Searching multiple systems by extra eclipses

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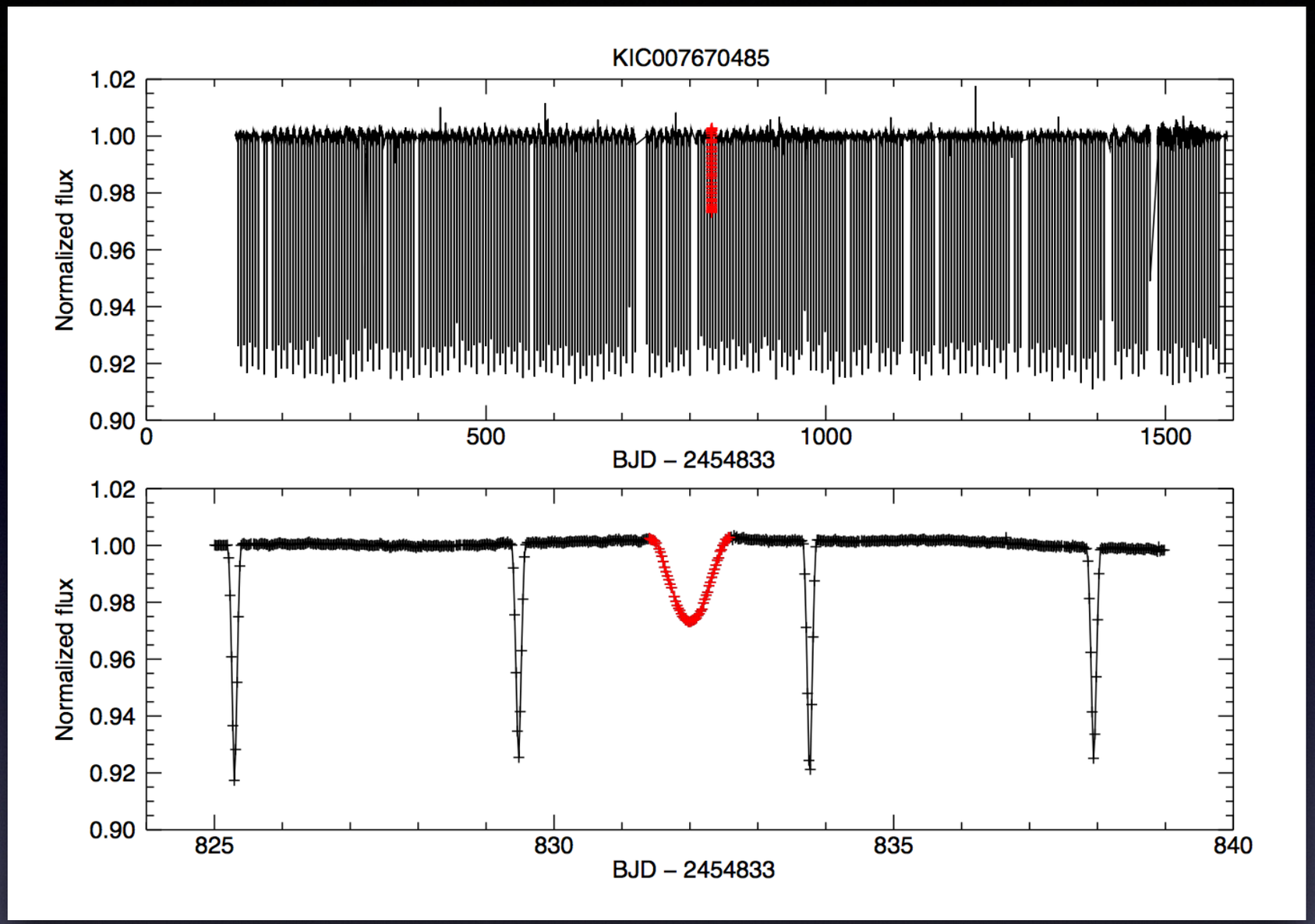
Method

- eclipses ⟶ binary systems
- additional eclipses ⟶ multiple systems

Very natural and straightforward



The light curves of KIC007670485 with only one extra eclipses indicated in red.

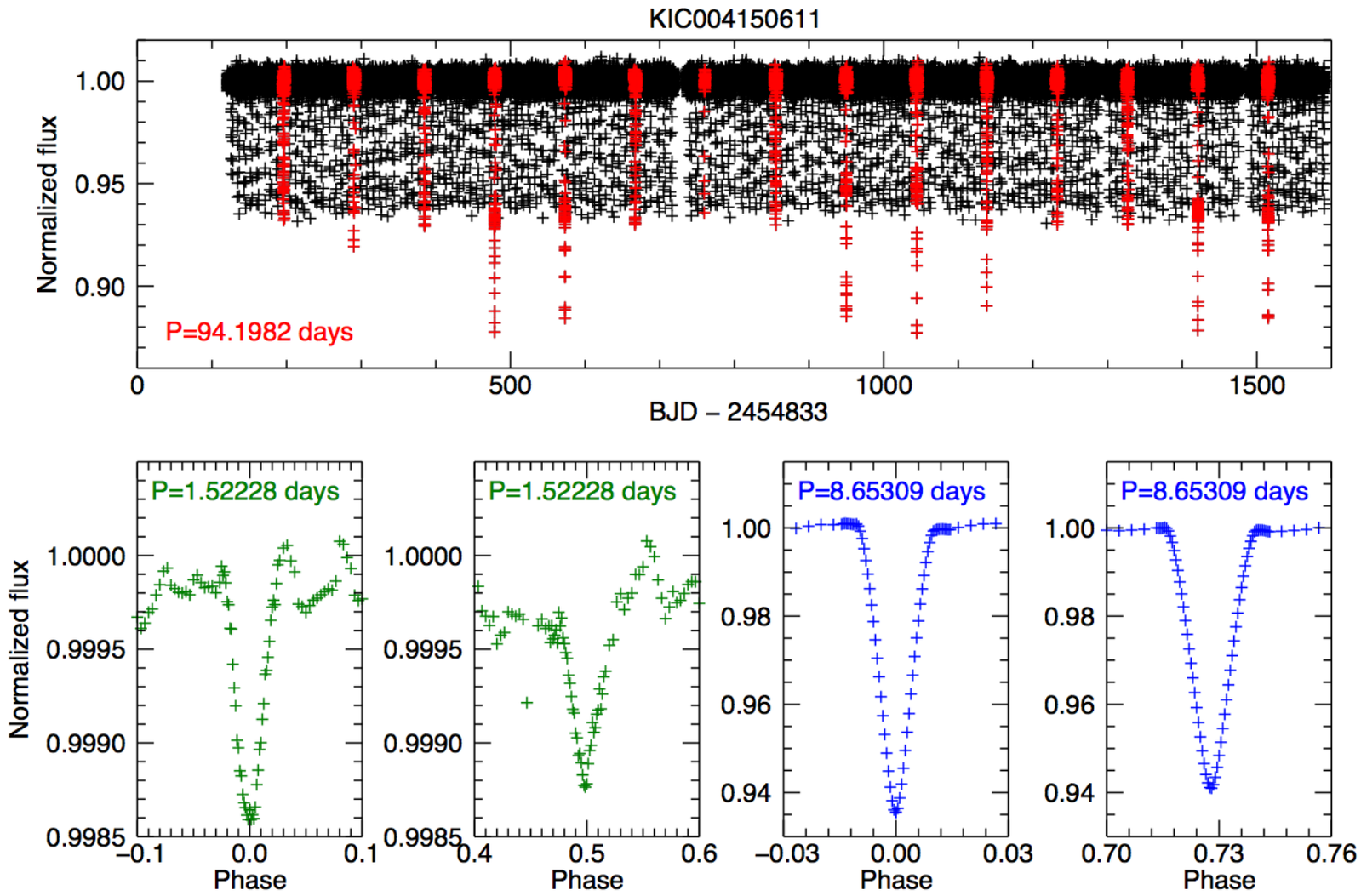
Why few multiple systems found by this method before?

- The additional eclipses are rare (i ~ 90 degree)
- The periods of additional eclipses are quite long
- It is difficult to predict the time of eclipse signal before observations

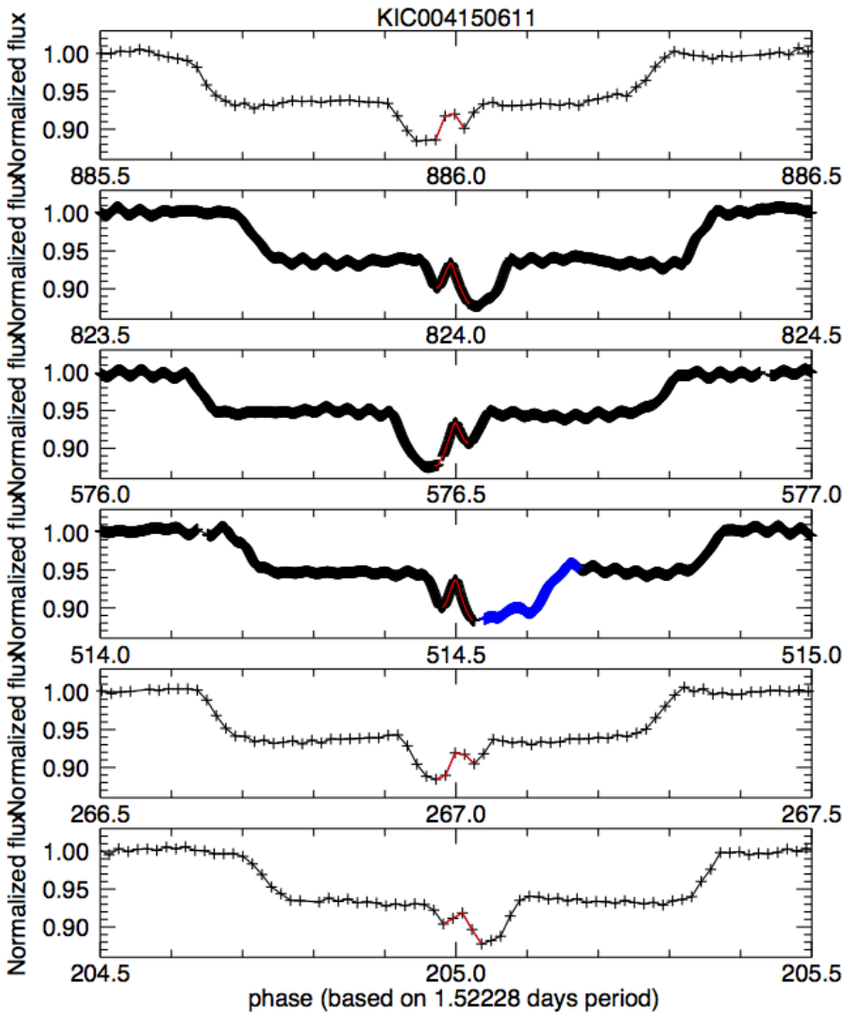
  (It is not efficient to do these observations)

