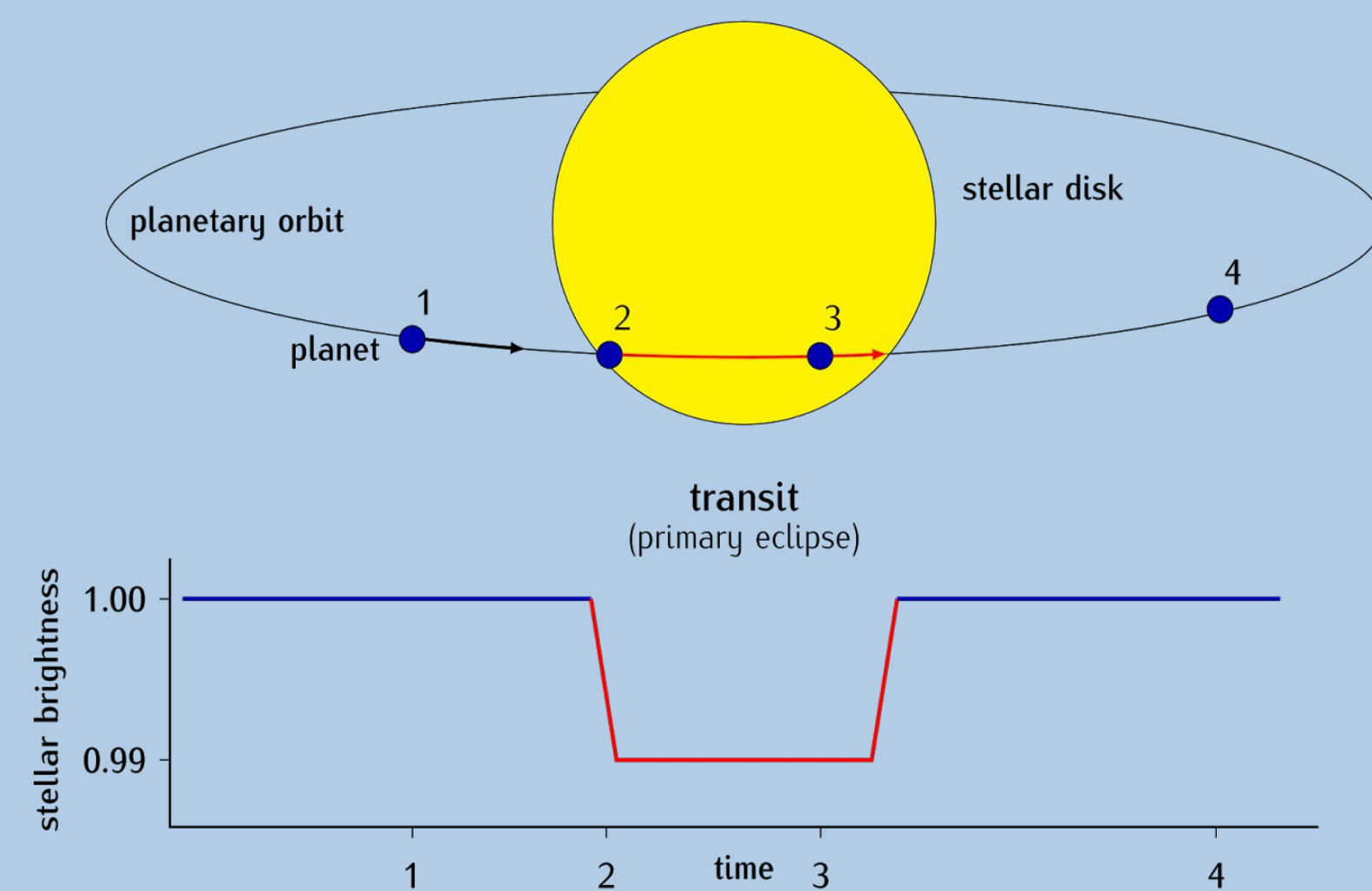


## Introduction/Abstract

Mass measurements for young exoplanets planets are invaluable, but cannot be found via transit measurements alone. Transit timing variations (TTVs) offer an alternative route to finding these measurements. In multi-planet systems, gravitational interactions between planets affects the transit midpoint ( $t_0$ ), telling us about mass ratios between planets.

