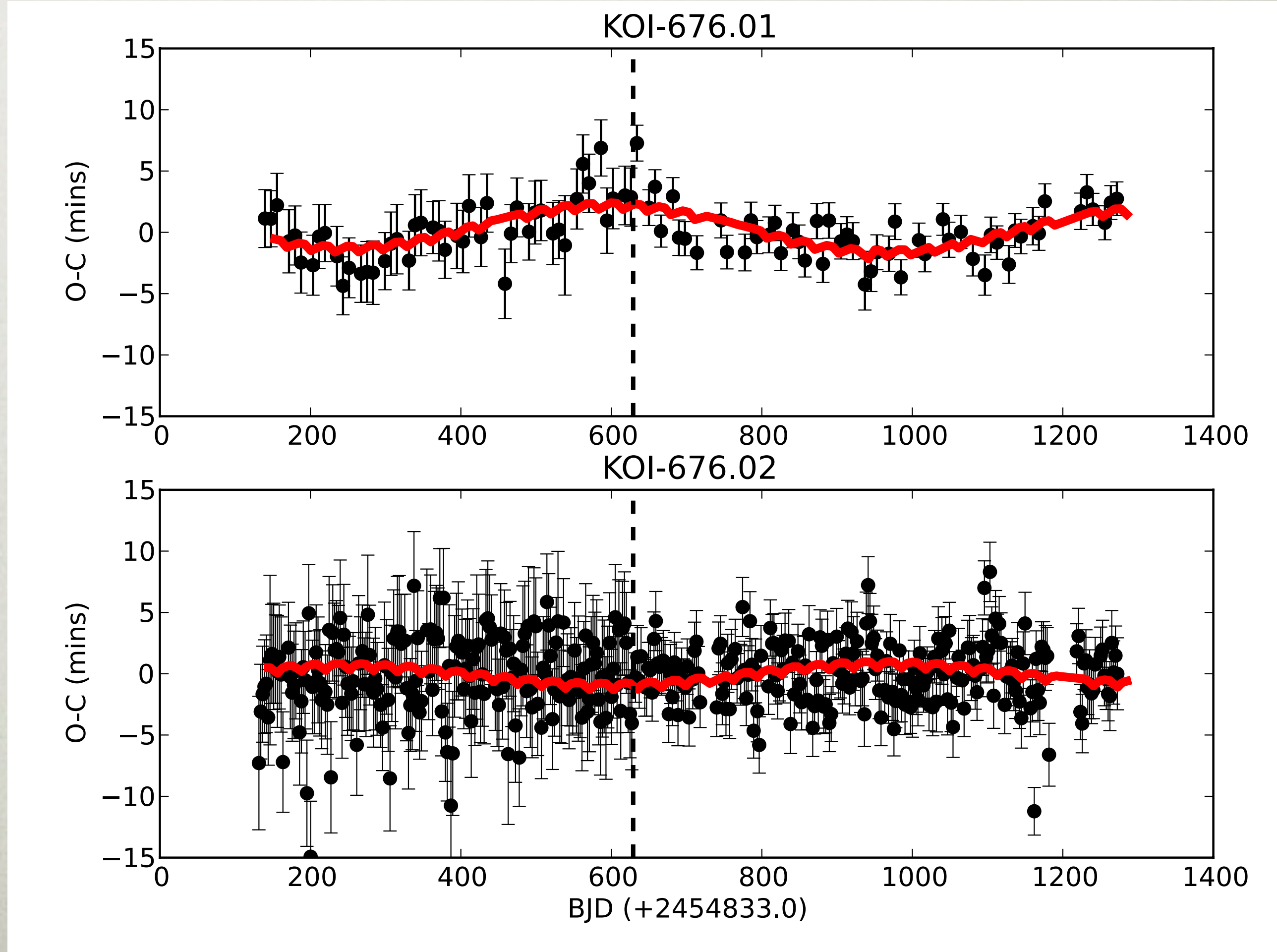

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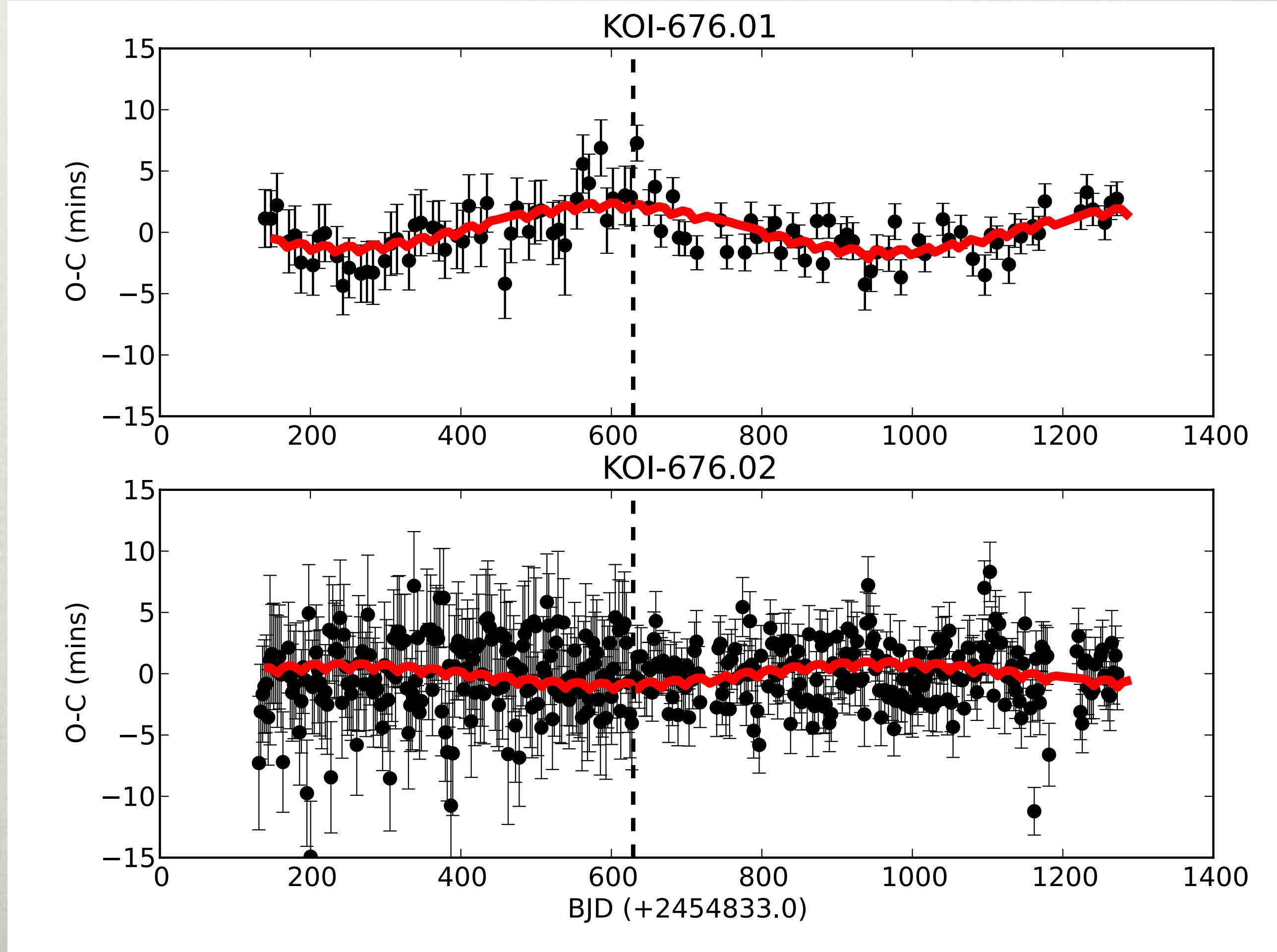
✖ incompatible ϕ values



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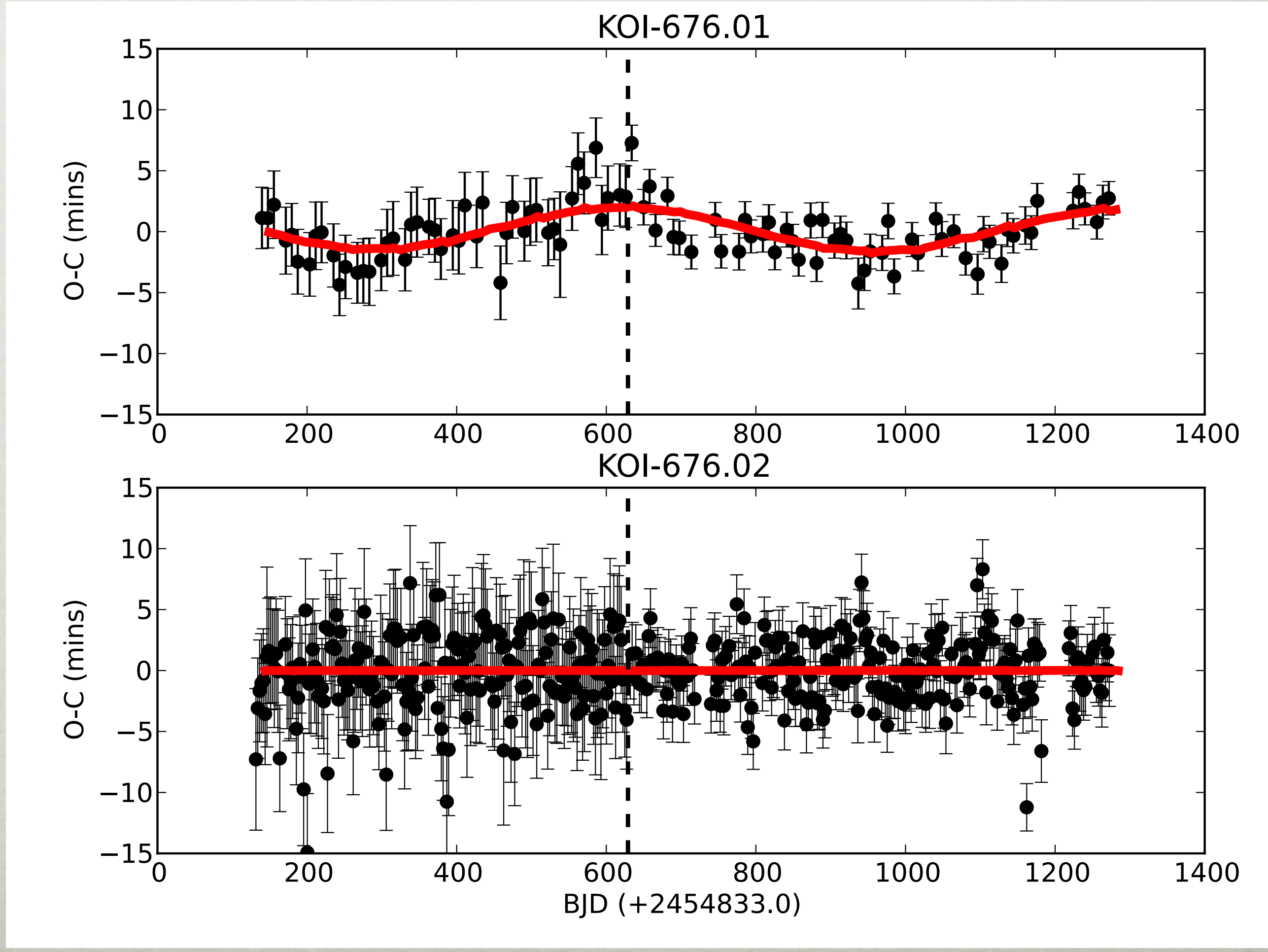

