BINARY STATISTICS IN TRANSIT SURVEYS: *THE CASE OF KEPLER*

Rob Farmer, Ulrich Kolb, Andrew Norton
The Open University
rob.farmer@open.ac.uk, ulrich.kolb@open.ac.uk

CEPSAR research centre for physical and environmental sciences

The Open University

ABSTRACT

We illustrate the approach required to interpret binary samples detected in transit surveys, using the Kepler field as a case study. We adapted BiSEPS, a population synthesis code that includes a fully self-consistent treatment of single and binary star evolution, to generate a sample of synthetic stars that represents the Kepler Input Catalogue (KIC). By subjecting this synthetic sample to the same target selection criteria that defined the actual Kepler target list we obtain a synthetic target list. We find that the binary star population is target-selected in a similar fashion to the single star population, and that the binary fraction is unchanged due to the target selection criteria. A preliminary comparison of eclipsing binaries in our synthetic sample and the catalogues of Prša et al (2011) and Slawson et al (2011) highlights inconsistencies with a simple power law initial mass ratio distribution (IMR) and a mass independent binary fraction. These may be caused by systematics in parameter determination by the EBAI code used by Prša et al.

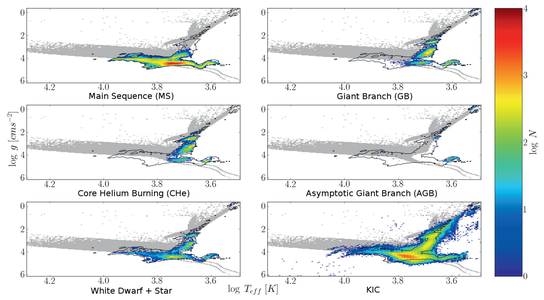
SYNTHETIC DISTRIBUTION

We use a fully self consistent binary star evolution scheme, combined with a comprehensive Galactic model, to

- generate a synthetic sample over the Kepler field.

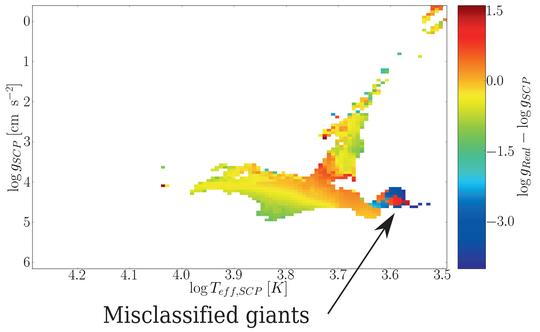
- apply the Kepler parameter estimation (SCP) to our synthetic sample.

Distribution over log T_{eff} and log g



This allows us to compare the real (grey) distribution with the SCP derived parameter distribution (coloured) and the real KIC (final subplot).

Difference between real and SCP derived log g

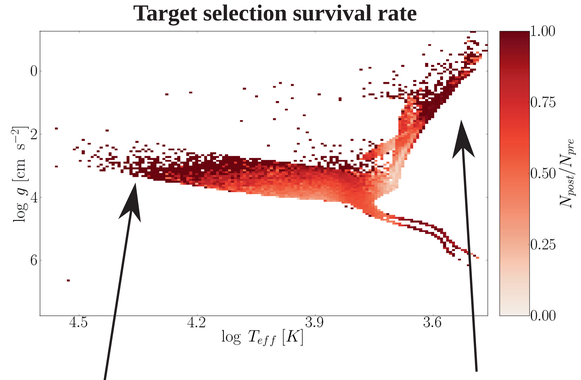


The SCP introduces a systematic shift across parameter space.

The median shift over the whole field, log g_{real} - log g_{scp} = -0.2 dex.

Misclassified giants

Target selection survival rate



With the addition of a comprehensive noise model we can derive the S/N and optimal apertures.

This allows us to derive a synthetic target list.

SCP's lack of hot dwarfs

Misclassified giants again

We find:
- primary components of binaries are affected in the same way as single stars.
- the binary fraction is preserved by the target selection.

Eclipsing Binaries

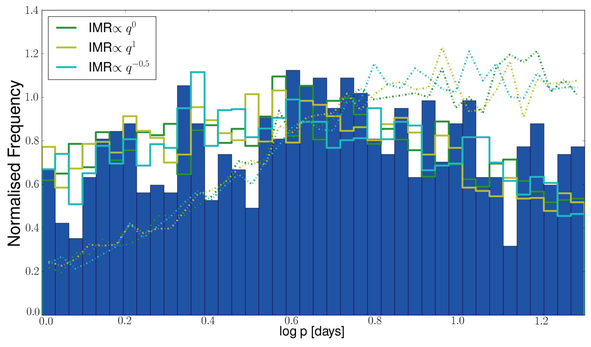
Each target selected binary is given a random inclination so we can compute its light curve with JKTEBOP (Southworth et al 2004).

We add a noise model,

compute the S/N for each eclipse

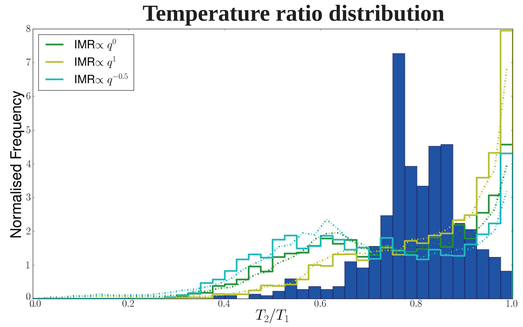
and derive the expected detection rate (Jenkins 1996).

Orbital period distribution



This allows us to compare a) all synthetic binaries in the Kepler field (*dotted lines*), b) a synthetic EB catalogue (*solid lines*) and c) the EB catalogue of Prša et al 2011 and Slawson et al 2011 (*solid bars*).

Temperature ratio distribution

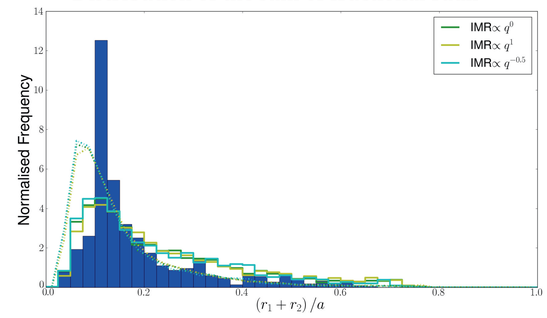


Clearly, models fail to reproduce T_2/T_1.

Appears to require a non constant binary fraction and/or IMR.

We need to replicate the EBAI systematics.

Distribution of the sum of fractional radii



$(r_1+r_2)/a$ also disagrees with Kepler's EBs.

Different IMRs are degenerate in $(r_1+r_2)/a$.

Conclusions

We have derived a synthetic binary population in the Kepler field, which has been subjected to the SCP and target selection procedures.
- Binaries are selected similarly to single stars and require similar corrections for log g.
- Our preliminary EB catalogue shows disagreements with the Kepler EB catalogue.
- This is inconsistent with a simple power law IMRD and a mass in dependant binary fraction.
- Initial tests with EBAI shows systematics similar to the differences highlighted here.

Our study demonstrates that it is crucial for theoretical population modelling to have access to the analysis tools used to derive physical properties listed in survey catalogues.

References

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