TESS's Circumbinary Planet TOI-1338b / EBLM J0608-59b May Not Be Alone…

Matthew R. Standing, Amaury H. M. J. Triaud (University of Birmingham)
D. V. Martin, J. P. Faria, J. A. Orosz, V. B. Kostov, W. F. Welsh

Circumbinary planets, which **orbit both stars of a binary** system, challenge our understanding of planet formation and orbital evolution. Planet formation around binary stars was thought to be difficult, and therefore these circumbinary planets were confined to the realm of science-fiction, until the discovery of Kepler-16b in 2011. Since then, **15 circumbinary planets** have been discovered in **13 systems** by transit missions.

TESS recently discovered its first confirmed circumbinary planet, TOI-1338b. Located in the mission's continuous viewing zone and confirmed with ground-based photometry. Observed as part of the **BEBOP (Binaries Escorted By Orbiting Planets) radial velocity survey**, we combine **ESPRESSO and HARPS radial velocity** data in an attempt to confirm TOI-1338b and constrain it's mass. With no sign of TOI-1338b in our current data we can place a **3-sigma upper limit on the mass at 12 Earth masses**, a low-density planet. Here I present our preliminary results on the system, including a candidate second planet. If confirmed, this would make TOI-1338 the **second ever multi-planetary circumbinary planet system, and the first circumbinary planet discovered by radial velocity data.**

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.

On the right is an RV plot of the binary:

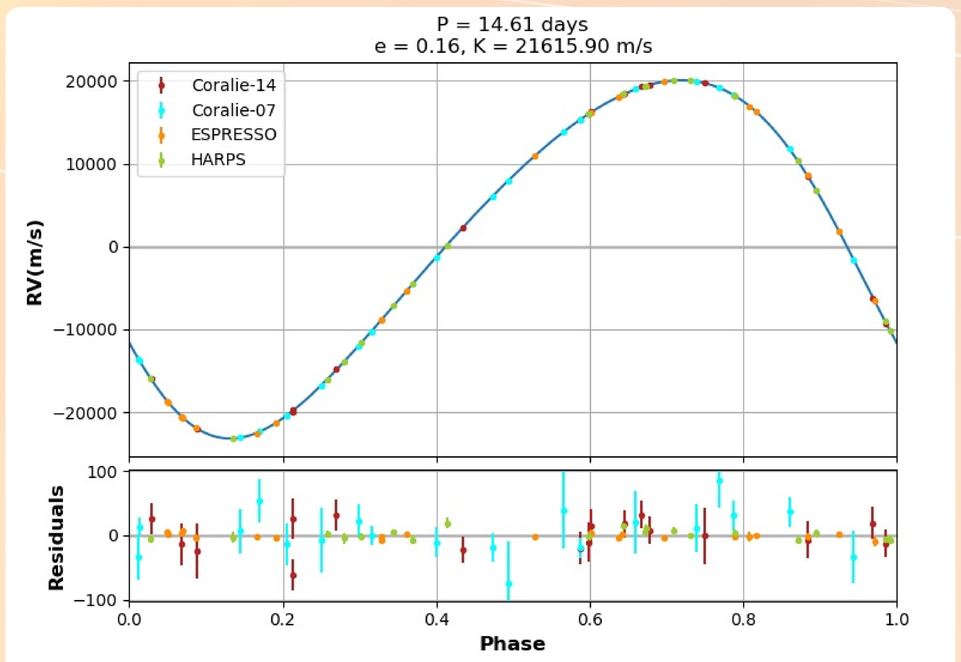
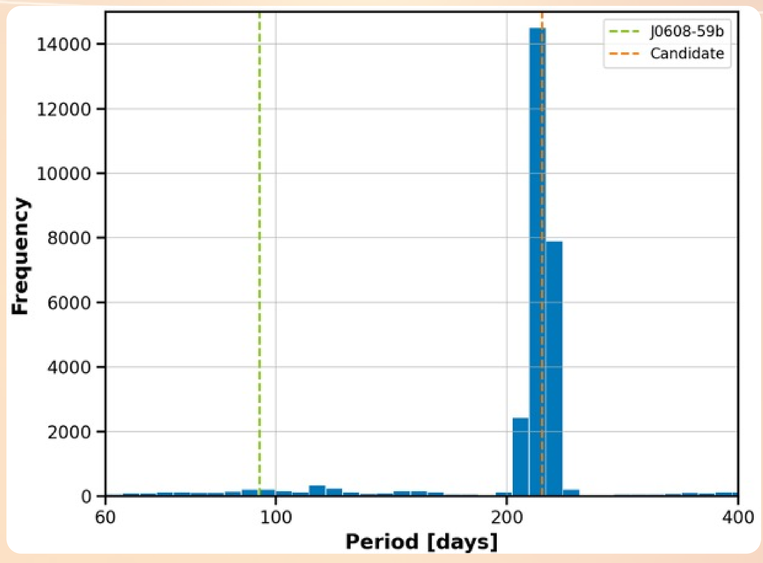