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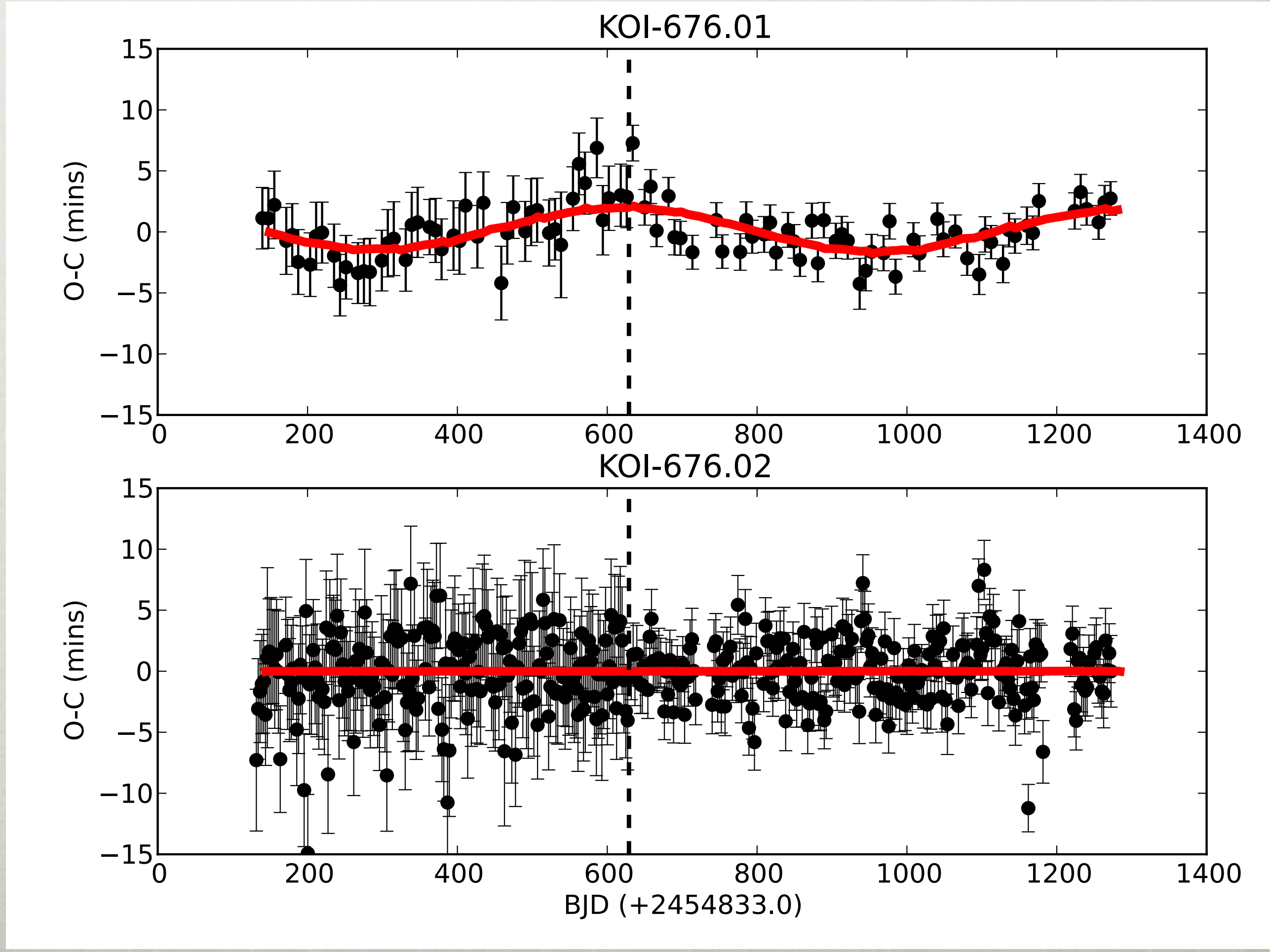
➕planet b variation



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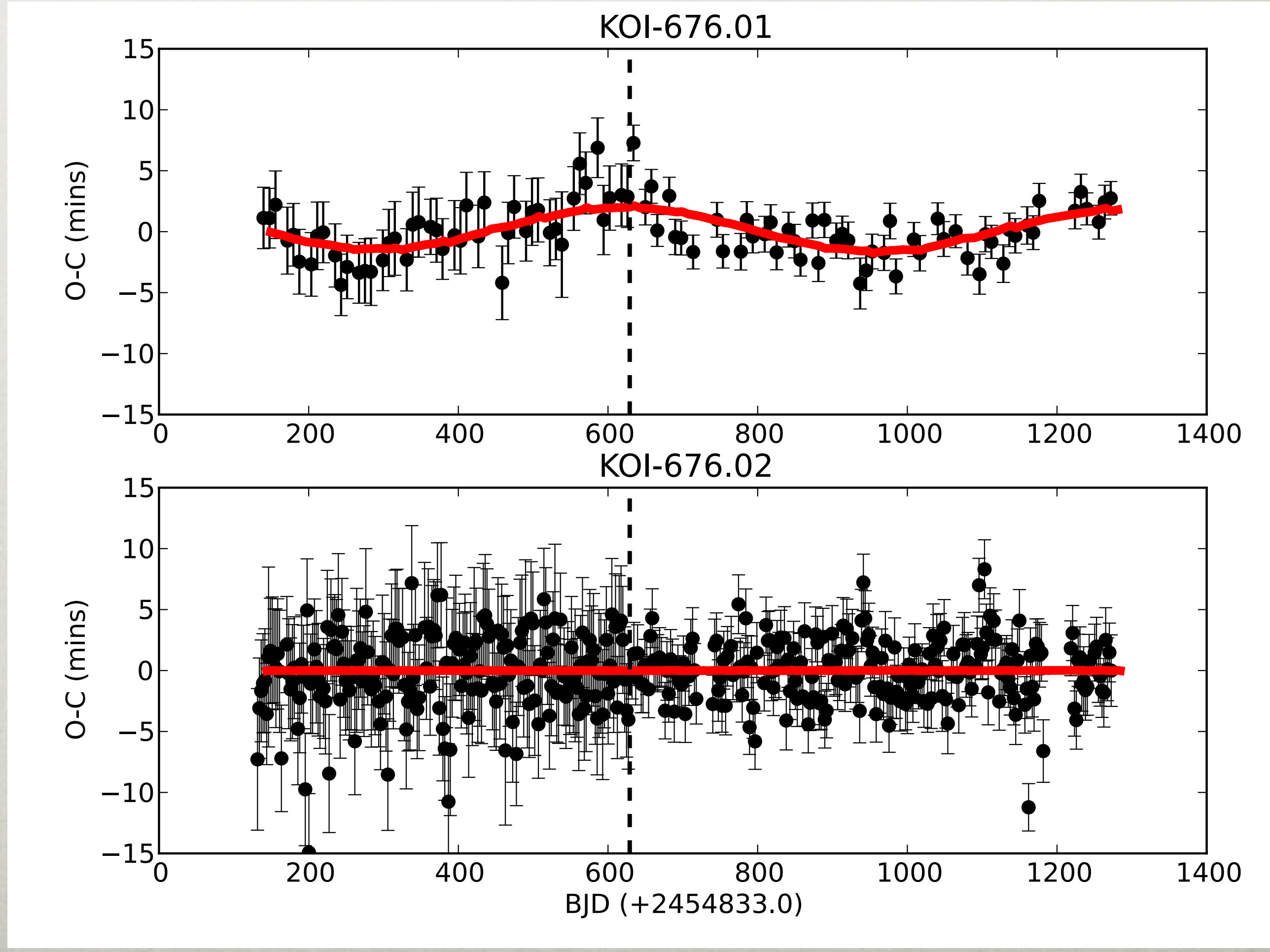
planet b variation

planet c variation



3 planets scenario

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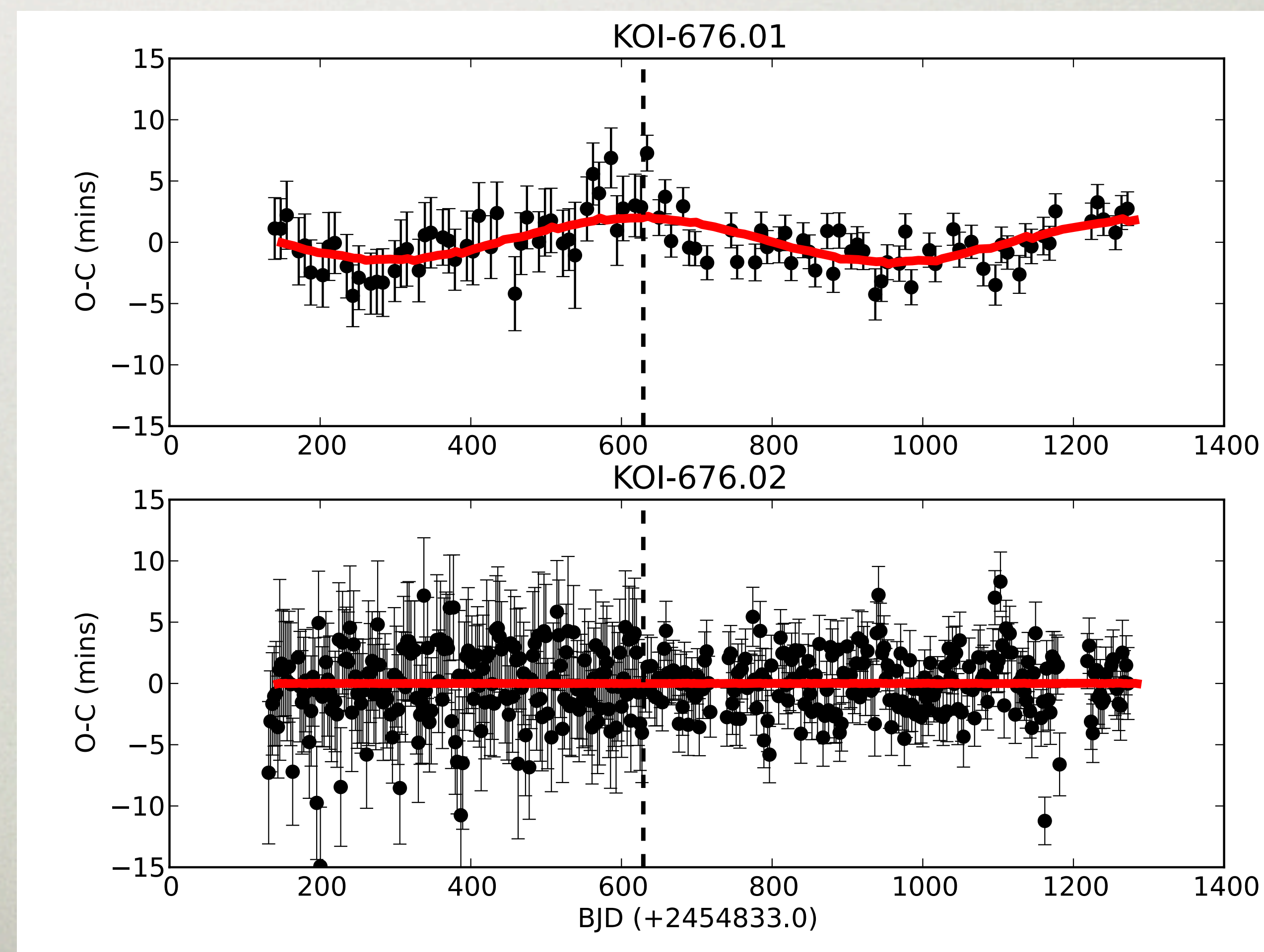
planet b variation