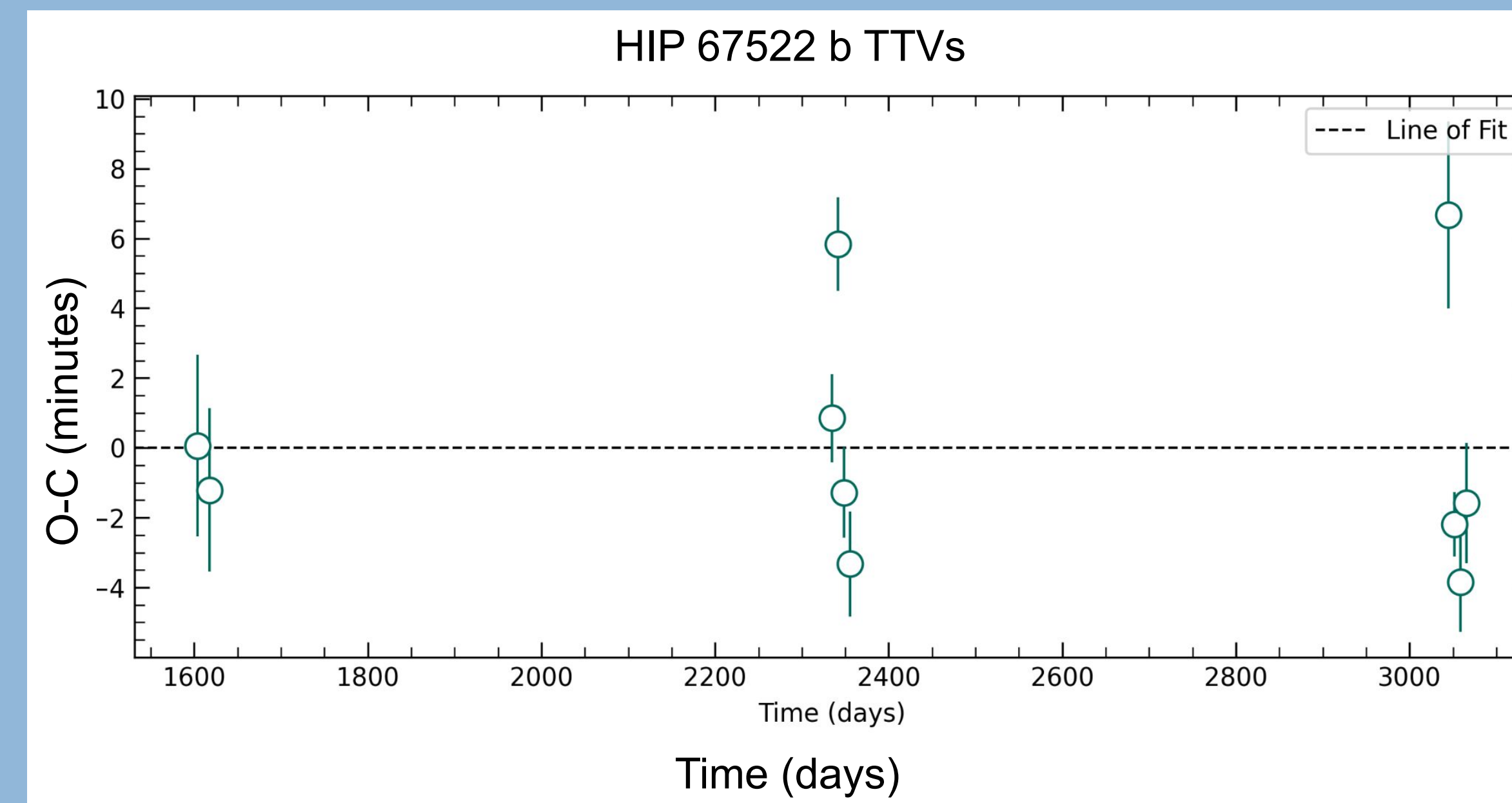
We present an ongoing TTV survey of 40 young systems hosting 59 planets using data from *Kepler*, *K2*, and *TESS*. We recover TTVs in previously reported systems and report the discovery of TTVs in systems such as HIP-67522 and TOI-1224.



**Left:** Diagram detailing phases of a transit and subsequent flux vs. time graph (lightcurve) used to analyze transits.

