# The First TESS Circumbinary Planet TOI-1338b / EBLM J0608-59b: A Possible Second Planet

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A circumbinary planet is one which orbits both stars of a binary star system. Since the discovery of the first circumbinary planet (Kepler-16 b) in 2011, 13 circumbinary planets have been discovered in 11 systems by transit missions. Despite the radial velocity method being the most established technique for planet detection, no circumbinary planets have been detected by radial velocity measurements to date. Planet formation around binary stars was thought to be difficult, and therefore these circumbinary planets were confined to the realm of science-fiction. Yet during its lifetime Kepler discovered several of these objects, a remarkably large amount for a population that was thought not to exist. Understanding how these planets form and how common they are can provide us with a unique insight into planet formation in these extreme systems.

TESS recently announced their first detection of a Neptune-sized circumbinary planet transiting the Eclipsing Binary Low Mass (EBLM) target J0608-59 (TOI-1338). This system is part of our Binaries Escorted By Orbiting Planets (BEBOP) radial velocity survey, searching for planets around single-line binary systems. With ongoing HARPS observations for this system along with recently allocated ESPRESSO time, here we will present our RV analysis of this system. Please refrain from tweeting about the following results as we would like to stress that they are very preliminary.

### **Fig. 1**

**TOI-1338 or EBLM J0608-59 has been** monitored as part of the BEBOP (Binaries **Escorted By Orbiting Planets) Radial** Velocity (RV) program since 2009. **BEBOP** monitors around 100 eclipsing binaries searching for circumbinary planets using RV measurements.

For more information on the BEBOP survey please email me with your questions.



#### **Fig. 2**

Following the TESS discovery we were awarded **DDT time on ESPRESSO**, expecting to see evidence for a planet corresponding to J0608-59 b at a period around 95 days. We used the KIMA RV analysis package to produce

a periodogram of our posterior samples which can be seen below:



### On the right is the RV plot of the binary:

### **Fig. 3**

This 200 day phased signal can be seen plotted below.

Unfortunately with our current data the posterior evidence for this second planet remains too low to claim a detection.



## **Fig. 4**

Simulating further ESPRESSO measurements assuming a mass for J0608-59b of 13 M<sub>a</sub> (the lower limit of the TTV signal) combined with the 200d signal, we obtain the posterior distribution seen below:



We don't see a trace of planet b, which allows us to place a  $3\sigma$  upper limit on the mass at 25 M<sub>o</sub> (down from 33±20 M<sub>a</sub> in the paper). What we do notice, is a peak in the number of posterior samples at around 200 days.

#### Conclusion

Current data enables us to place an upper mass limit of ~25 M<sub>o</sub> on J0608-59b and find evidence of a second planet with onoriod of around 200 dave