planet c variation

stable



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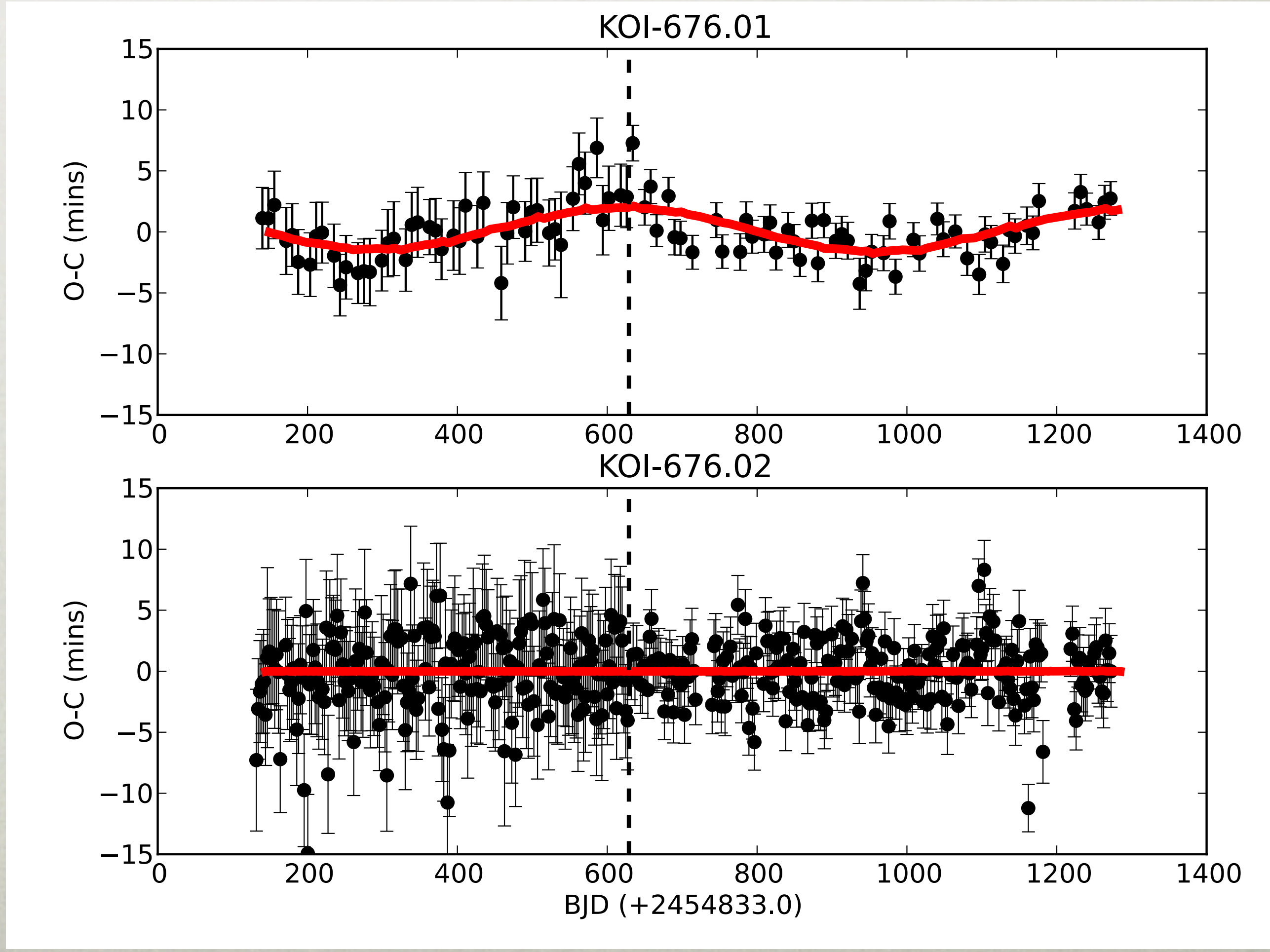

+ planet b variation

– planet c variation

+ stable

✗ Qo

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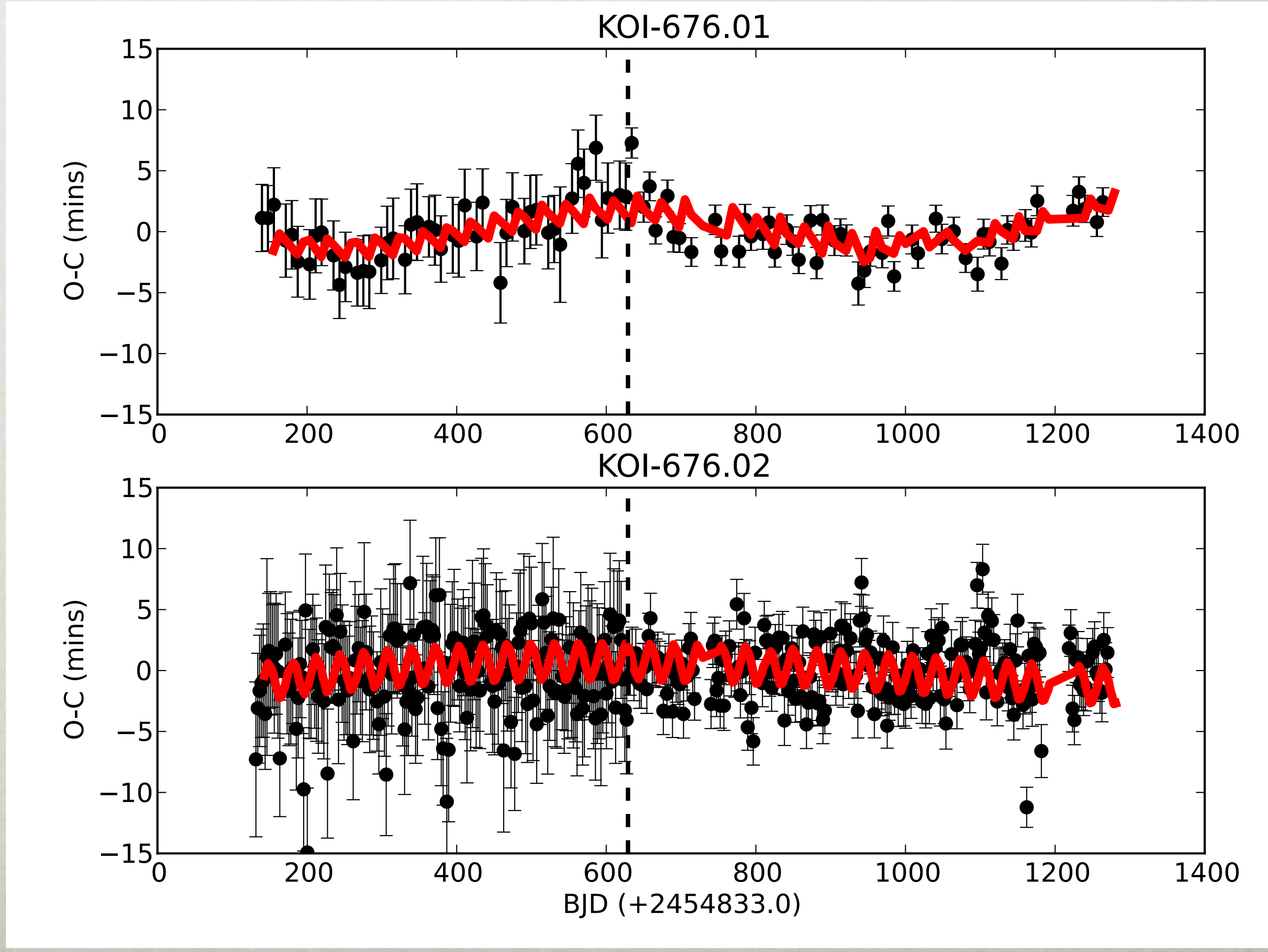

3 planets scenario

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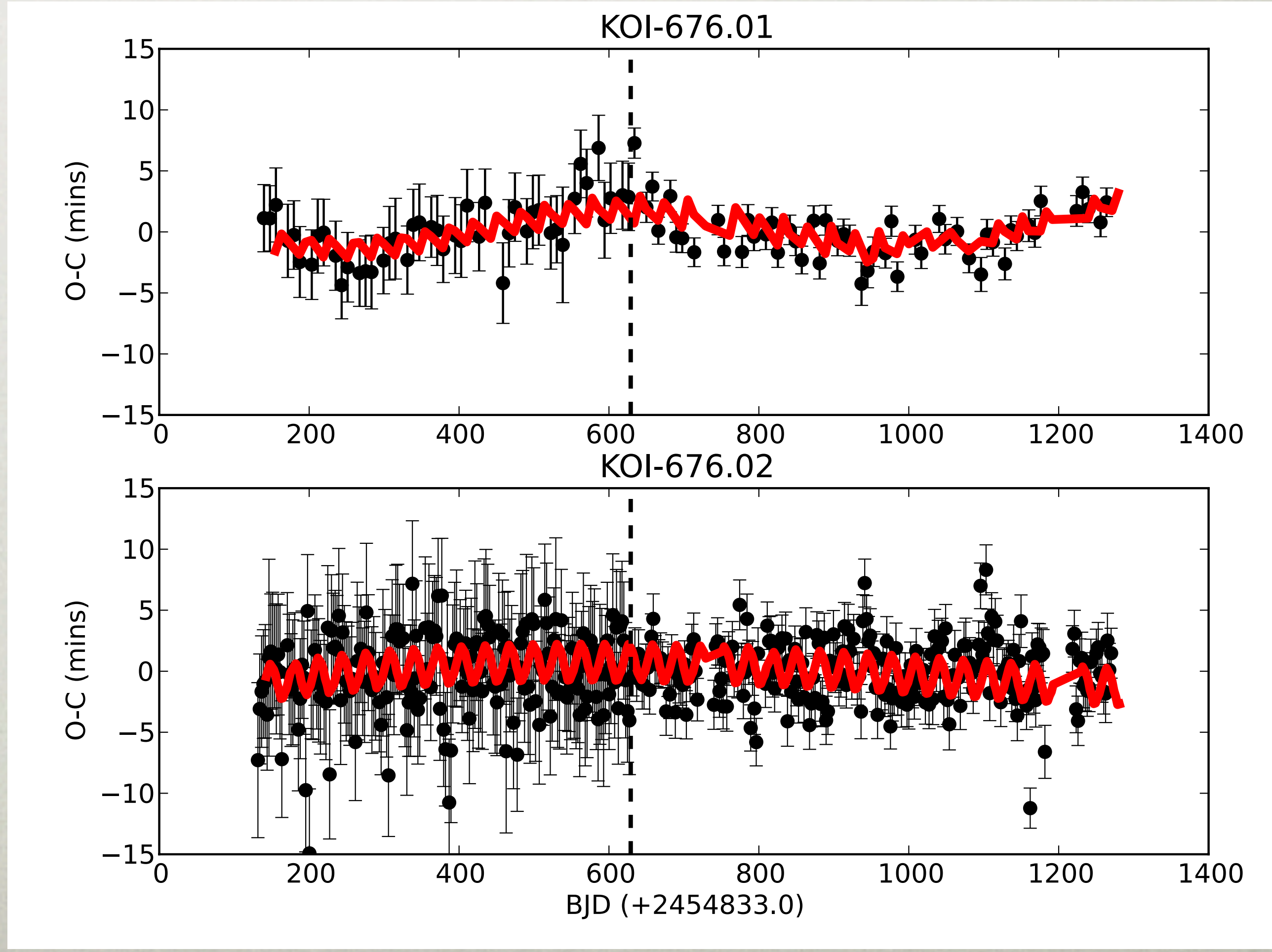
➕planet b variation