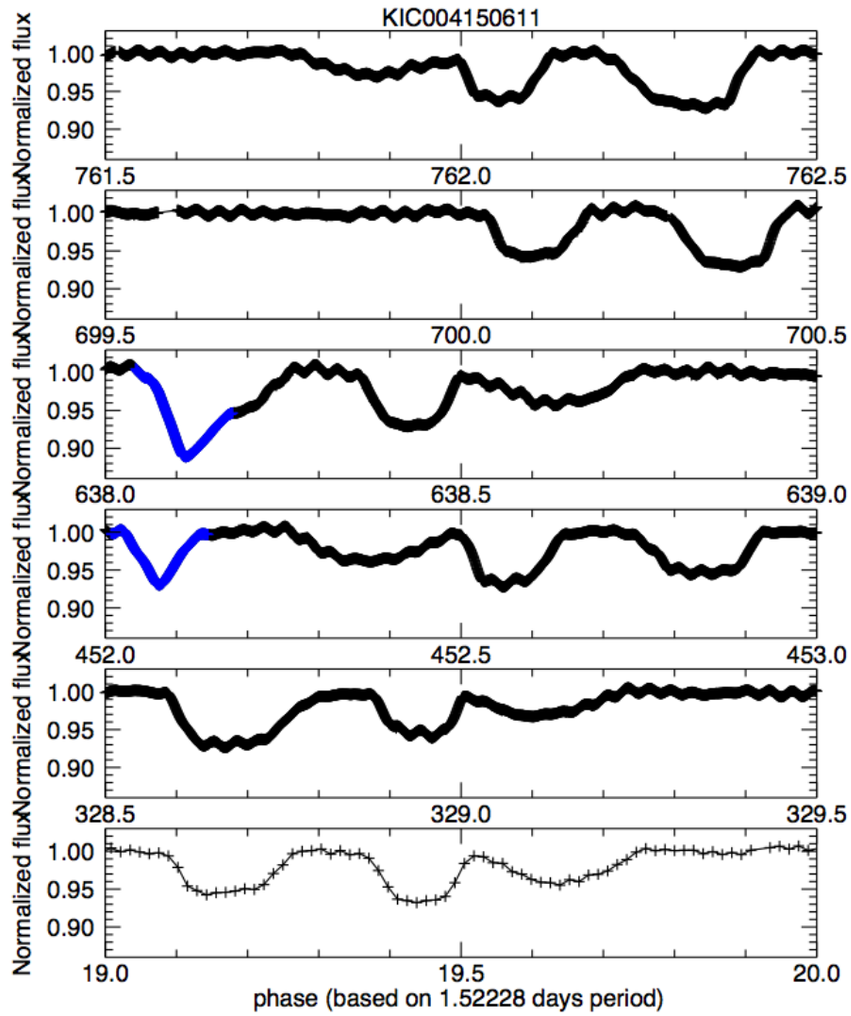
The Observations from *Kepler* Satellite

- long term monitoring (~3.5 years)
- uninterrupted observations
- unprecedented high precision

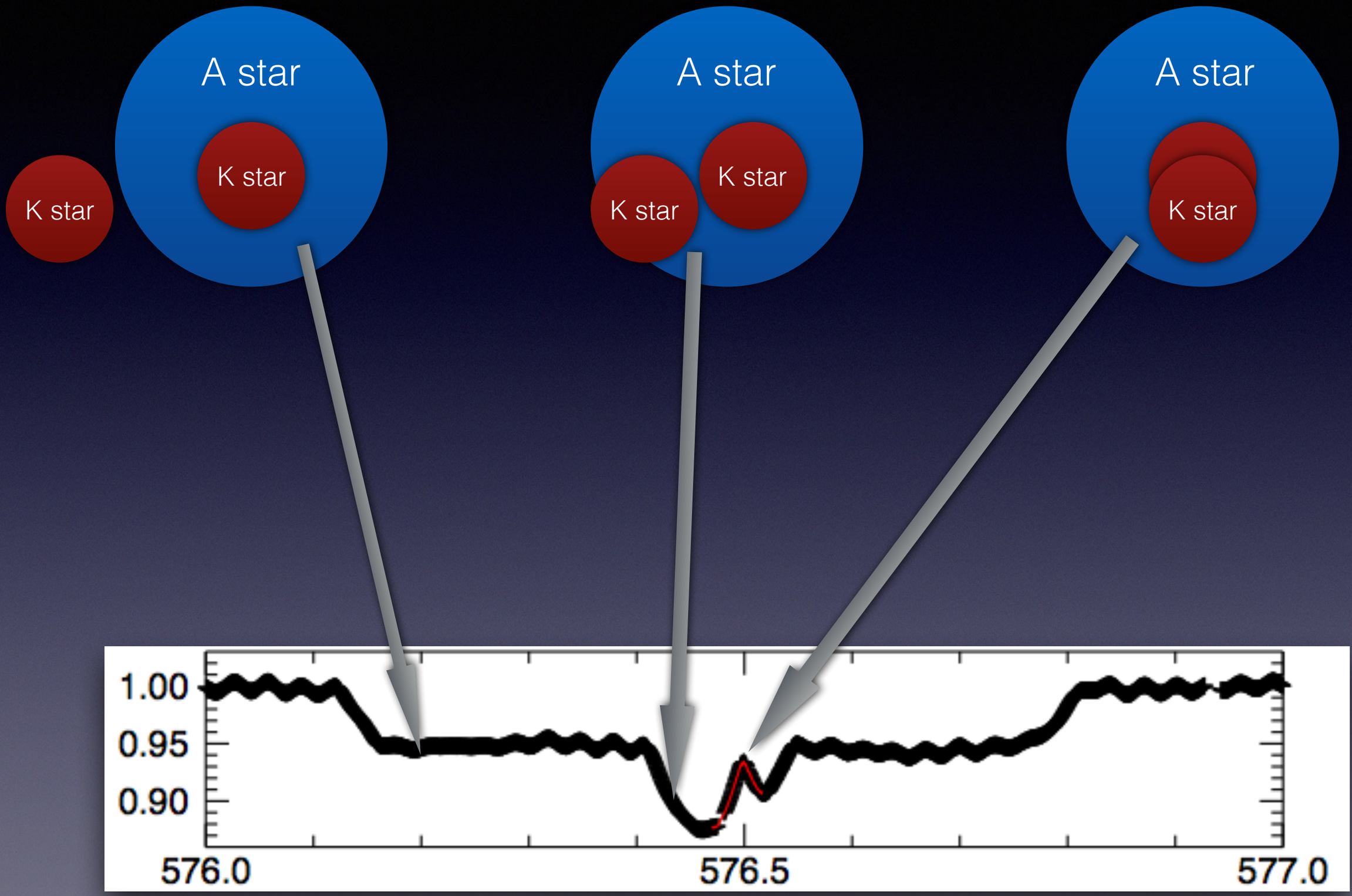


The light curve of KIC004150611.
There are three sets of eclipses, the red points are the extra eclipses of 94.1982 days.

