A search for giant planets orbiting M-giant stars in the Kepler database

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Introduction

Planetary occurrence rate with respect to stellar type has been found to increase with increasing stellar mass for late type stars (Johnson et al. 2007,2010). However, doppler and transit detection of planets orbiting A-stars is difficult due to stellar noise and low transit probabilities. Observations of evolved A-stars with large radii promise to increase the probability of transit detection, though identification of these stars may prove difficult (Lloyd 2011).

We have examined a sample of ~350 *Kepler* light curves of late type giant stars for evidence of planetary transits and have developed a pipeline capable of extracting periodic behavior from these light curves. We find no conclusive evidence for detectable planetary transits. While this is not consistent with previous results in literature, we note that there are several distinct physical interpretations for such a result.

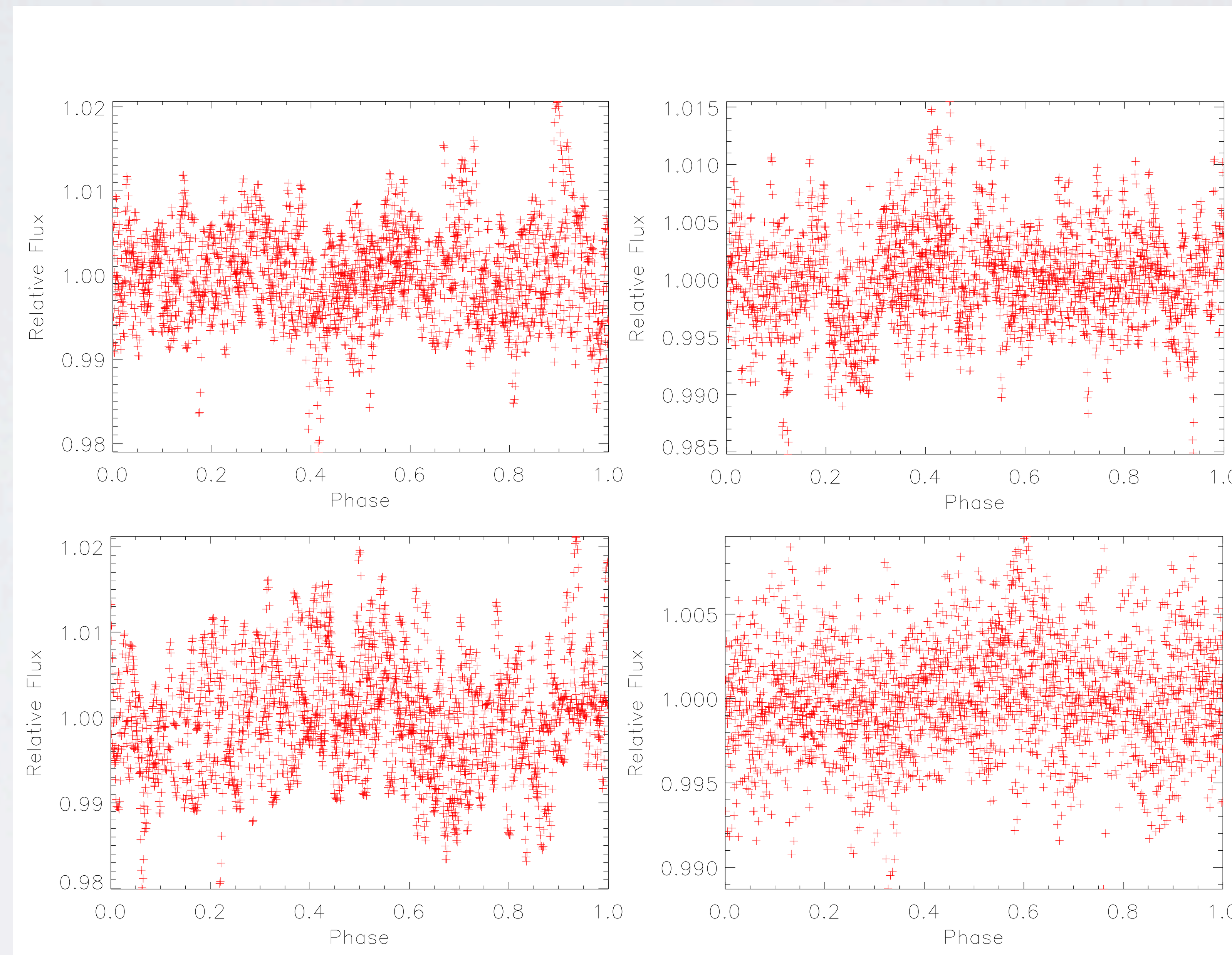
Data Search

We selected our sample from the Kepler data set using intrinsic infrared color cutoffs from Ducati et al. (2001), and effective temperatures and surface gravities from the Kepler catalog. This yielded a sub-sample of 349 probable M-giant stars.

We then performed a Lomb-Scargle periodogram analysis on the light curve to search for periodic behavior. Though our technique is capable of finding both our target objects and longer-period planets orbiting dwarf stars, we note that it is incapable of finding extremely short-duration transits and short-period planets. Our tests on already-known *Kepler* discovered planets show that our pipeline is capable of finding single transiting planet systems with orbital periods of greater than ~3 days.

After eliminating all obvious false positives, we are left with four significant periods found which are not easily explained as long-period regular stellar variability. These are shown phase-folded in figures 1-4.

Results



Figures 1-4: Phase plots for candidate transit signals detected by our pipeline. KICs clockwise from top right: 2714635, 6714282, 8712103, 7351518.

Our four identified periods all show various features which appear to be transit events. However, these features are very broad in phase space. The durations of these events are many tens of days long. Given the identified orbital periods and our knowledge of stellar properties, we arrive at transit durations of ~0.5-2.0 days in all four cases. Durations of several tens of days are inappropriate for the parameters known.

Each of the four identified significant periods are thus likely either low-amplitude, long-period stellar activity, or noise, leaving us with no definitive detection of planetary transits. In a sample of 349 stars and given the occurrence rates suggested in the literature, we might expect to find ~14 planets. Our null result is then significant at a level of ~3.7σ. We can conclude, then, that either the expected planet occurrence rate given in the literature is not correct for evolved A-stars or the expected planetary and orbital parameters are different than those given in the literature. Beyond this statement, we can only speculate as to the reasons for this discrepancy.

Conclusions

Our search was sensitive to single planet systems with orbital periods in excess of 3 days. We estimate that the *Kepler* spacecraft is sensitive to planets the size of Jupiter and larger orbiting these stars. This leads us to three possible direct conclusions:

- The planet occurrence rate around M-giants may be lower than suggested.
- The population of planets orbiting M-giants may be preferentially smaller than the size of Jupiter.
- The population of planets orbiting M-giants may have small orbital periods and short transit durations

None of these options absolutely requires that the suggested properties for planetary systems around non-evolved A-stars be changed. The effects of the later stages of stellar evolution on planetary systems is still poorly constrained, and may be able to entirely explain our result. Thus, we can say that this issue is still not clearly settled, and requires further work, both observational and theoretical, to be definitively resolved.

References

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