3 planets scenario

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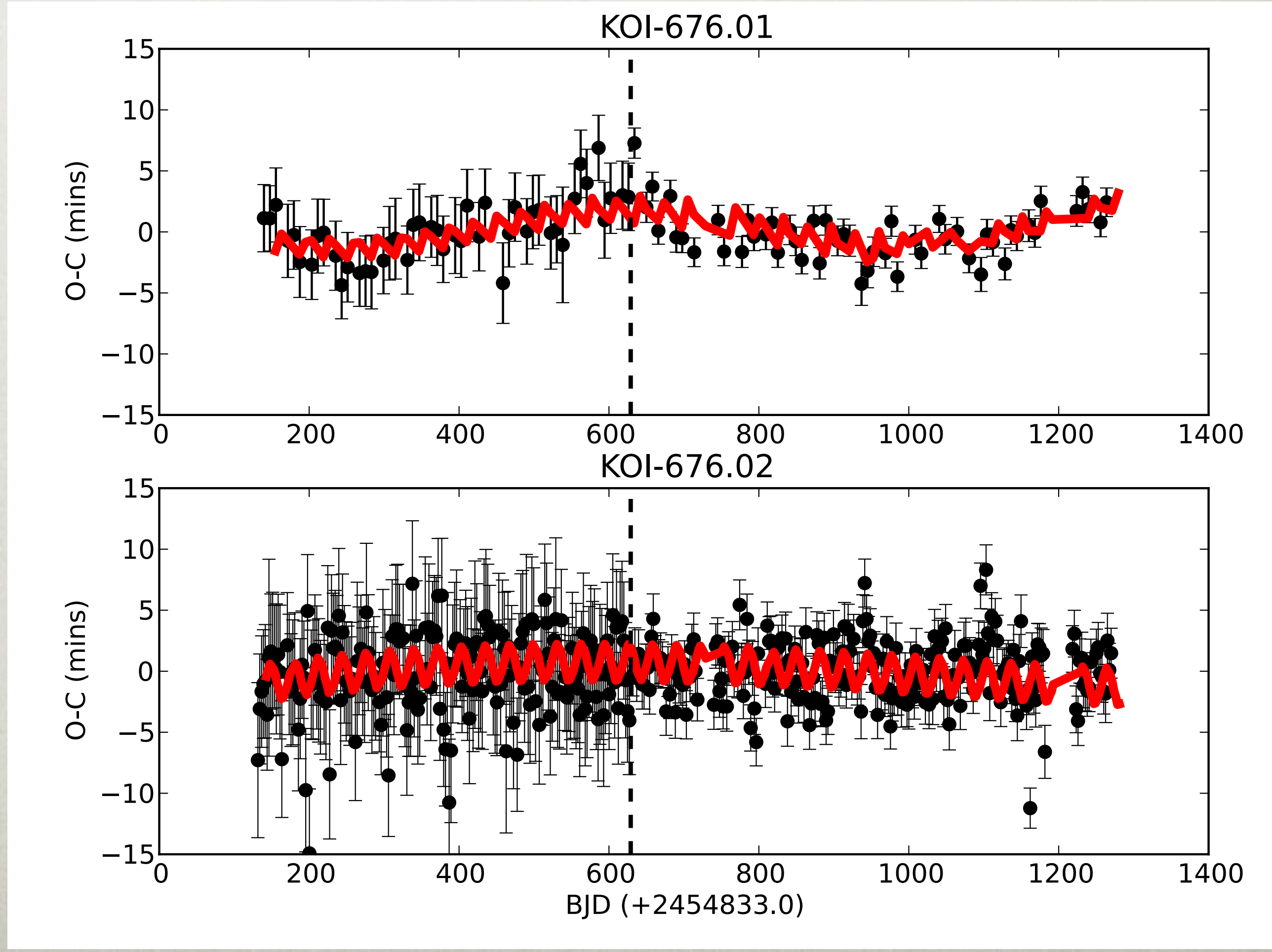
- ✚ planet b variation
- ✚ planet c variation



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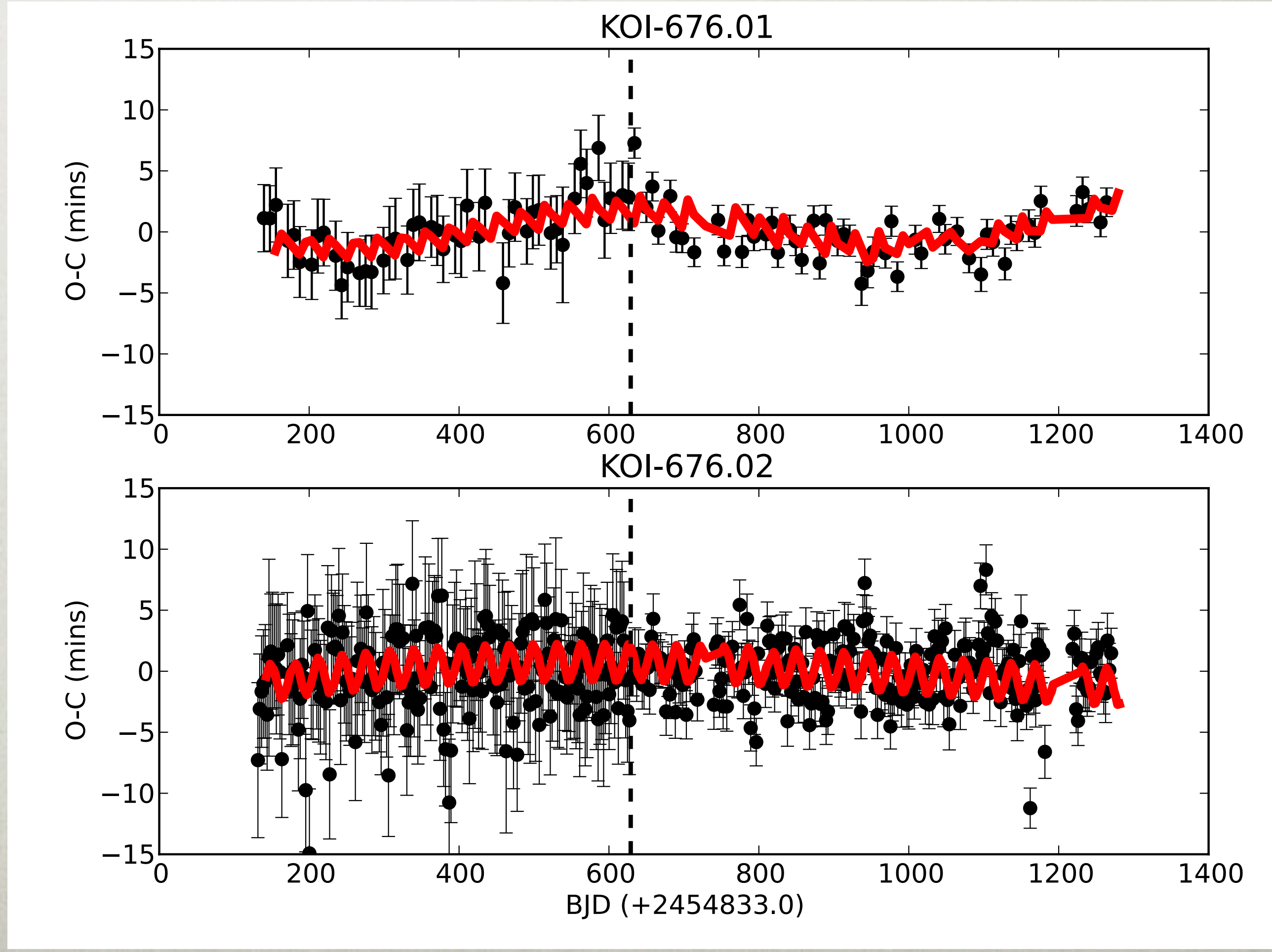

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- planet c variation
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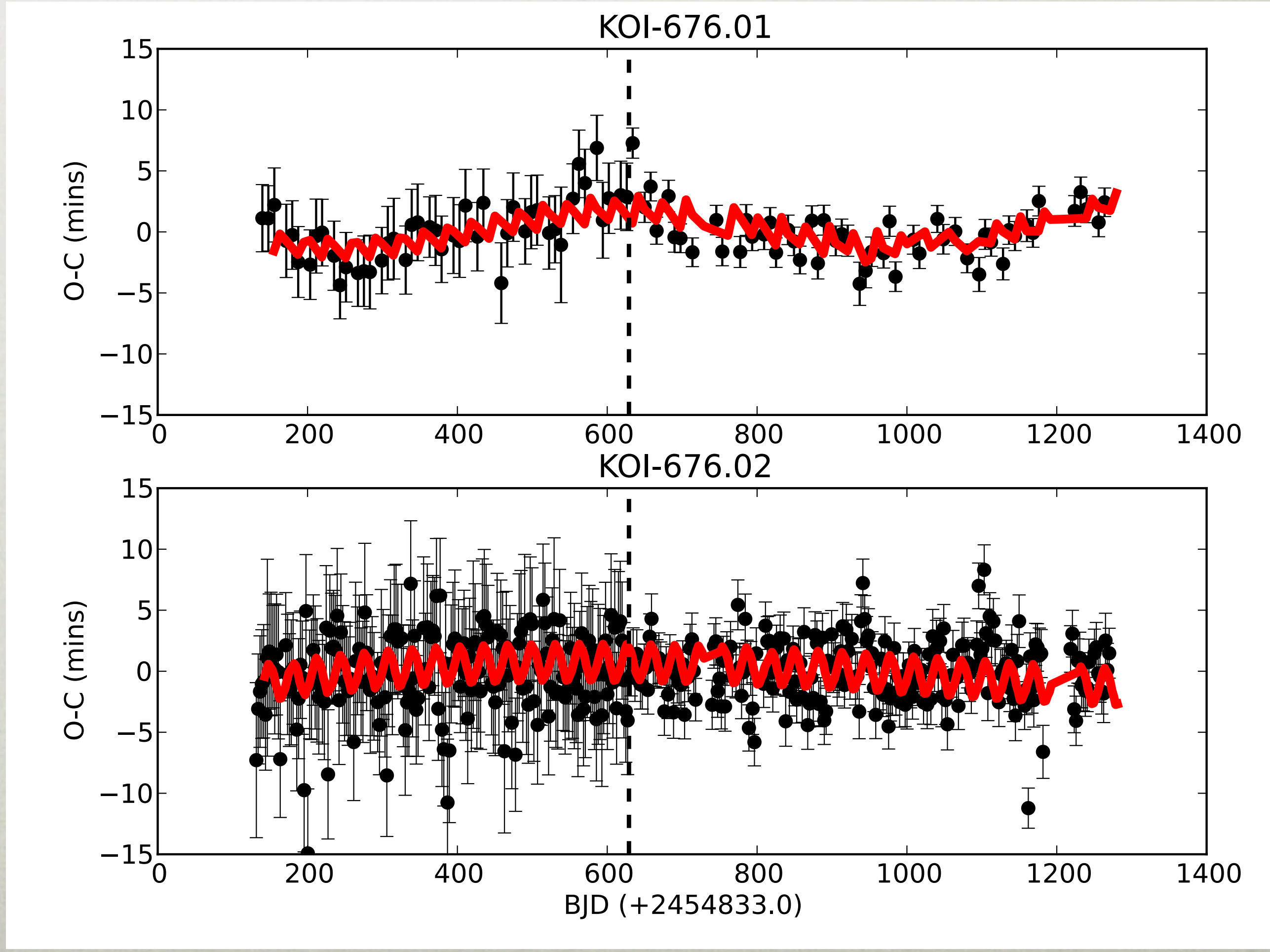
- ✚ planet b variation
- ✚ planet c variation
- ✚ stable
- ✚ acceptable φ values