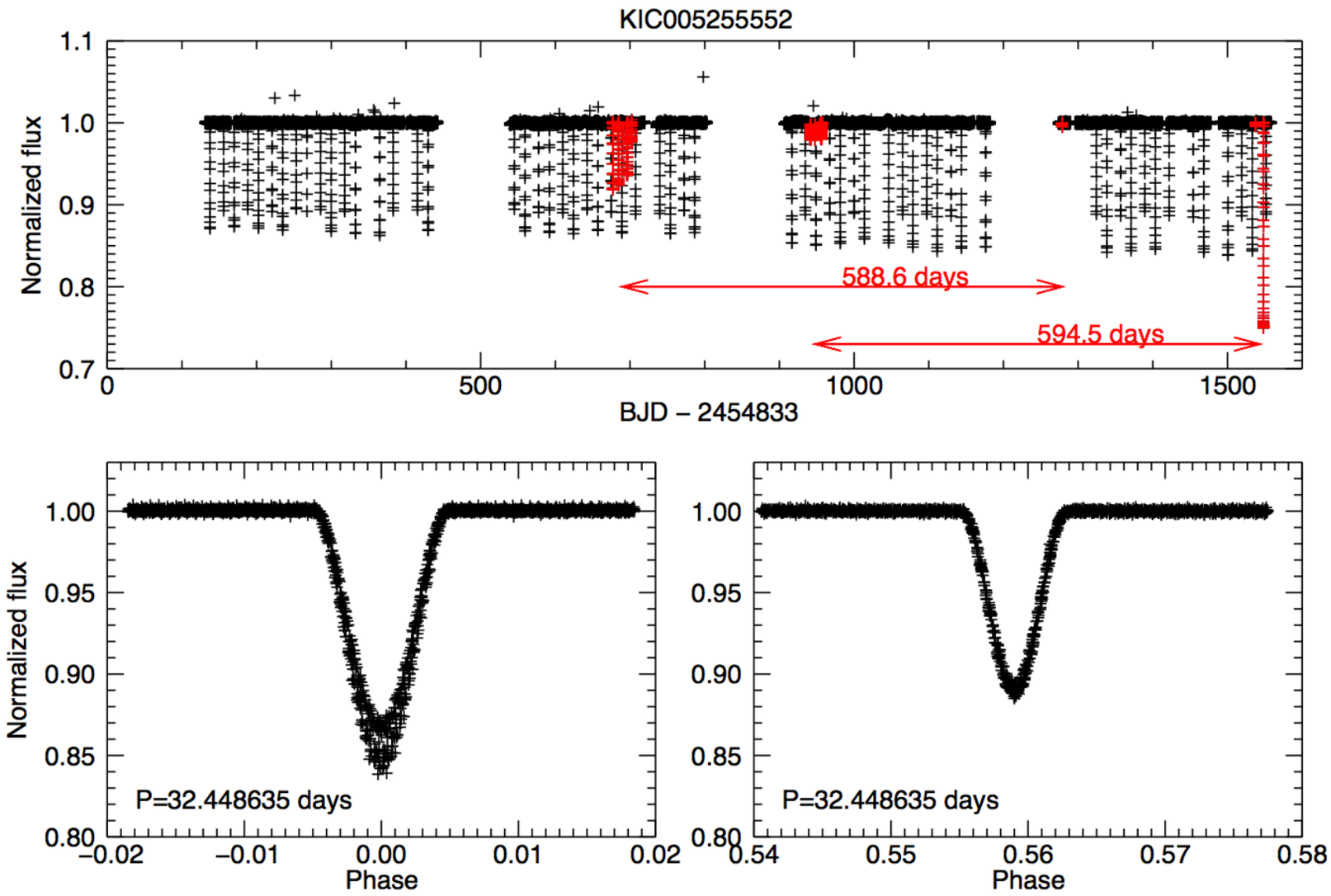




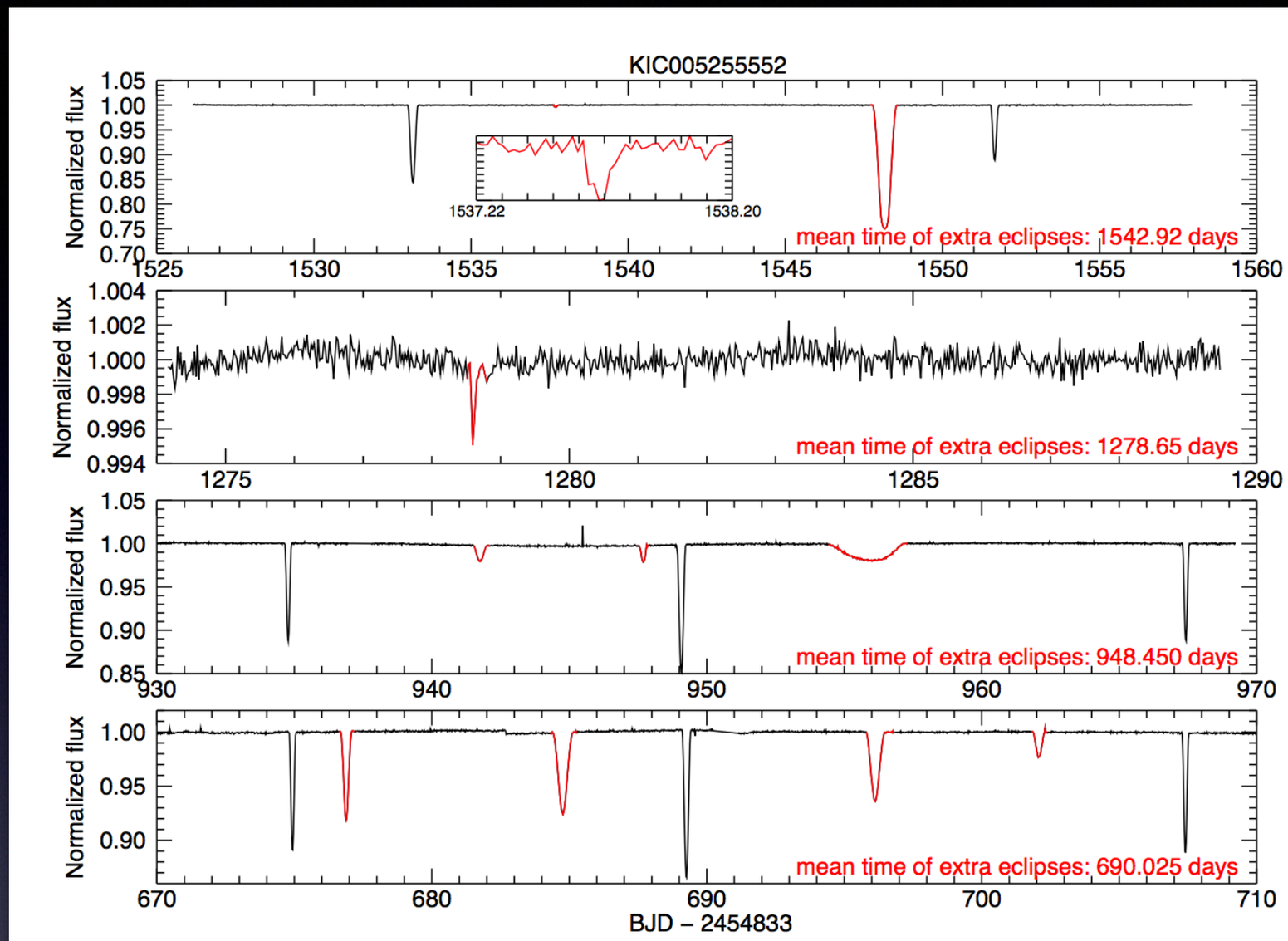
The detailed light curves of extra red eclipses of KIC004150611.
Left: “primary” eclipses Right: “secondary” eclipses
red lines stand for the peak inside the eclipses.
blue points caused by the 8.65309 days binary eclipses.



