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Title: Mapping a star with transits: orbit precession effects in the Kepler-13 system
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Abstract: Kepler-13b (KOI-13.01) is a most intriguing exoplanet system due to the observed precession of planetary orbit. The transit curves show significant distortion that is stable in shape, and the transit curve asymmetry is consistent with a companion orbiting a rapidly rotating star on an oblique orbit. Variation of transit duration has been reported due to the precession of the orbital plane around the total angular momentum vector of the system.

A second periodic signal was discovered with 25.4 hour period. There is a controversy about the origin of this signal, that could either be pulsation (Mazeh et al. 2012, Shporer et al. 2011) or stellar rotation and activity (Szabo et al. 2012). In the latter case, the companion would orbit in 3:5 resonance to stellar rotation, on a special orbit which is quasisynchronous at large siderocentric latitudes.

We analyzed Kepler SC data up to Q14, investigating long-term variations of transit light curves, testing for duration, peak depth and asymmetry. We also performed cluster analysis on Kepler quarters. We computed the autocorrelation function of the out-of-transit light variations.

Transit duration, peak depth, and asymmetry evolve slowly, due to the slowly drifting transit path through the stellar disk. We found a very significant clustering pattern with exactly 3-orbit period. Its source is very probably the rotating stellar surface, in the 5:3 spin-orbit resonance reported in a previous study. The autocorrelation function of the out-of-transit light variations, filtered to 25.4 hours and harmonics, shows slow variations and a peak around 300--360 day period, which could be related to the activity cycle of the host star.

In summary, we have found proof for that the 25.4-hour signal comes really from the host star (instead of the companion), and is really due to the rotation. Therefore, there is a proven resonance between the planetary orbit and stellar rotation, a novel type of resonance that has no theoretical reasoning yet.