3RD Companion

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- P ~ 63 days

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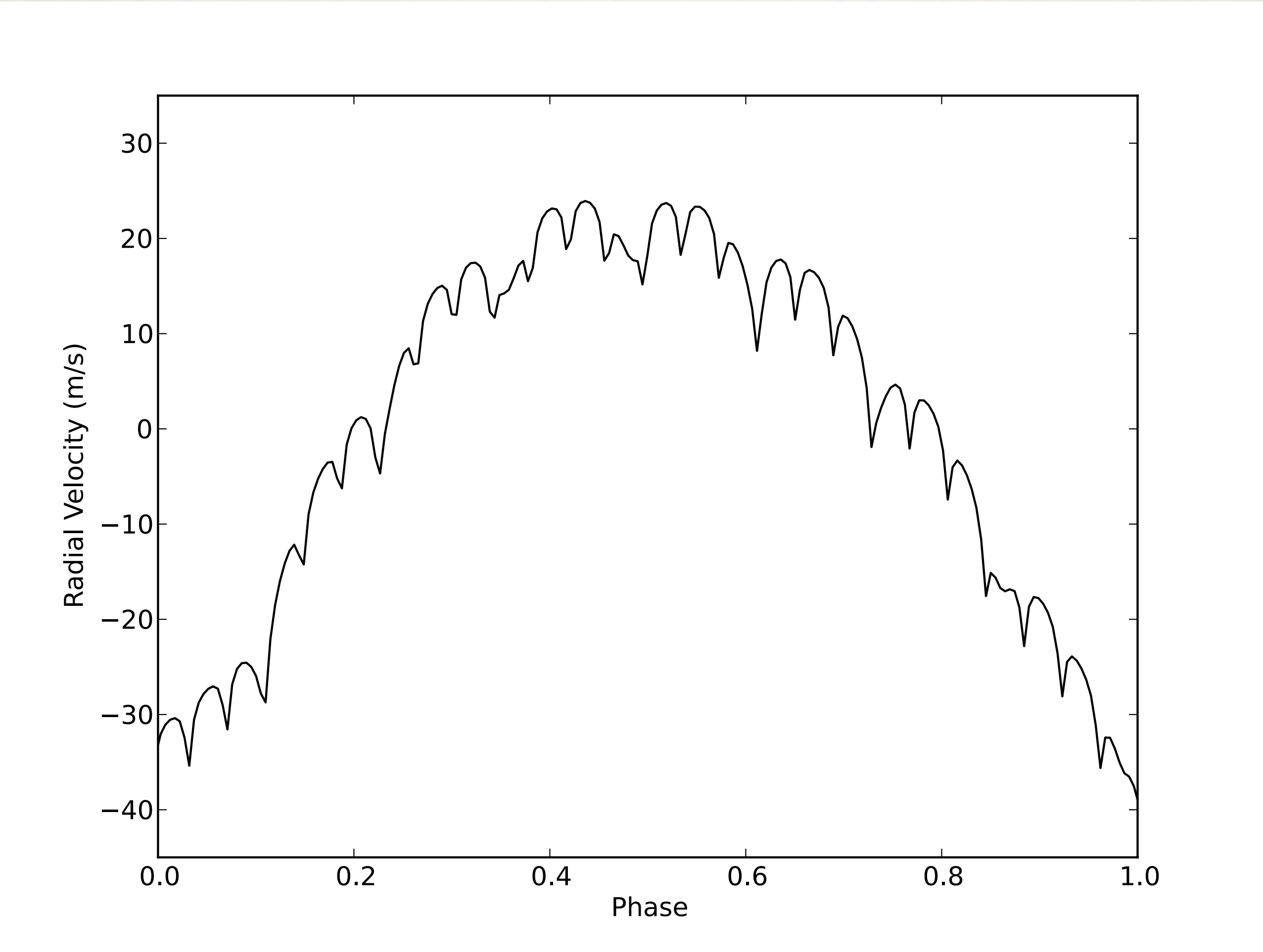
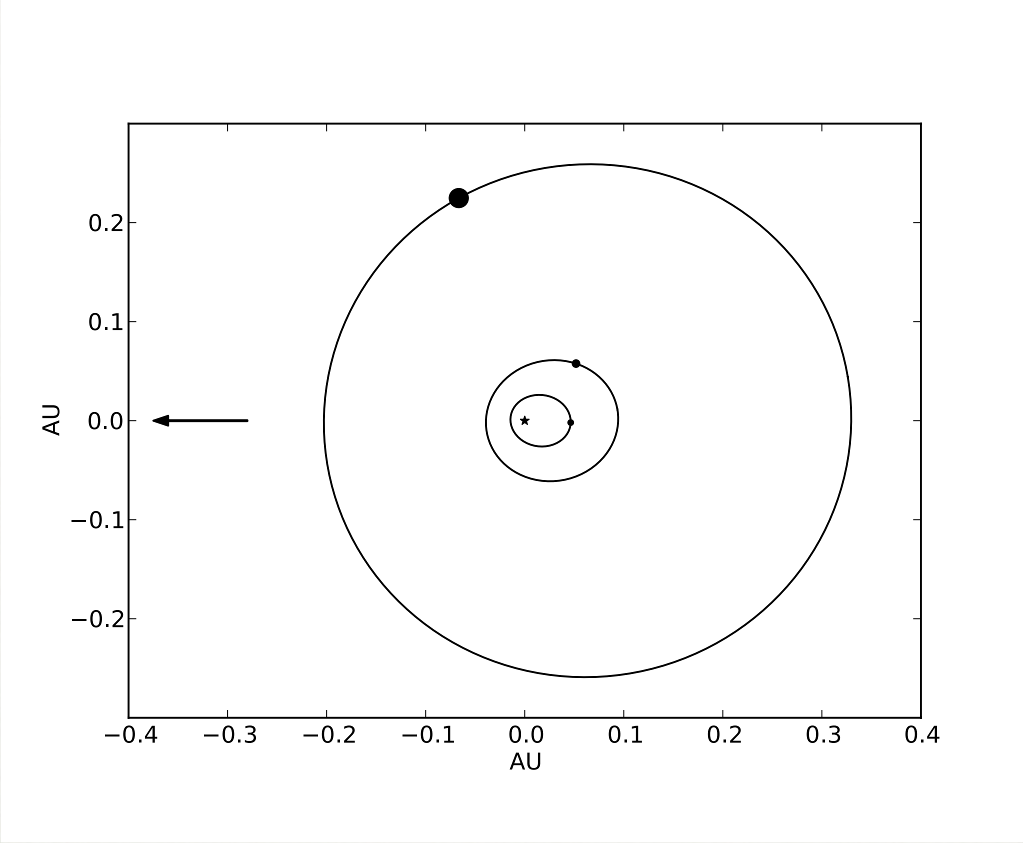
3RD COMPANION



- P ~ 63
- Not o ... m our mode
- Massive enough to produce detectable RV

Conclusions



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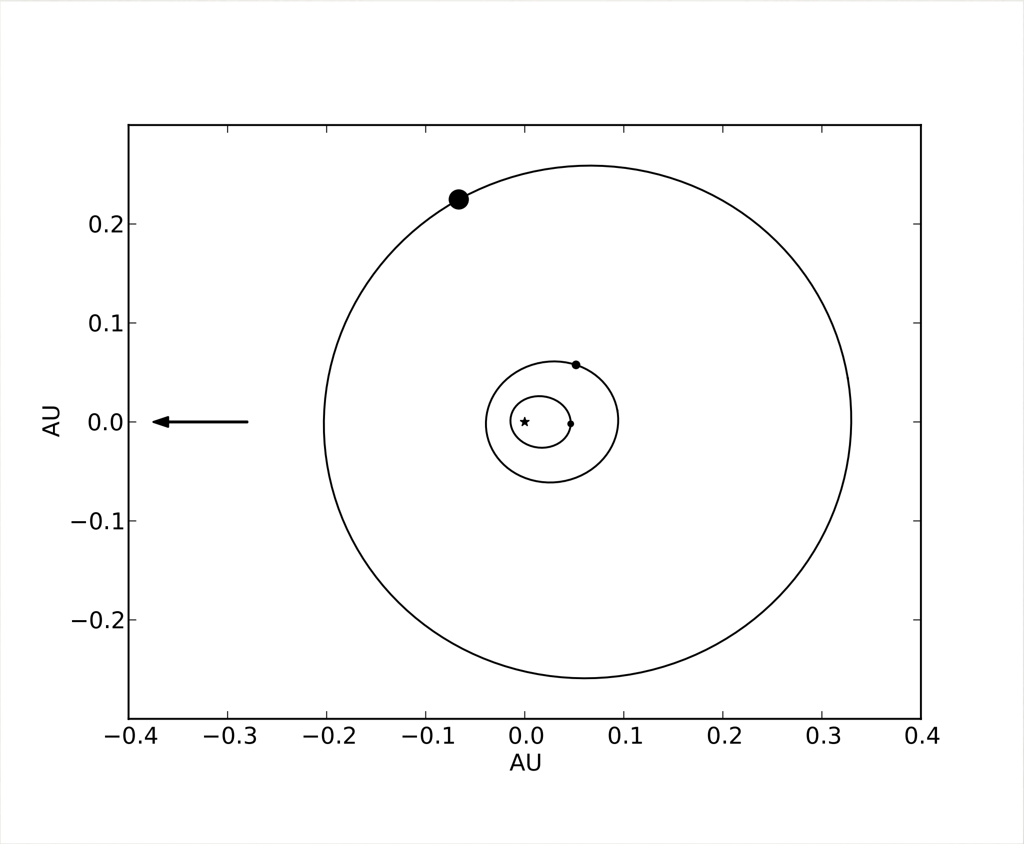