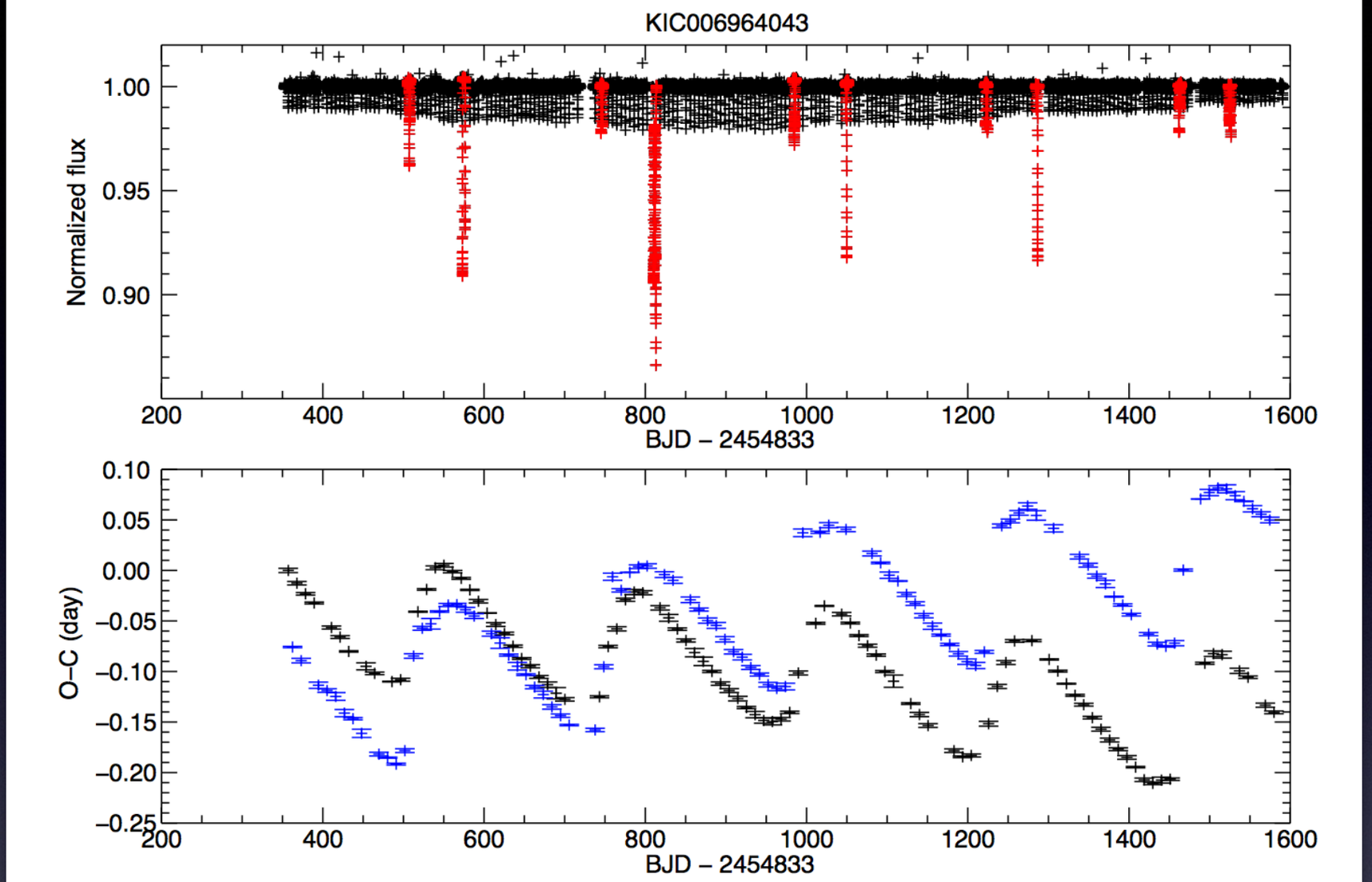
extra eclipses of KIC004150611



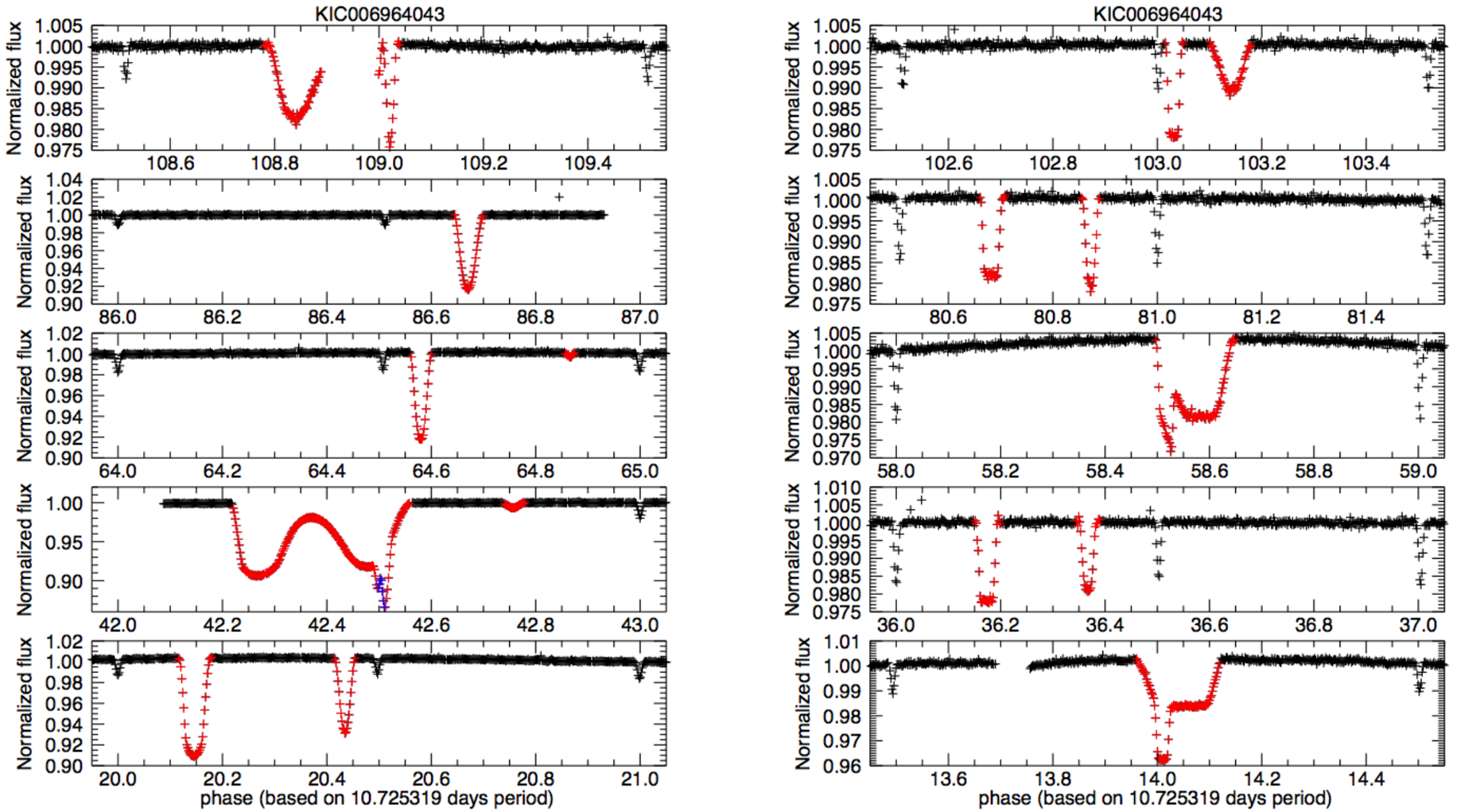
The light curves of KIC005255552. The red points are the extra eclipses that can be seen more clearly in the next slide.



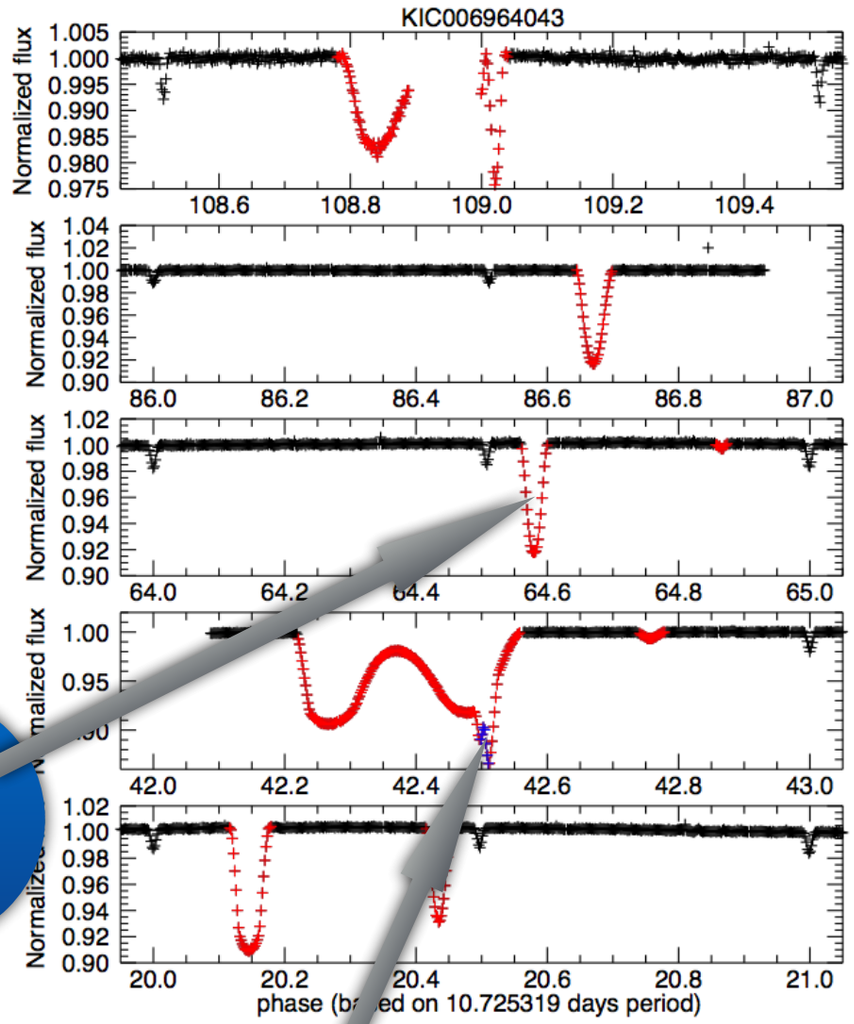
The extra eclipses of KIC005255552. The red points are the extra eclipses.

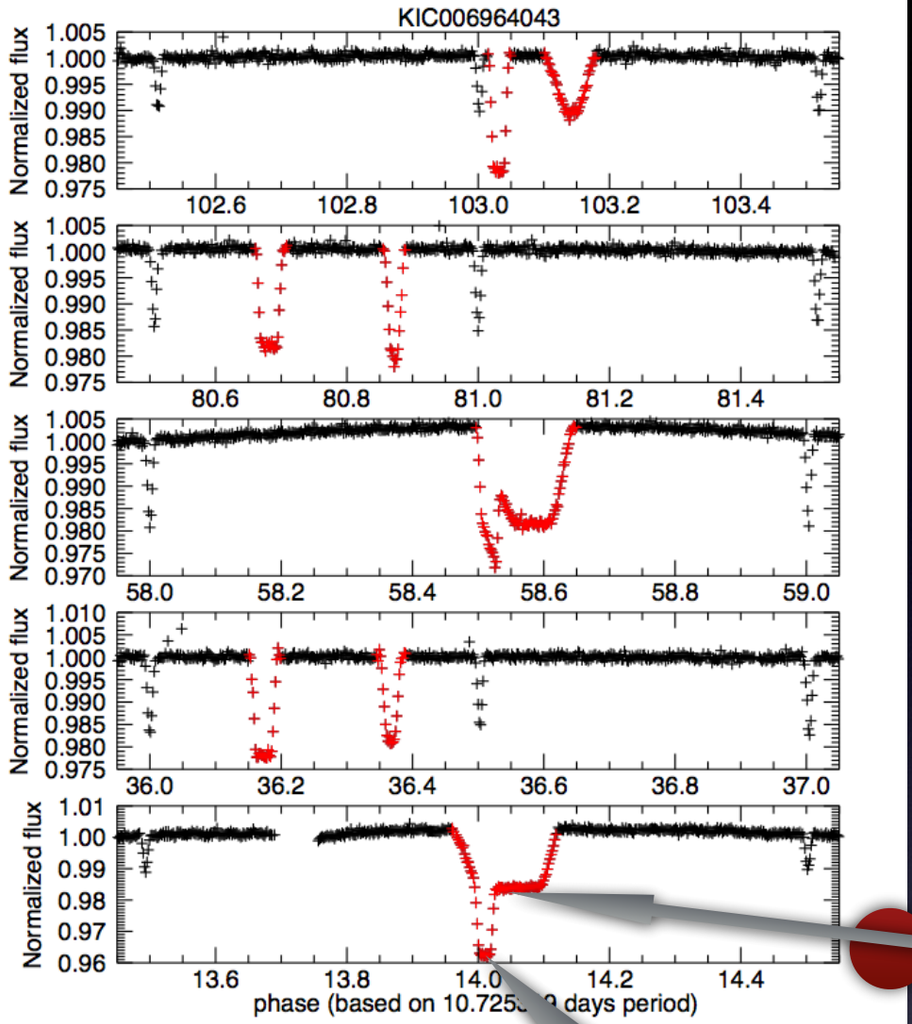


The light and O-C curve of KIC006964043.



The extra eclipses of KIC006964043 with ~240 days period. The blue points (the left second panel from the bottom) indicate the position of the secondary eclipse of 10.725319 days period.