Image credit: Exoplanet Diagrams

## O-C Visualization

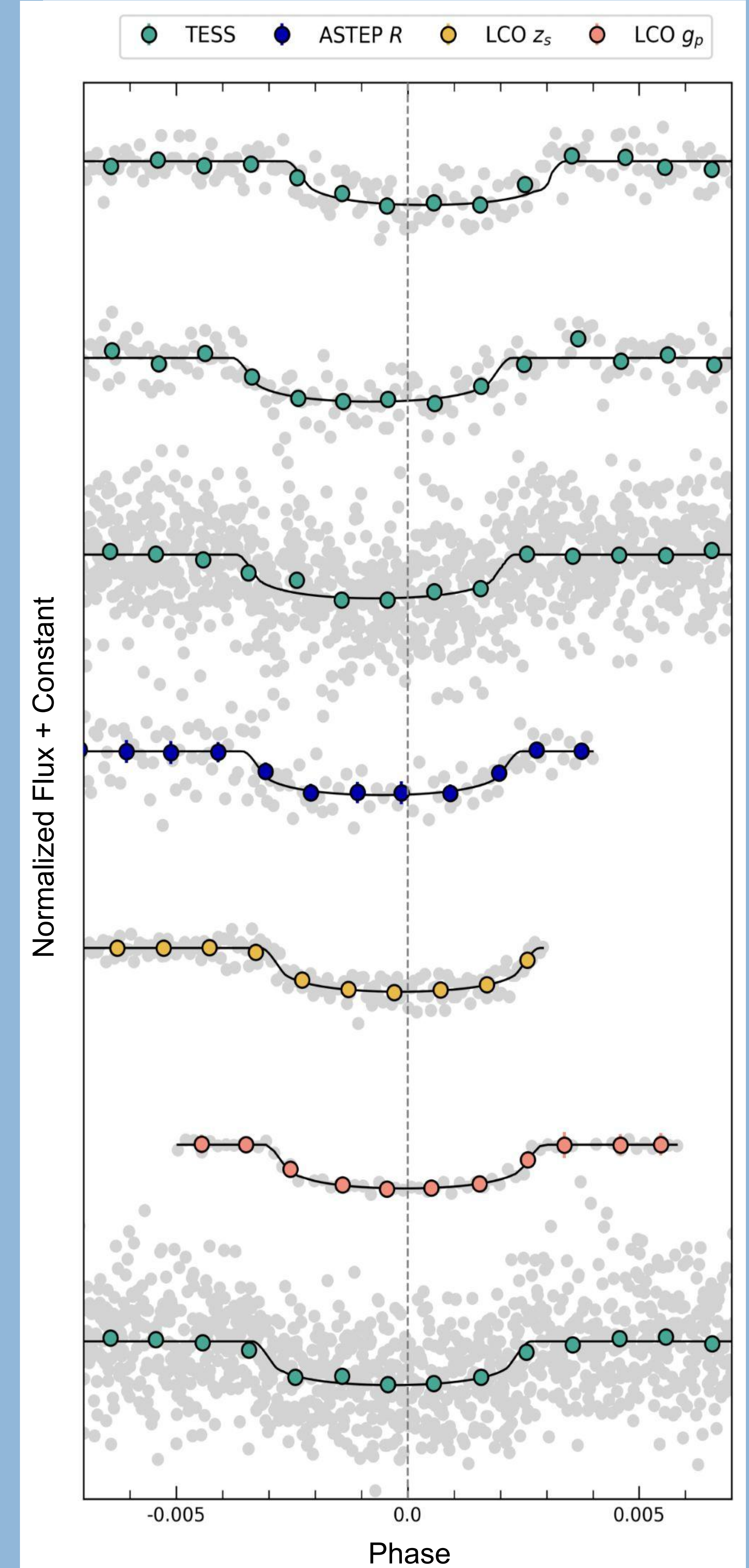


Observed - Calculated (O-C) Diagram for HIP-67522 b.

Results are calculated by recording the observed time of transit midpoint (via our analysis) vs. expected by calculation using planetary period. If a TTV is significant, we expect more than 1-sigma of points (~33%) to be located off the O-C=0 line, indicating there is a significant variation in transit midpoint.