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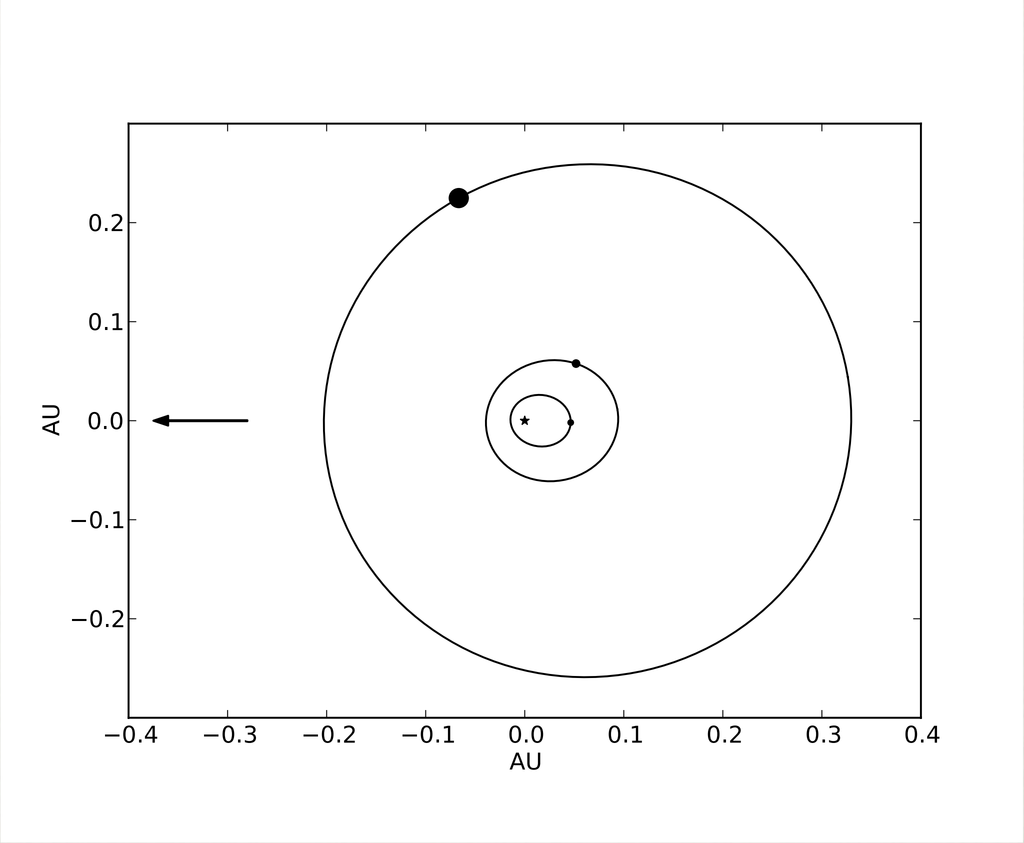

- The orbits of both planets are eccentric, which confirmed with 2 different approaches
- There is a third perturber, causing the totally uncorrelated TTV

Activity Removal

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- Selection of the transit areas in the lightcurve

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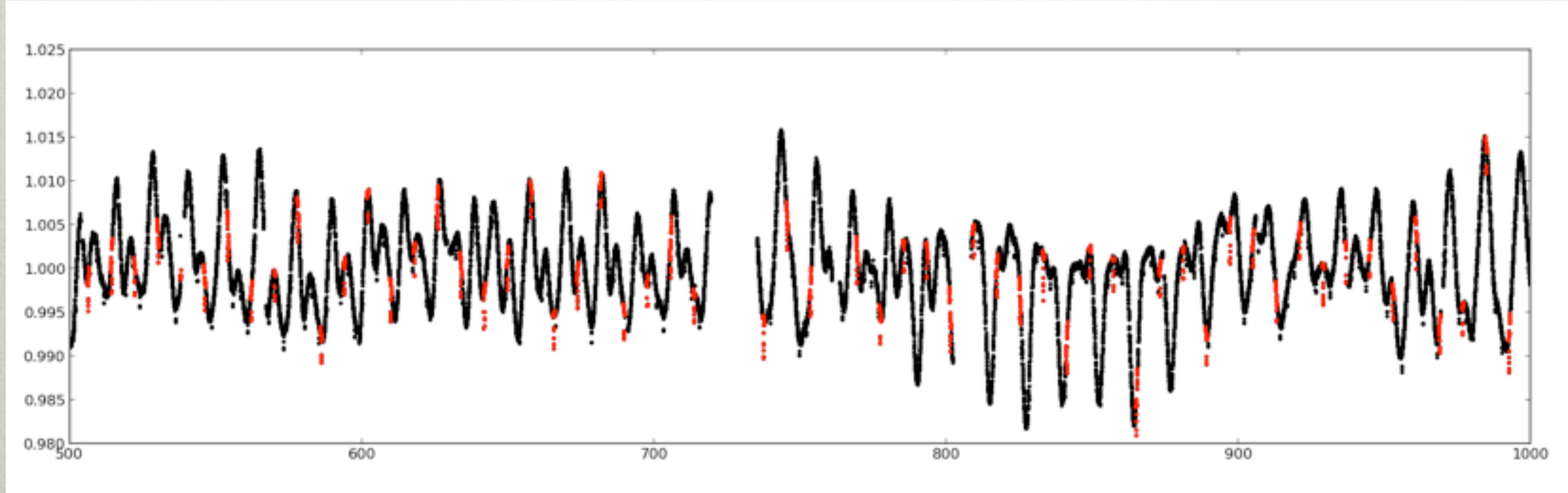

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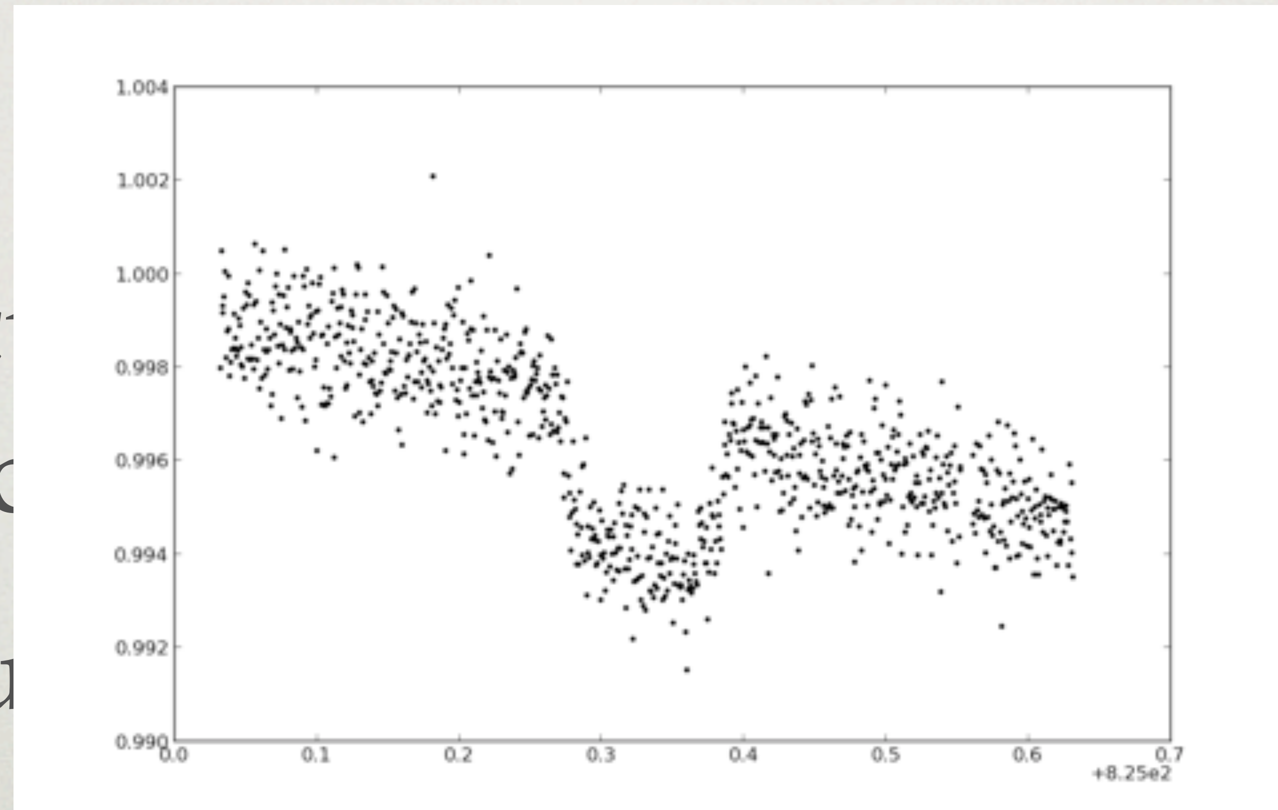
- 2^{nd} order polynomial fit to the points before and after transit

Activity Removal



- Select … the lighto…
- Exclu… s
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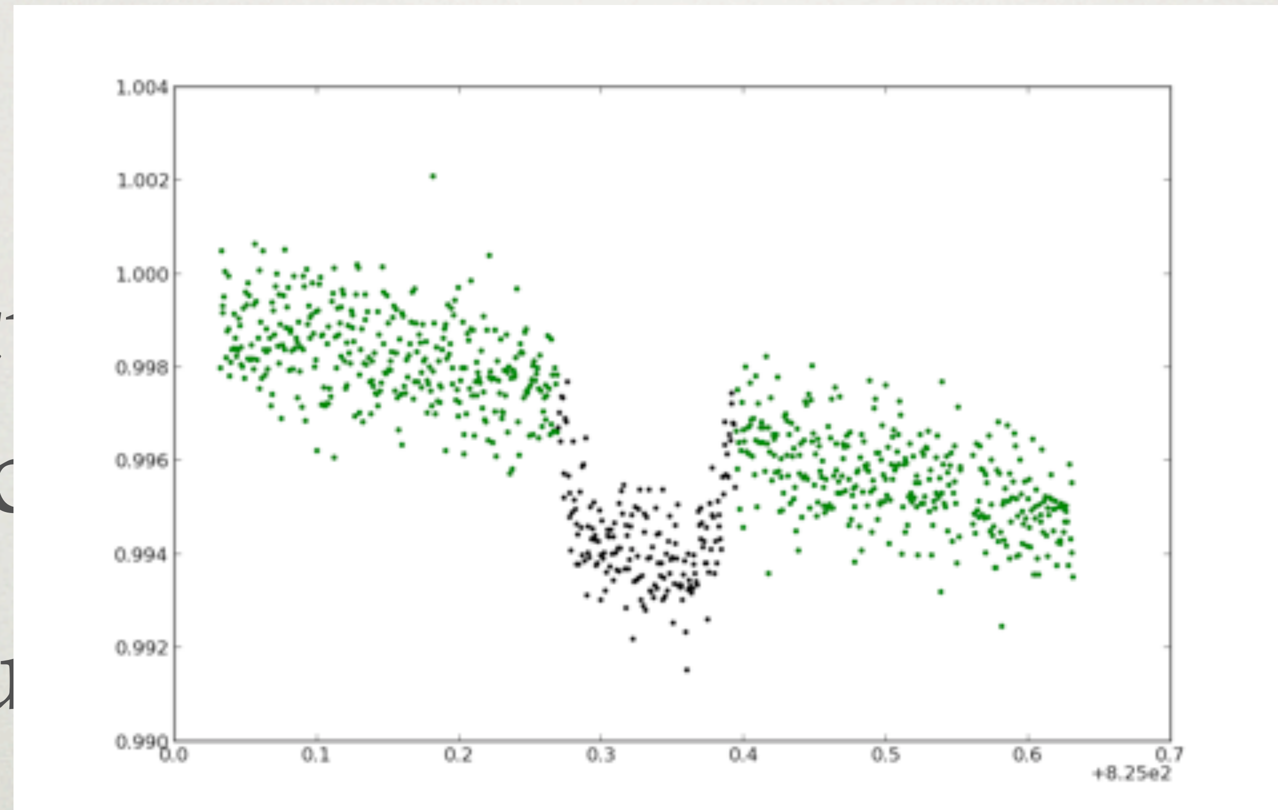