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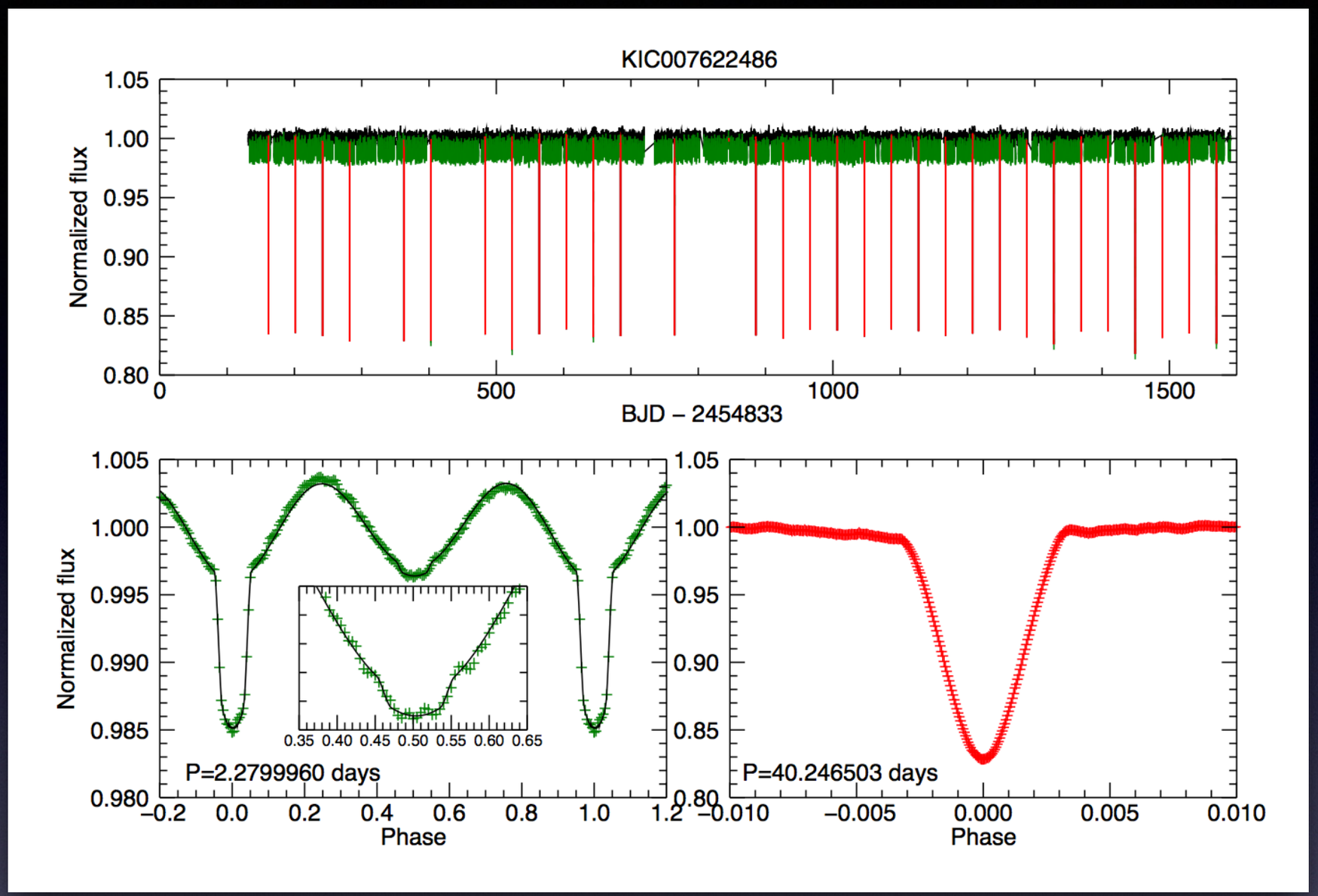
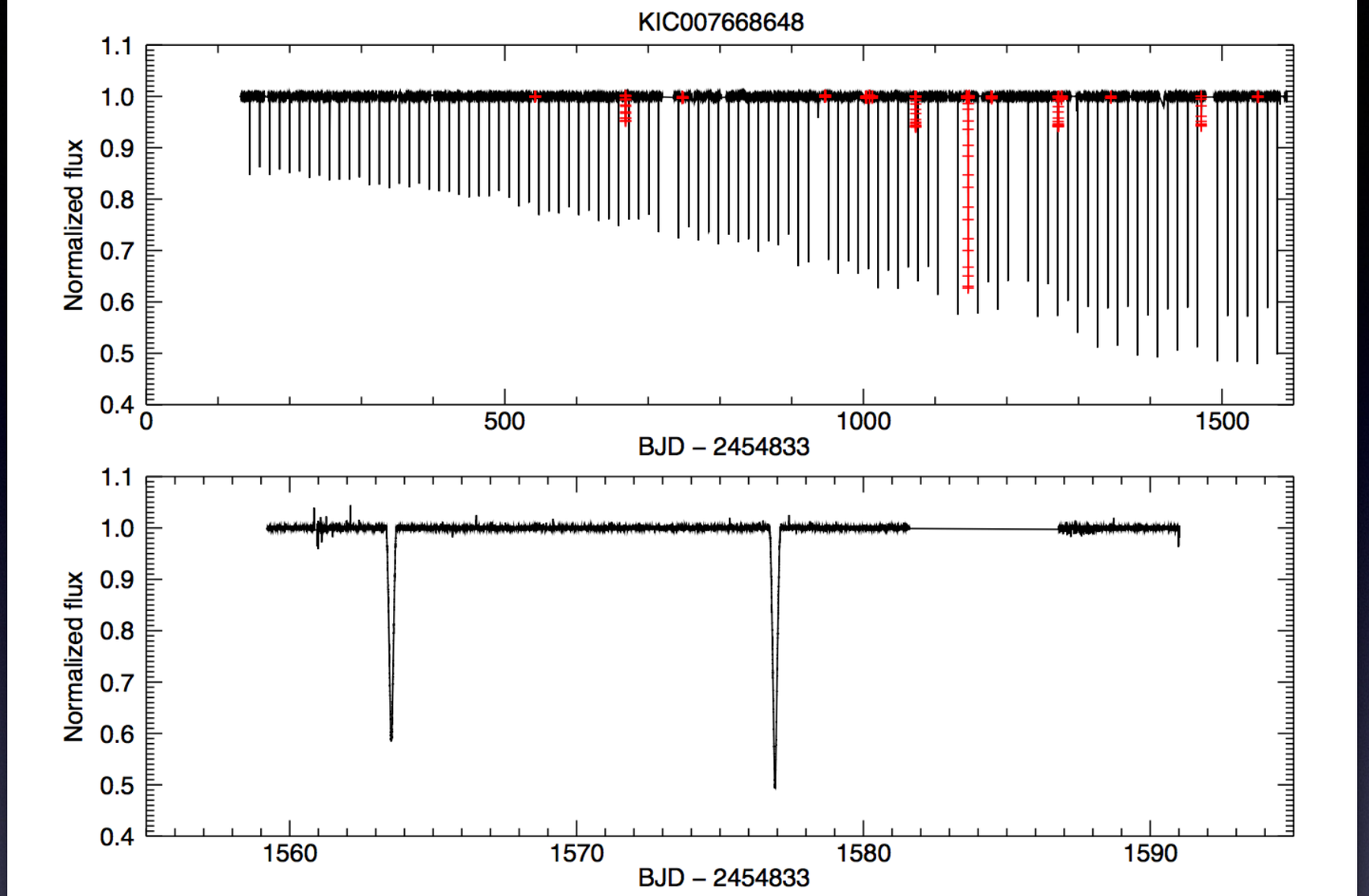
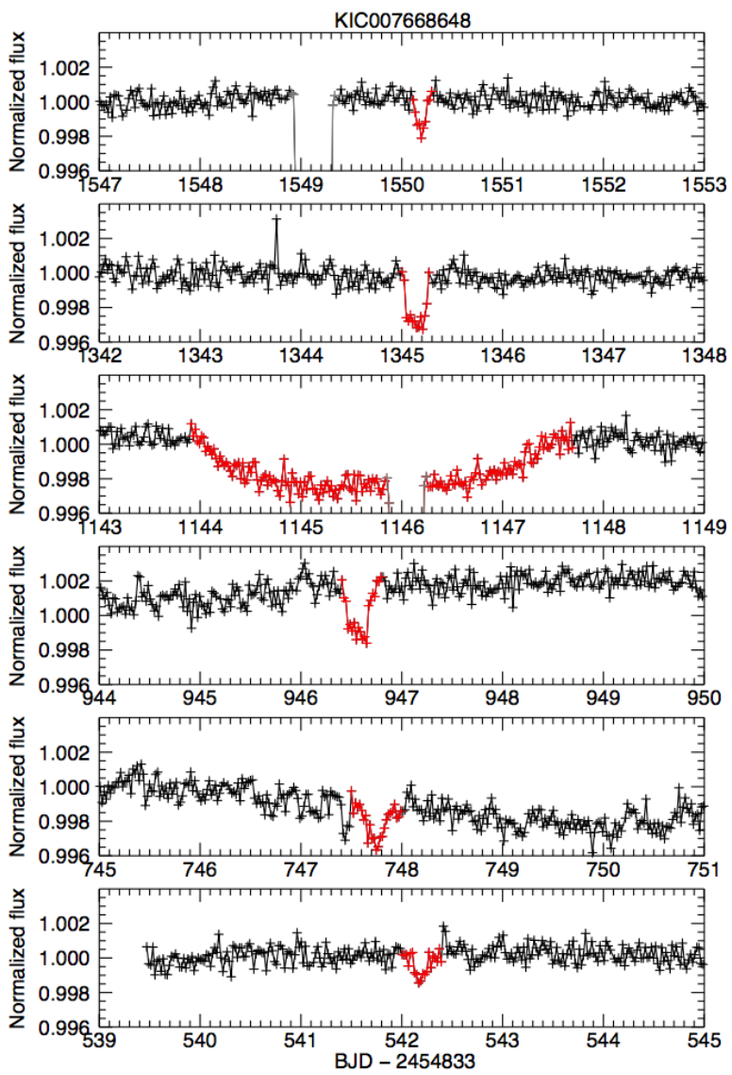
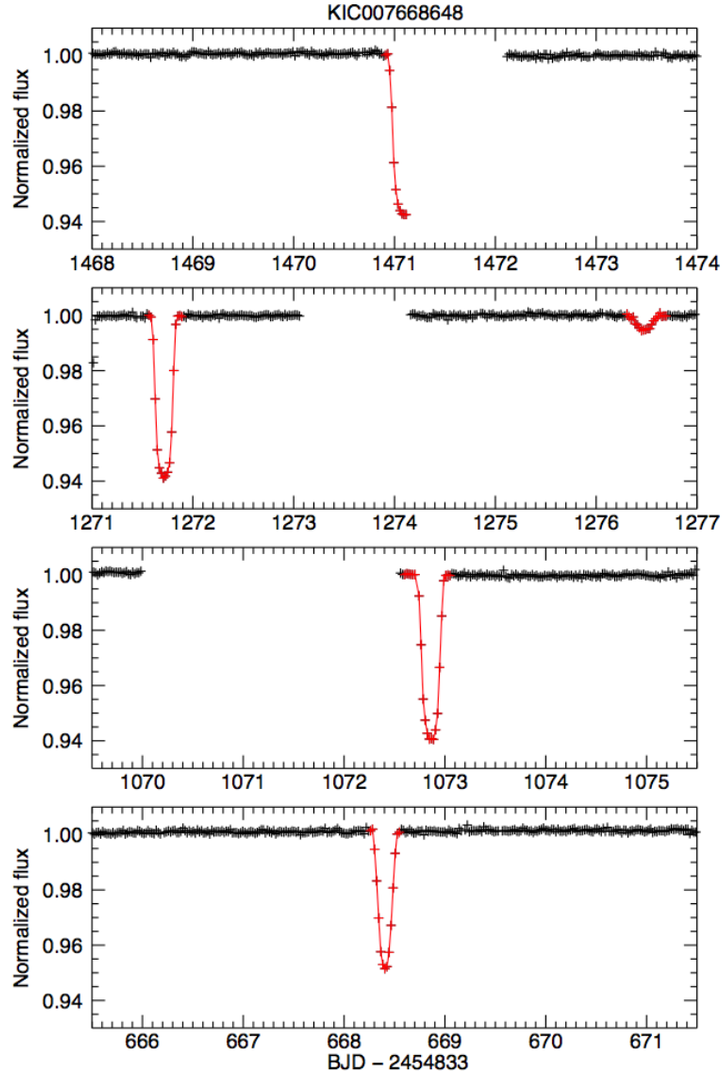