**We have discovered significant TTVs for AU Mic b and c, HIP 67522 b, and TOI-1224 b and c.**

## TTV Oscillation for TOI-1224 c

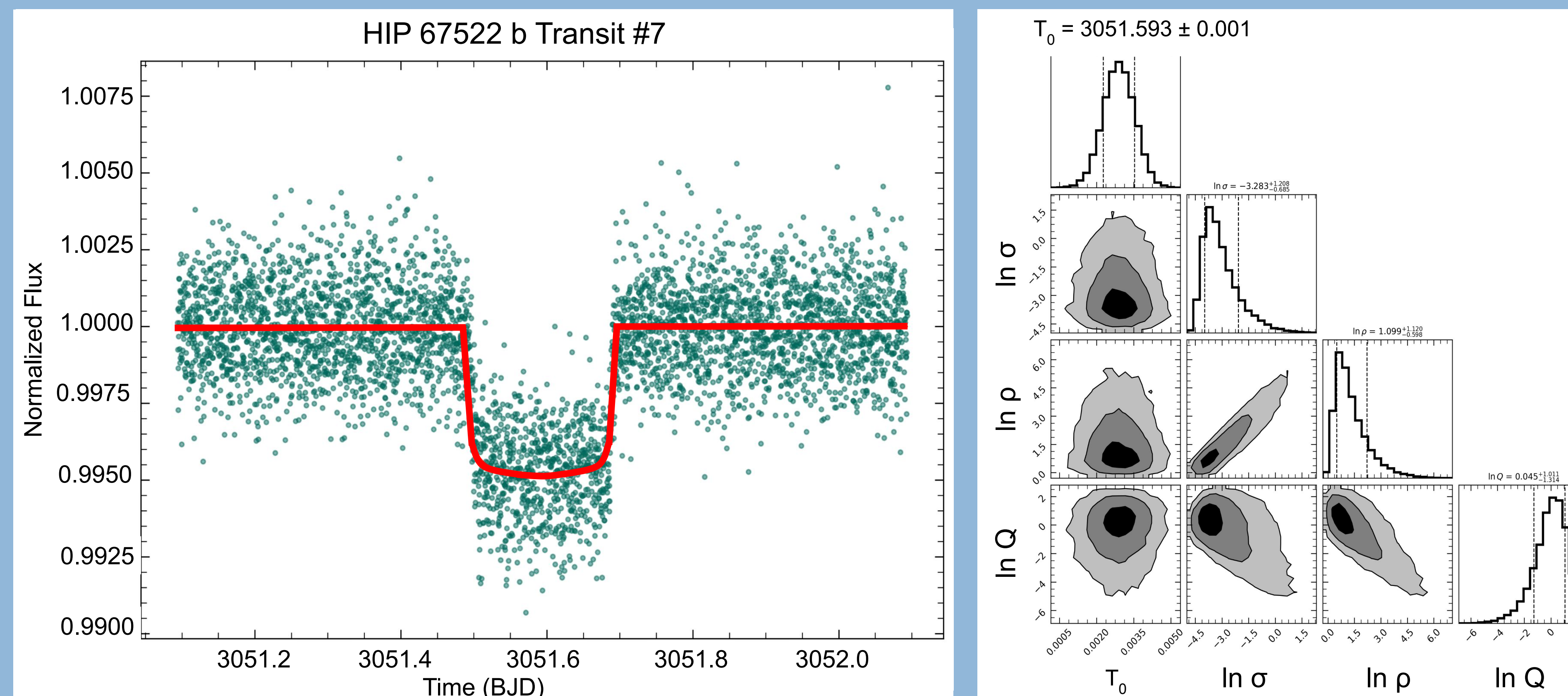


Phase-folded light curves for TOI-1224 c from TESS and ground-based data. TTVs are caused by perturbations due to TOI-1224 b, the first planet in the system.

## Analysis

We use the BATMAN Python package for modelling transits and iterate through the lightcurve dataset, fitting each transit. We set the transit midpoint ( $t_0$ ) free in the BATMAN fit and analyze within  $\pm 1$  of transit.

To account for stellar variability, we model the region outside the main transit using a Gaussian process (GP) from Celerite2 with a simple harmonic oscillator (SHO) kernel. We explore the parameter space using a Monte-Carlo Markov Chain analysis with 30 walkers for 10,000 steps.



Transit fit and MCMC parameter exploration for transit #7 of HIP 67522 b.