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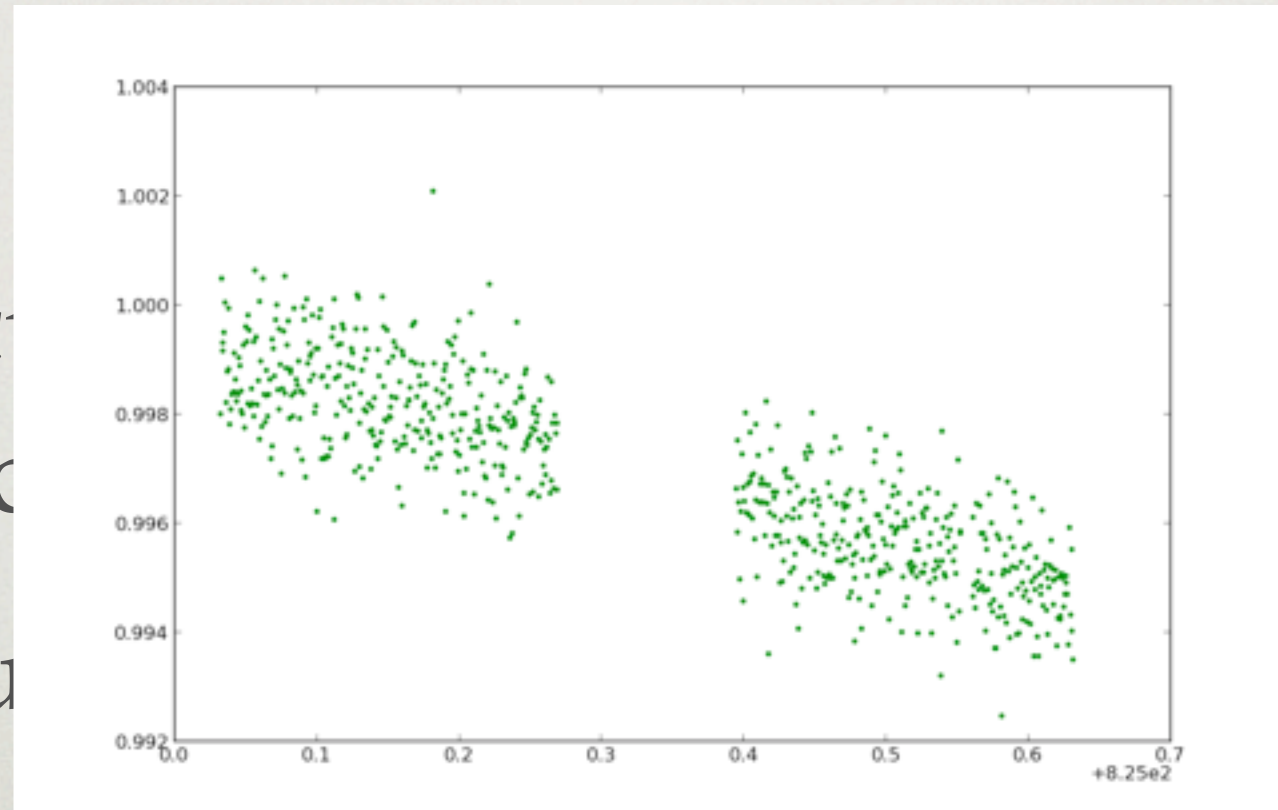

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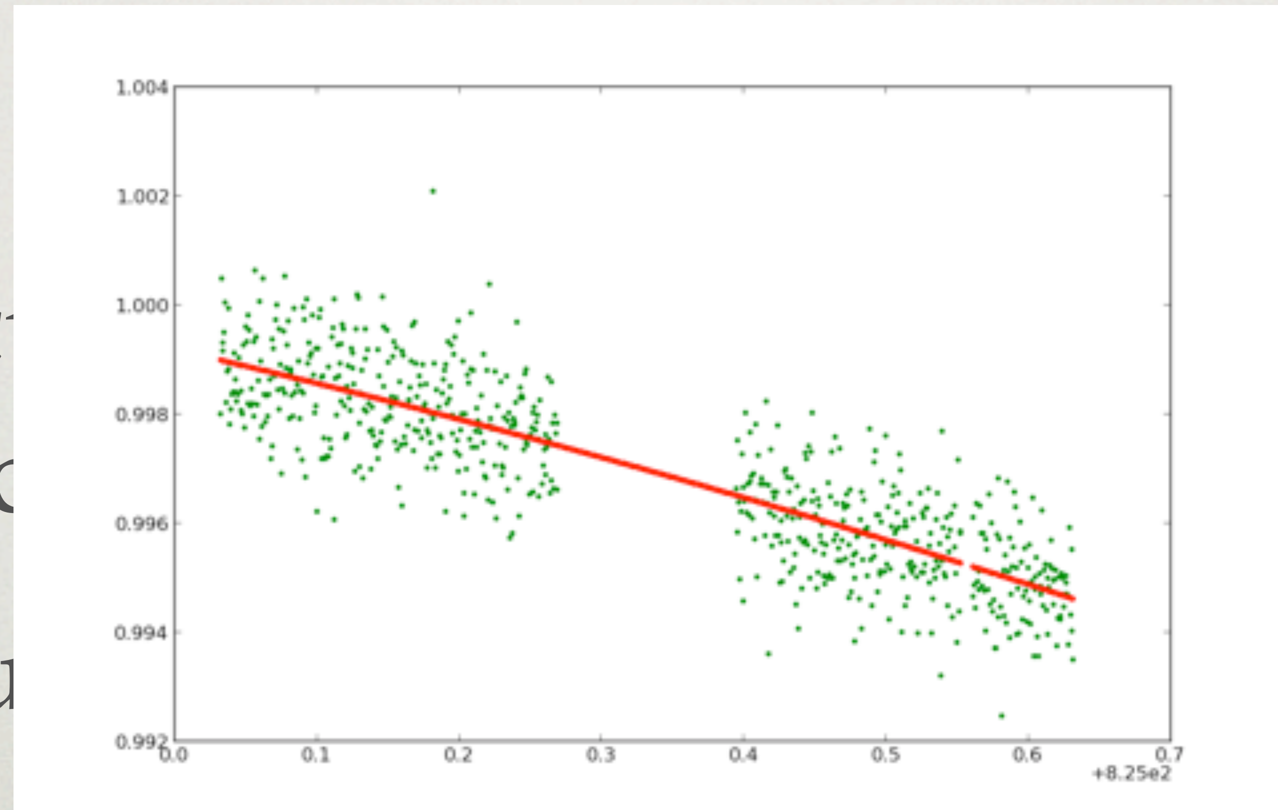

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Activity Removal

- Selection of the transit areas in the lightcurve
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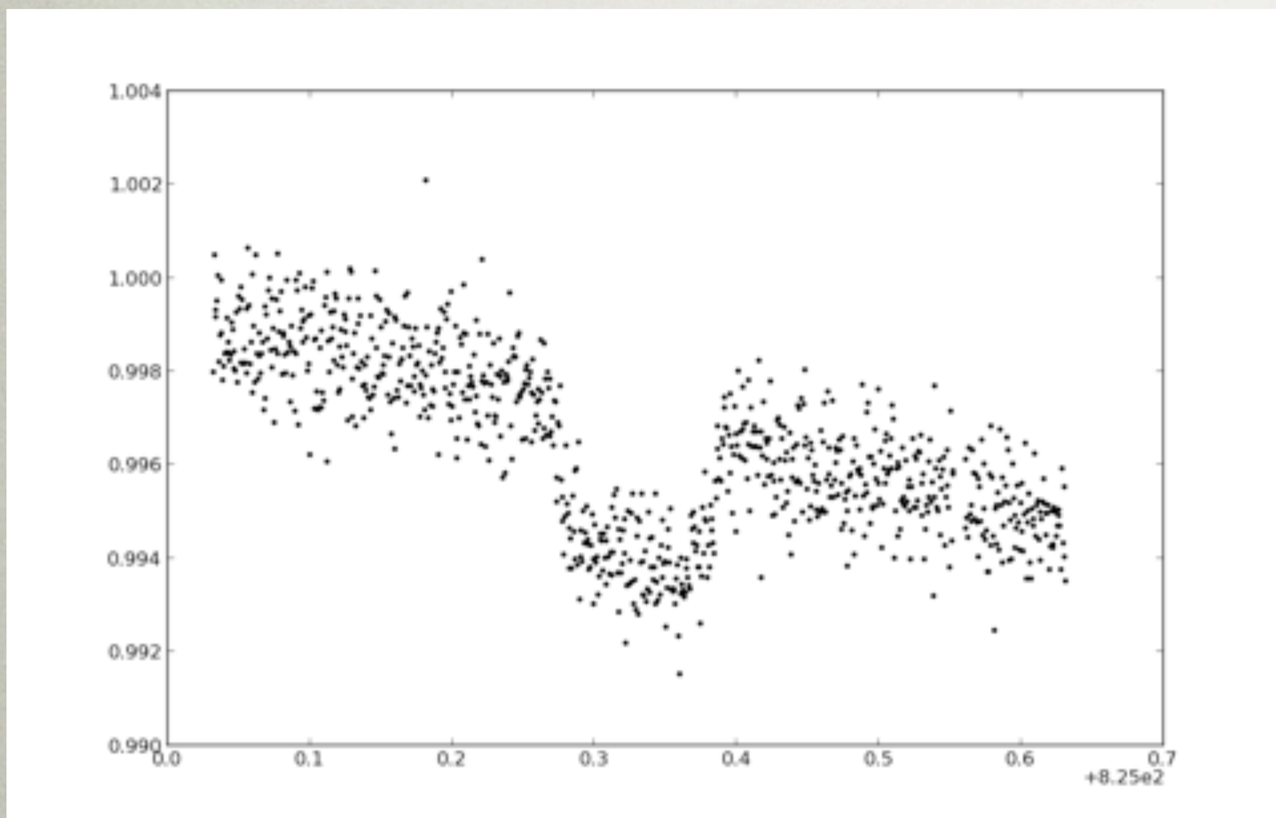
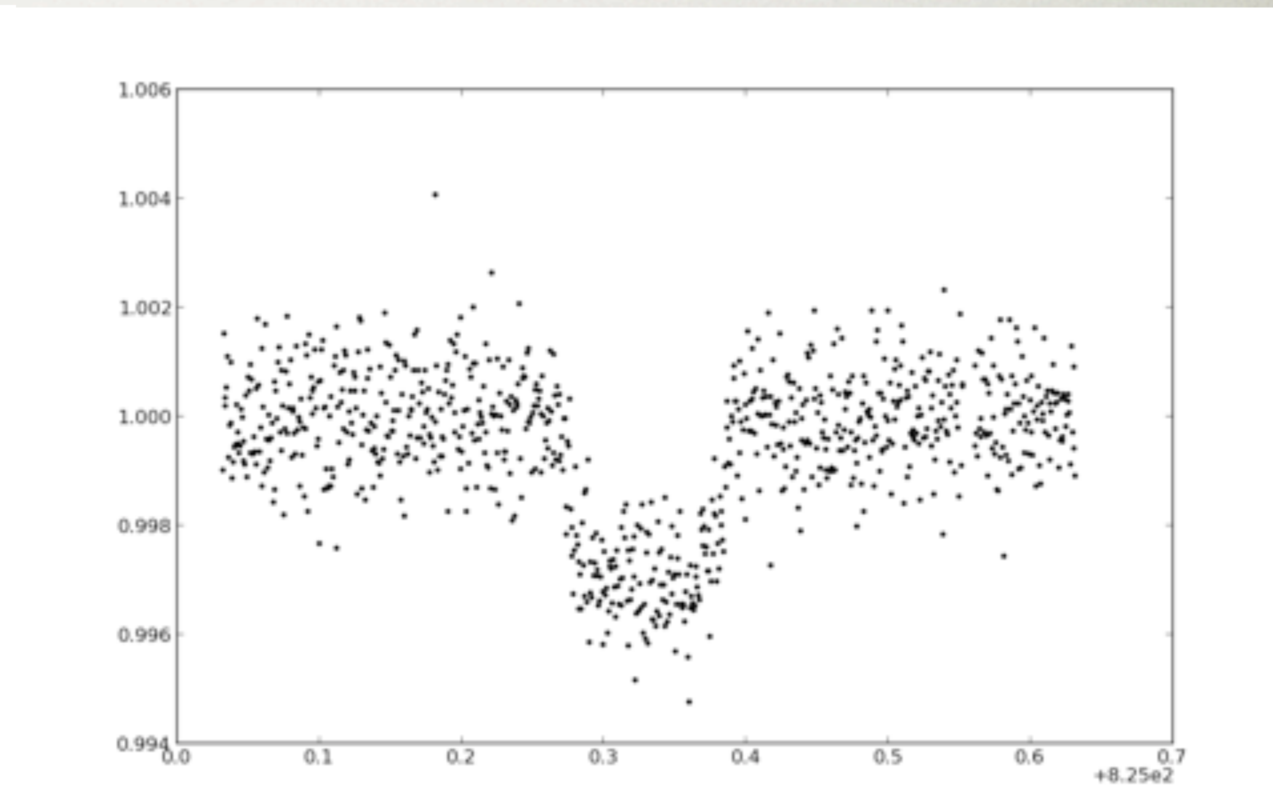
Activity Removal