The light curves of KIC007622486.

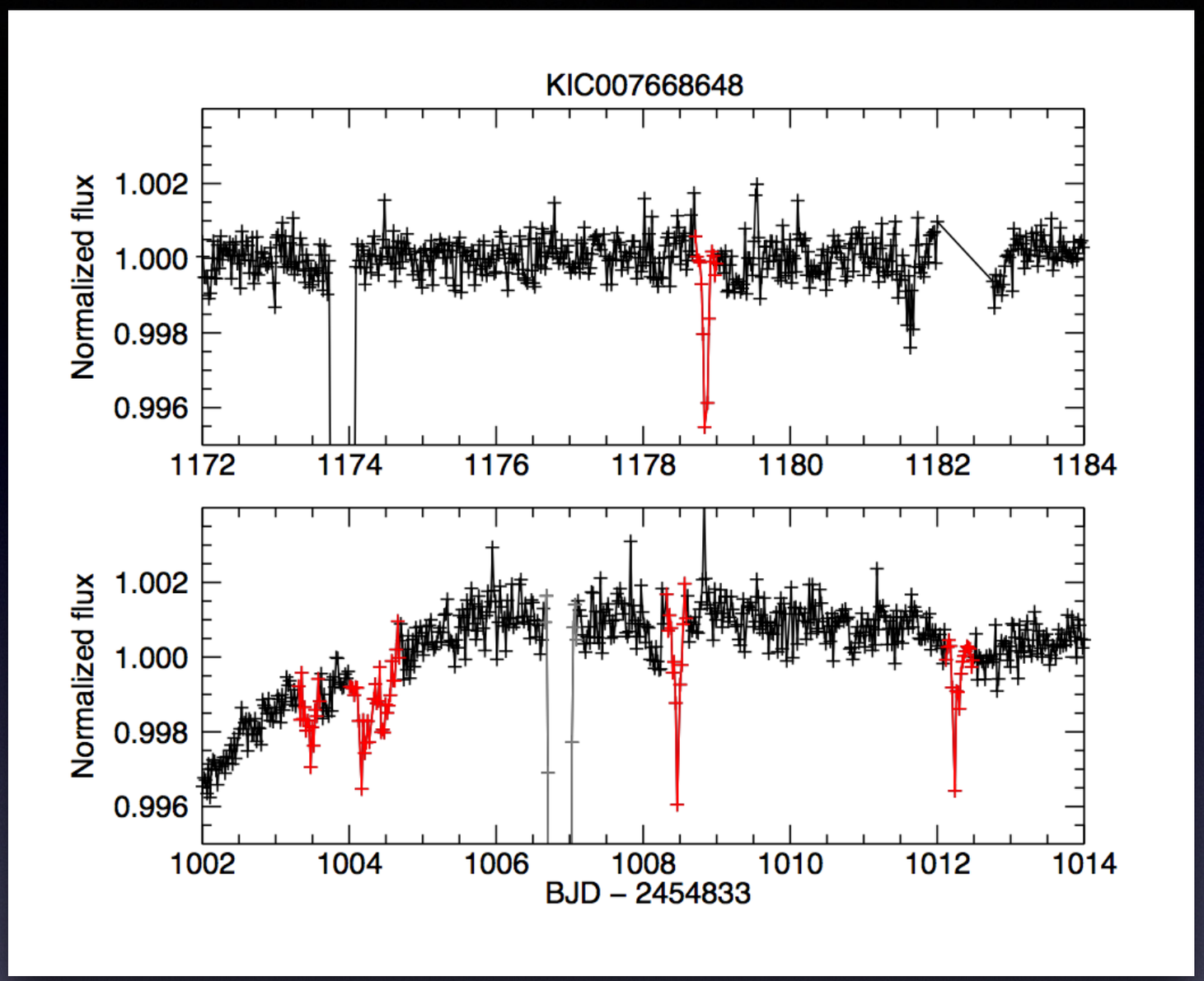


The light curves of KIC007668648. The red points are the extra eclipses. The deepest extra eclipse around 1146 days overlap a binary eclipse.

