Transiting Planets
Proceedings IAU Symposium No. 253, 2008
Frédéric Pont, Dimitar Sasselov & Matthews Holman, eds.

doi:10.1017/S1743921308026719

Transits in Poorly Sampled Data – Gaia and Beyond

Brandon Tingley

Institut d'Astronomie et d'Astrophysique
Université Libre de Bruxelles
CP226
Boulevard du Triomphe
B-1050 Brussels
Belgium
email: btingley@ulb.ac.be

Abstract. Gaia, an ESA cornerstone mission, will obtain of the order of 100 high-precision photometric observations over five years for tens of millions of stars with $V < 17$. The vast number of red dwarfs in this data set, with their correspondingly deep (high S/N) transits, makes it worthwhile to explore the possibility of detecting transits in such data. Searching for transits under these circumstances requires a very different approach from that used for a normal, highly-sampled transit survey if the search is to be performed in a reasonable amount of time. It should be possible to identify a portion of the transiting Hot Jupiter/M dwarf systems in the data set, if the photometry is as stable and precise as specified by design. This same approach could be applied to ground-based transit searches – a transit survey targeted at red dwarfs with Jupiter-sized companions.

Transit detection codes work by testing a subset of the observations in a light curve to determine the likelihood that a particular subset describes a transit. The normal transit detection code is designed to stack many in-transit observations, enabling highly confident identification of events that can be shallower than the precision of the average observation. The codes are designed to do this stacking as efficiently as possible, scanning a parameter space containing period, duration, and ephemeris. The step sizes for the parameters are chosen so that the last test transit in the light curve steps by 1/4 of a transit duration. This means that the longer the time baseline of the light curve, the smaller the steps in period. Therefore, the approximately 100 observations over 5 years planned for Gaia (an ESA cornerstone mission) create a data set that is not well-suited to this method of searching for transits, requiring a different approach to transit detection, one focused on recovering the periodicity of scattered in-transit observations of deep events. The periodicity test is based on the concept that if these scattered deep events are periodic, the difference in time between any two of these events will be an integer multiple of the period modulated by the duration of the event, leading to an error in the estimated period. By analyzing the differences between all the deep events, it is often possible to recover at least an integer multiple of the period. This same approach can be used to plan a ground-based survey that could monitor a statistically robust number of red dwarfs – the best candidates for deep transit events due to their small size – for transits.

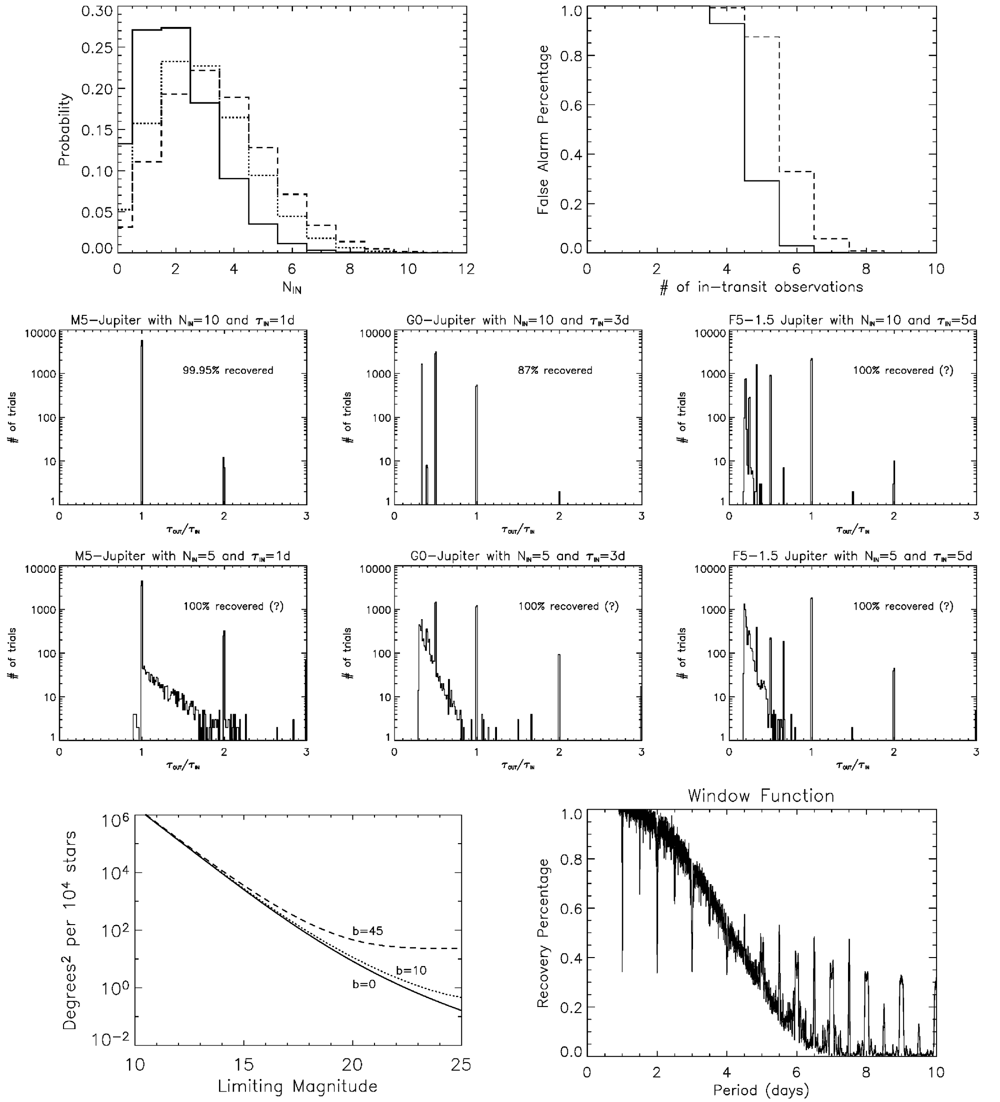

Figure 1.

Figure 2. (top-left) Probability distribution of the number of in-transit observations, given 100 total observations for M5-Jupiter systems (solid line, in transit 2.0% of the time if in a 5d orbit), G0-Jupiter systems (dotted line, in transit 2.9% of the time, and F5-1.5 Jupiter systems (dashed line, in transit 3.4% of the time). (top-right) Probability of a periodicity false positive as a function of number of test points for an M5-Jupiter system (solid) and a G0-Jupiter system (dashed). (middle rows) Period recovery for systems with $N_{IN} = 10$ (top) and $N_{IN} = 5$ (bottom) for M5-Jupiter systems with 1d periods (left), G0-Jupiter systems with 3d periods (denter), and F5-1.5 Jupiter systems with 5d periods (right). For $N_{IN} = 10$, almost all periods were accurately recovered with either 1× or 2× the inputed period for M5-Jupiter systems, while integer-fraction periods appeared for G0-Jupiter systems and some non-integer fraction periods appears for F5-1.5 Jupiter systems. For $N_{IN} = 5$, many periods were recovered, but many clearly incorrect (non-integer) periods are apparent, with recovery worsening with increasing period and stellar radius. (bottom-left) Number of M dwarfs per square degree as a function of Galactic latitude. (bottom-right) Window function for a 3-month ground-based transit survey targeted at red dwarfs.

https://doi.org/10.1017/S1743921308026719 Published online by Cambridge University Press