Fig. 2
Following the TESS discovery we were **awarded time on ESPRESSO**, expecting to see evidence for a 95d planet corresponding to J0608-59 b.
A periodogram of our posterior samples from the ***KIMA*** RV analysis package can be seen below:



Seeing no trace of planet b allows us to place a **3σ upper limit on the mass at 12 $M_\oplus$** (down from 33±20 $M_\oplus$ in Kostov et al.). What we do notice, is a peak in the number of posterior samples at around 220d.

Fig. 3
This 220 day phased signal can be seen plotted below, and corresponds to an approximately **48 $M_\oplus$ second planet.**
With our current data the **posterior evidence for this second planet is close to claiming a detection.**

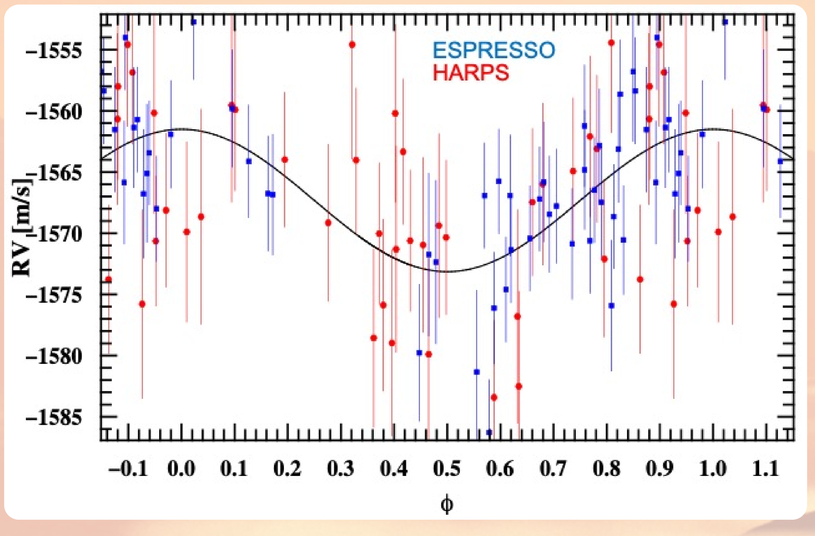
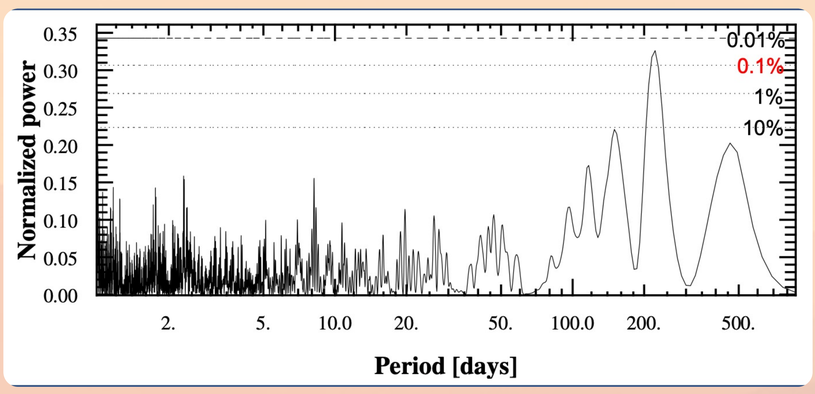


Fig. 4
Below is a more **traditional periodogram** of the data. You can see the peak of normalized power at ~220 days exceeding the false alarm probability line of 0.1%, **passing the usual threshold for detection**.



We're still **collecting data on ESPRESSO and HARPS** to confirm this candidate and determine the mass of the TESS circumbinary planet.

Conclusion

Current data lets us to place an upper mass limit of ~12 $M_\oplus$ on J0608-59b and find evidence of a second planet with a period of around 220 days.
With further ESPRESSO observations we hope to confirm this second planet and obtain a mass measurement for J0608-59b.
This could be the first circumbinary planet discovered with Radial Velocity (RV) data, and only the second multi-planetary circumbinary system!

References
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Background Image: NRAO/AUI/NSF, S. Dagnello

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Scan for TESS's press release video

Credit: NASA's Goddard Space Flight Centre

Matthew R. Standing
mxs1263@bham.ac.uk