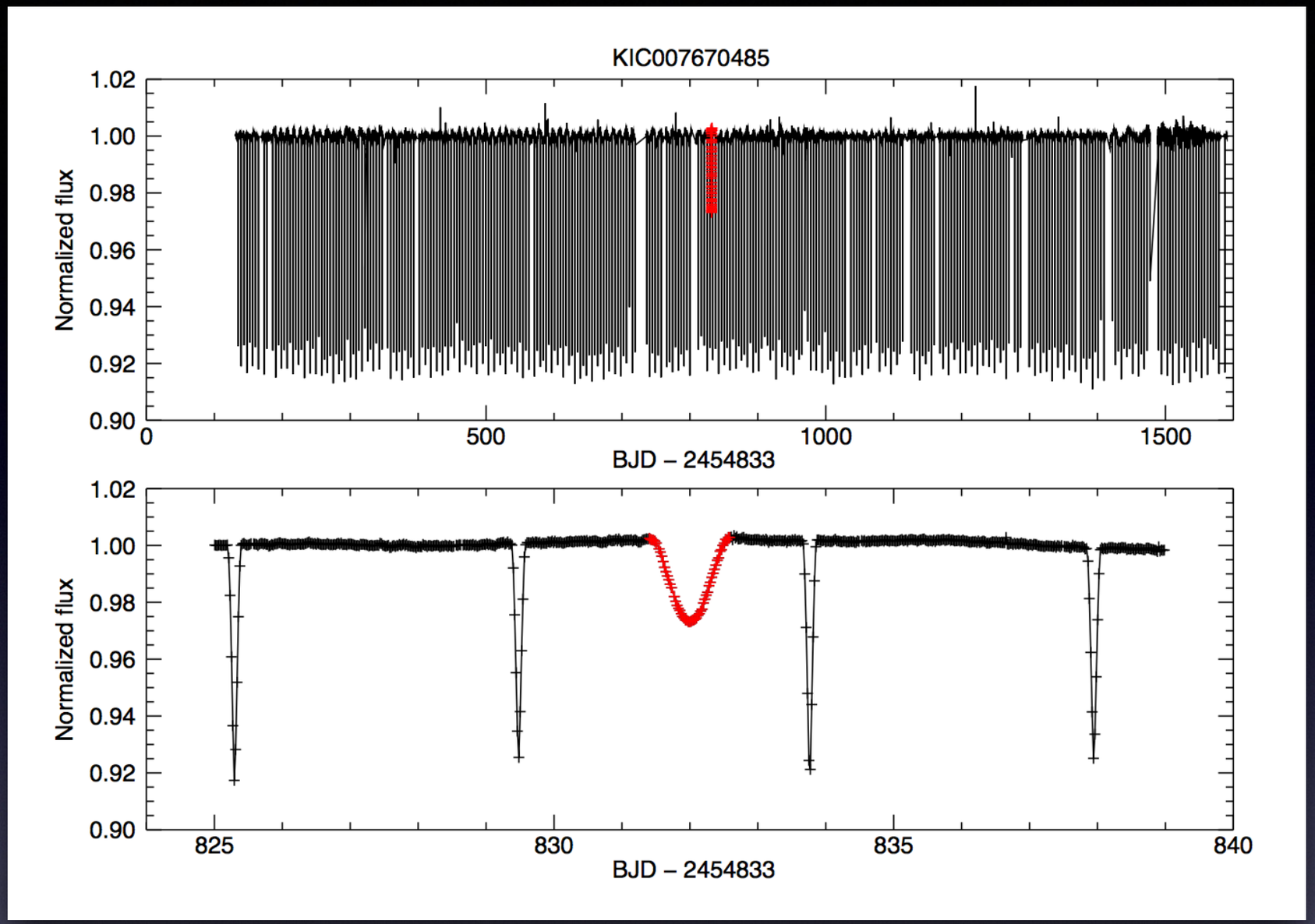




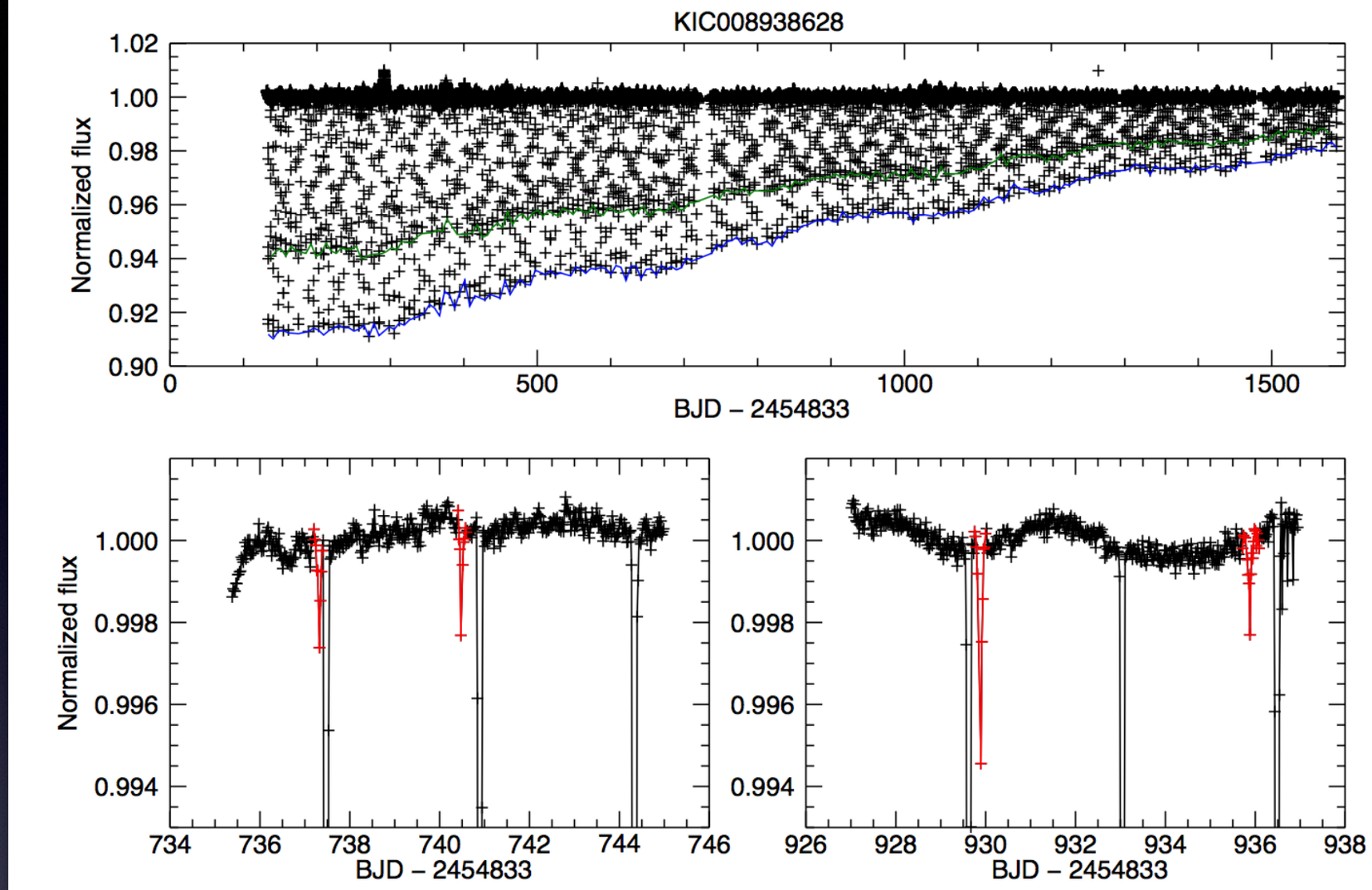
The extra eclipses of KIC007668648. Left: one sets of extra eclipses with adjacent intervals about 203 days Right: Another set of extra eclipses light curves with adjacent intervals also about 203 days.



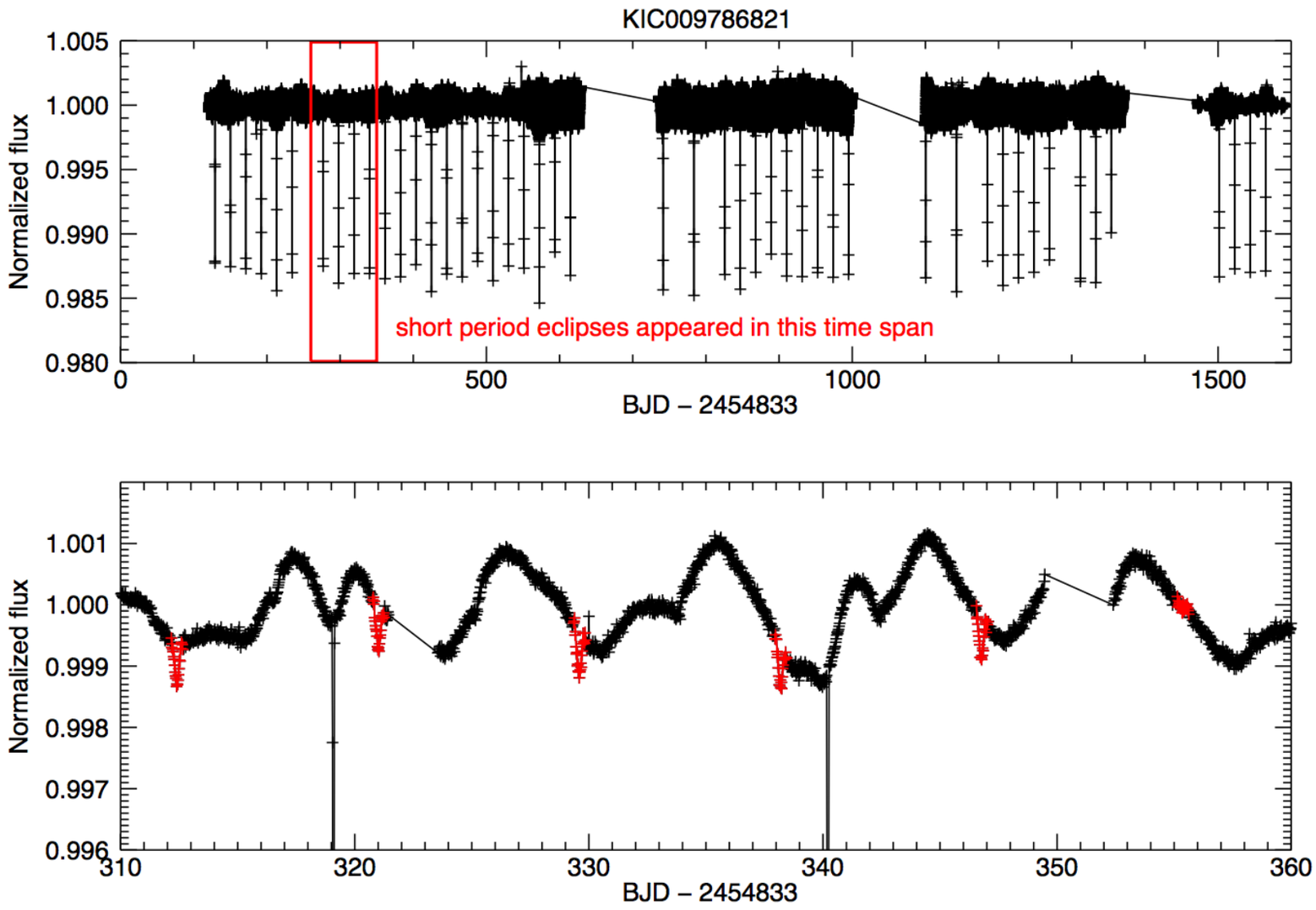
The third set of extra eclipses of KIC007668648.



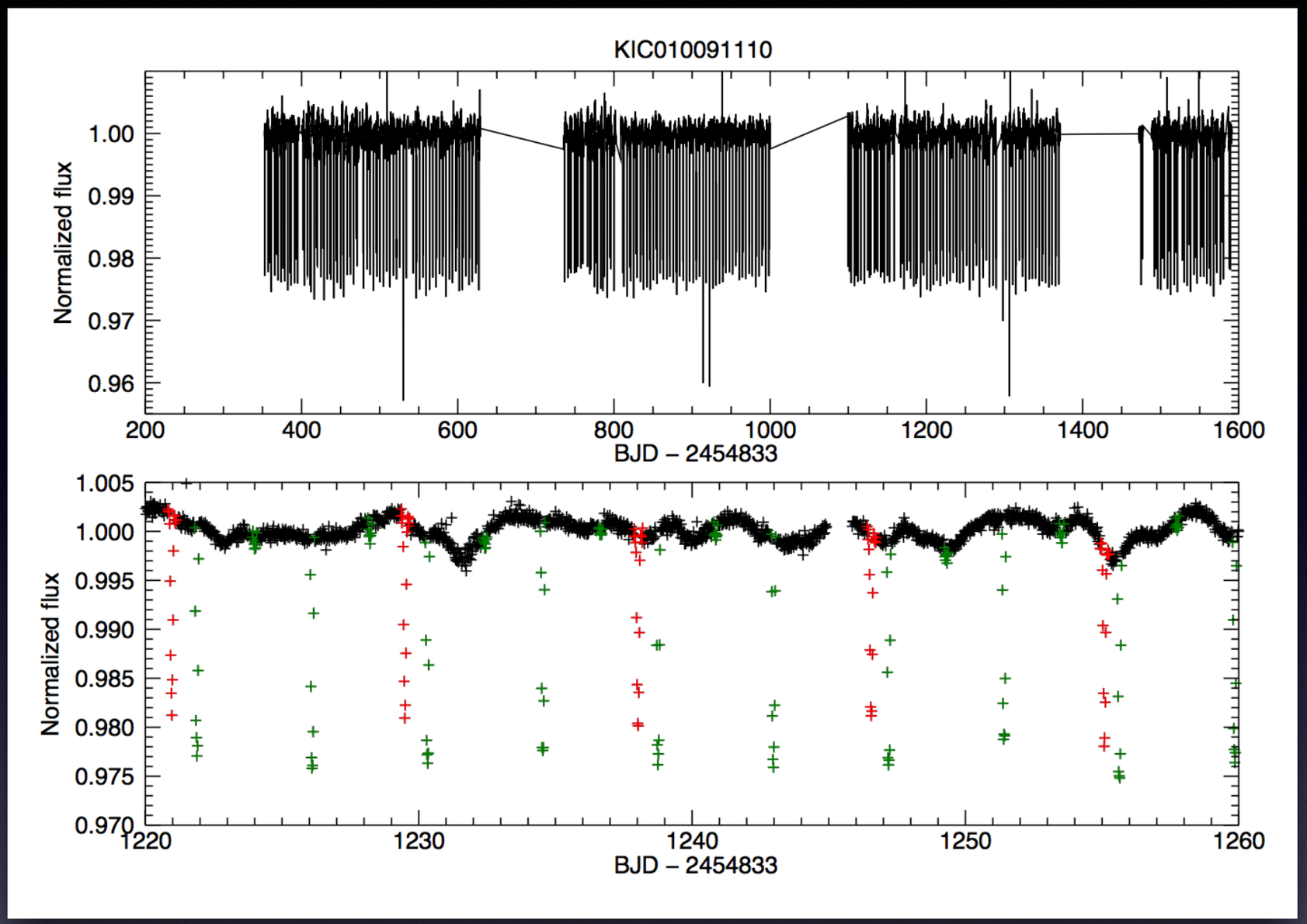
The light curves of KIC007670485 with only one extra eclipses indicated in red.