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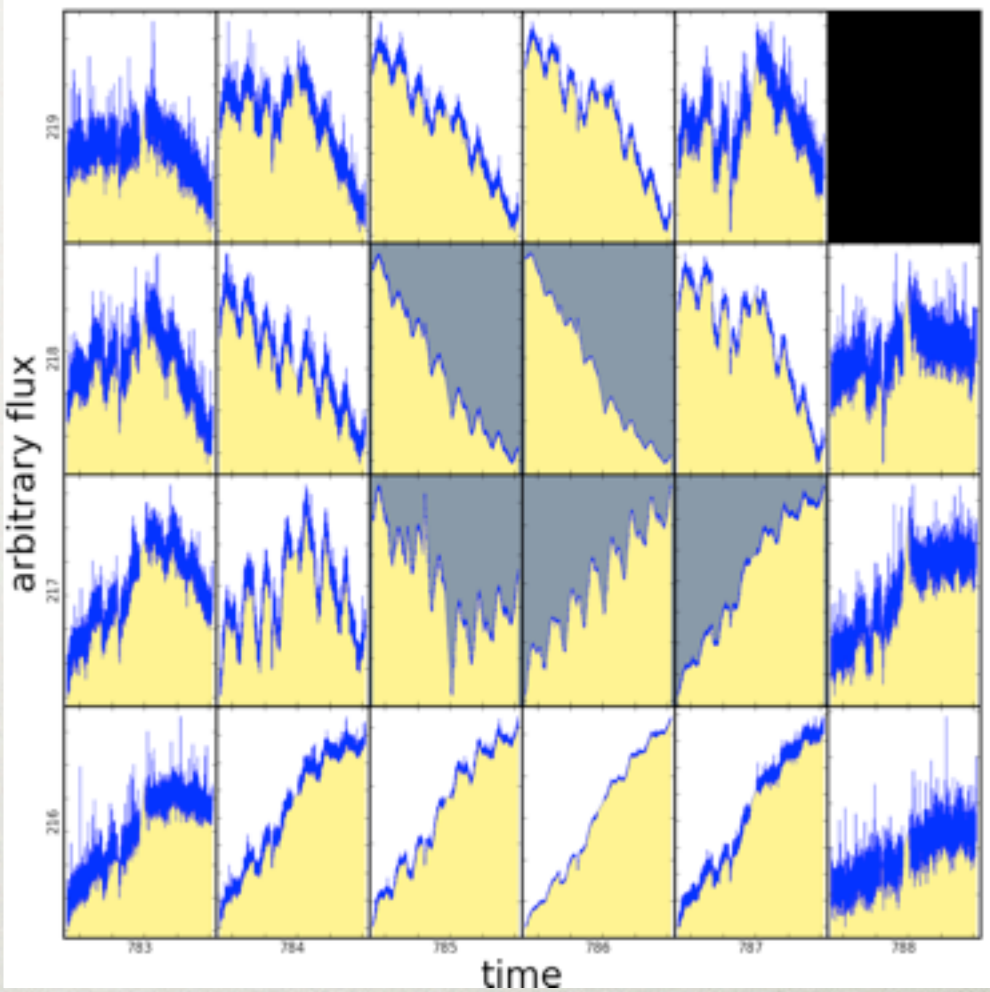

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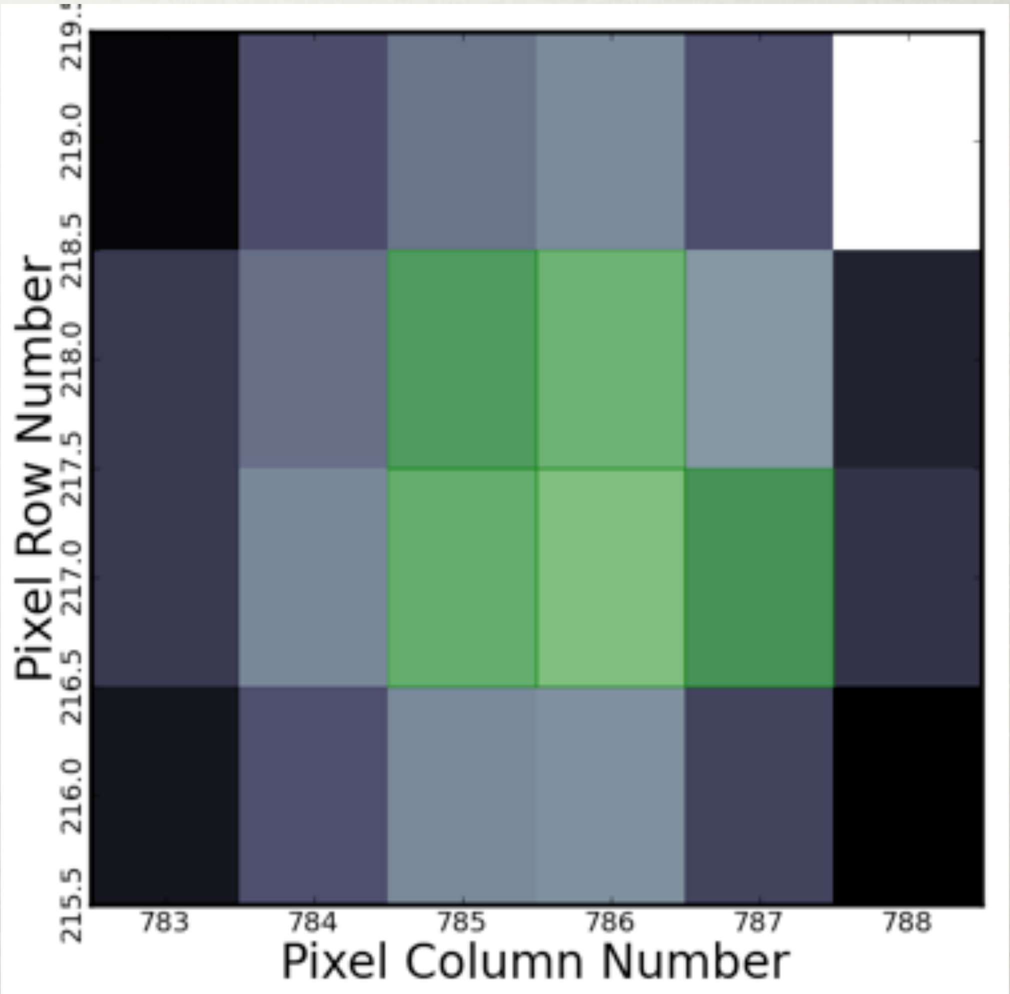

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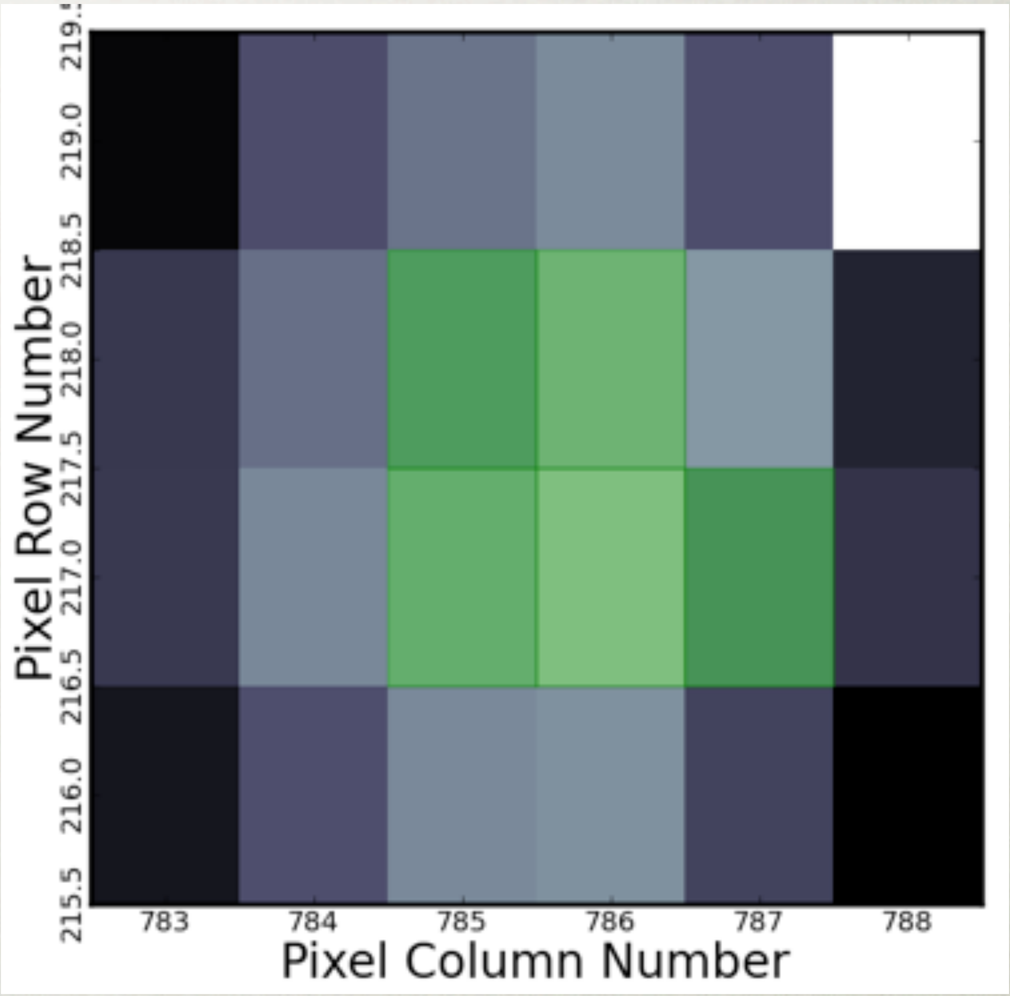
  - ☑ Examination for nearby variable stars
  - ☑ Examination for possible centroid displacement during transit
  - ☑ Spectrum



Kepler data

Kepler data

- Retrieval from MAST archive for Kepler data

Kepler data

- Retrieval from MAST archive for Kepler data
- Q9-Q12

Kepler data

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- SAP instead of PDC_SAP

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- Long and short cadence data

Transit Model Fit

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- Mandel-Agol model fit

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- MCMC Analysis for errors

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- WAIT !!! Outer planet is highly affected by spots...

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- Choose the less disturbed epochs closer to the highest flux