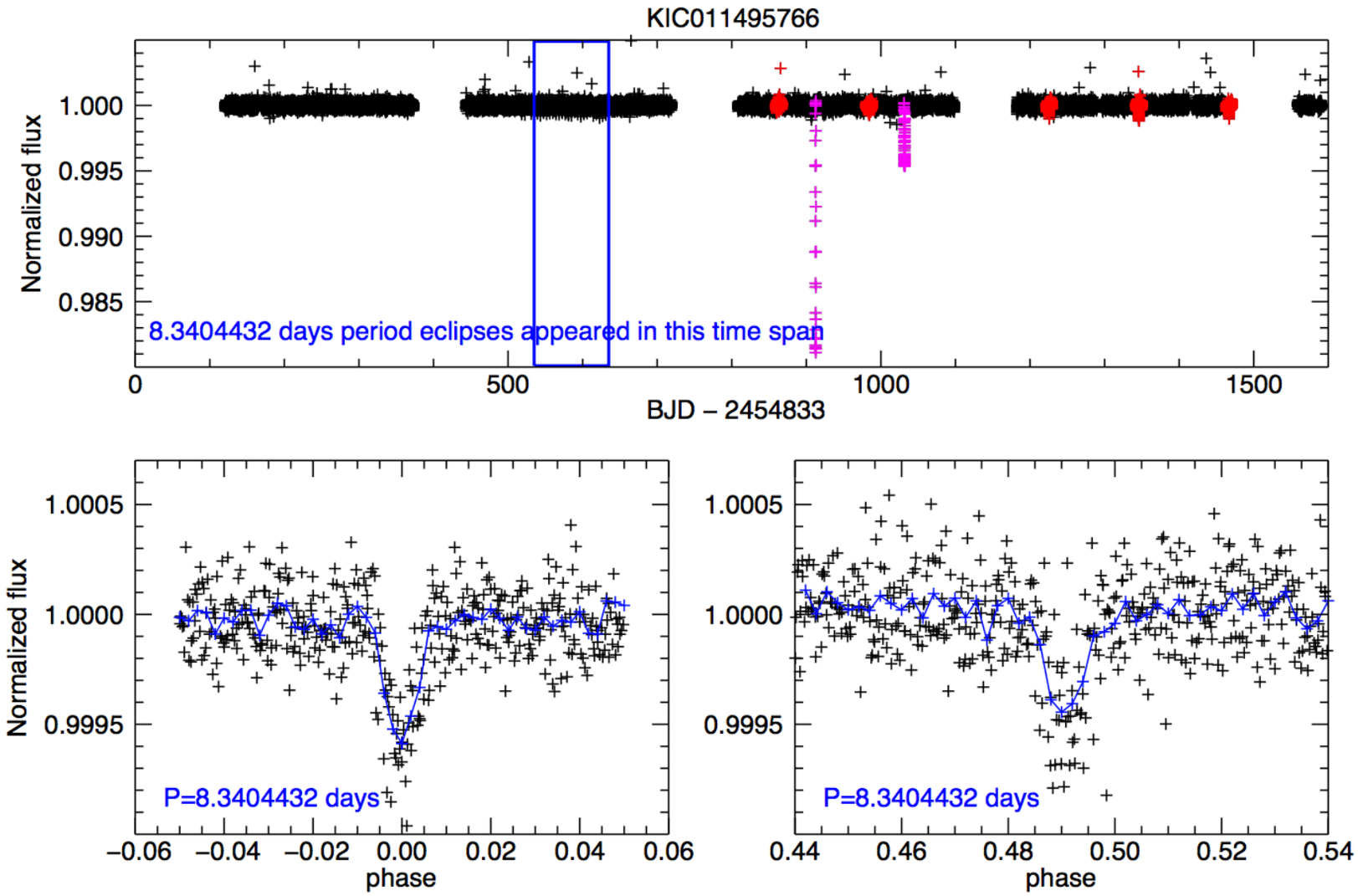
The light curves of KIC008938628. The blue and green lines stand for the lowest positions of primary and secondary eclipses. The groups of extra eclipses are in red.



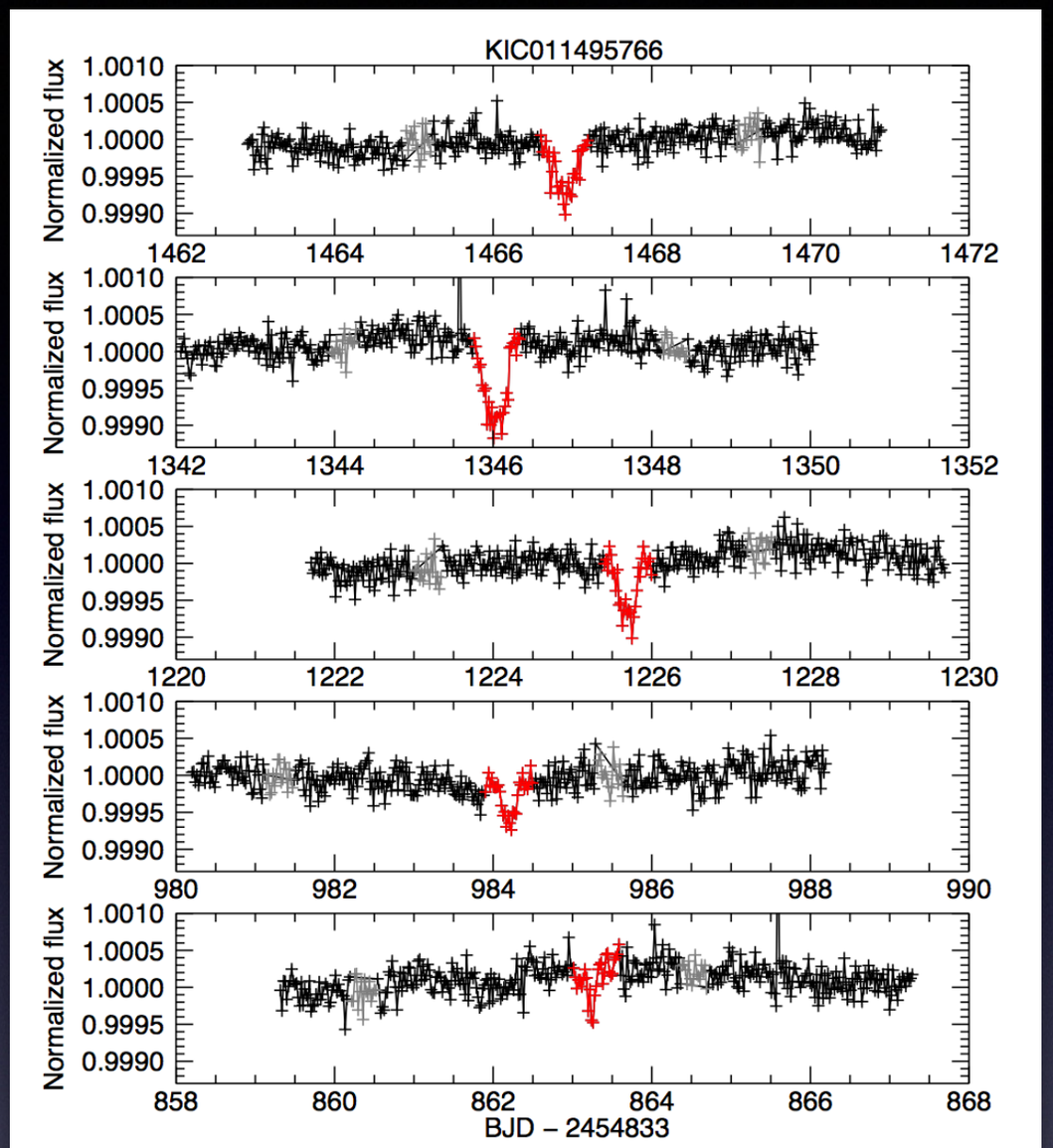
The light curves of KIC009786821. The lower panel is the expanded red square in the upper panel. The extra eclipses only appears in this time span. They appear and disappear suddenly.



The light curves of KIC010091110. The green and red points are the eclipses of 4.21185174 days and 8.5303353 days. The probable 2:1 resonance case.



The light curves of KIC011495766. Upper: The red and magenta points are the extra eclipses. The blue square is the time span where the 8.3404432 days period eclipses show up. Lower: the folded phase light curves of period 8.3404432 days.



The extra eclipses of KIC011495766 with interval of ~121 days.

Summary

- Among the 10 candidates, 7 candidates are at least quadruple systems.
  There is the clustering properties in stellar system. This is similar to the case of exponent candidates —40% candidates belong to multi-planets systems (Rowe et al. 2014)

- Extra eclipses on contact binaries are rare. This is a support to the formation of contact binary that the binaries need angular extraction by companions to become close, and meanwhile to make companions distant.

- A possible 2:1 orbital resonance case is found (KIC010091110). A hint to us that the formation of multiple stellar systems have intercommunity with that planets systems.

Ďakujem!

děkuji!

谢谢!