A Search for Transiting Objects Orbiting White Dwarf Stars

Seth Redfield (Wesleyan University)

Given their small size, white dwarf stars present a very intriguing sample to monitor for transiting objects. Several papers have described the possibility of detecting very small objects, even down to exoasteroids, around white dwarf stars (e.g., Di Stefano et al. 2010, Agol 2011, Loeb & Moaz 2013). The transit of an Earth-sized planet would cause a full eclipse of the host star, and therefore would be easy to detect, however, it would be very short, on the order of seconds to minutes, and would therefore require short cadence observations. The size of the host star also makes any followup observations of the exoplanet significantly easier (e.g., transmission spectroscopy of the planetary atmosphere [e.g., Redfield et al. 2008, Jensen et al. 2013]). Given the extreme difficulty of measuring atmospheric properties of Earth-sized planets around solar-like stars, our first observation of an Earth-sized planetary atmosphere, may come from an object transiting a white dwarf star. Regardless of the relative ease of follow-up observations, the atmospheric measurements of a planet around such an evolved star, would provide critical information regarding the composition and formation of such objects. I propose a sample of 2 white dwarf stars for consideration in Campaign 2 and 7 in Campaign 3 (all located on silicon according to `K2fov` and all but two in EPIC).

While no white dwarf is known to have a transiting object, there are several indications that there may be significantly sized objects in short period orbits around such a compact star. Among the first detections of planetary mass objects, was a multiple planet system around a pulsar (Wolszczan & Frail 1992), so presumably planetary mass objects are also possible in short period orbits around white dwarf stars. Also, there is a growing population of white dwarf stars that are clearly accreting asteroidal material, as indicated by infrared excesses (e.g., Kilic & Redfield 2007) and by stellar absorption lines of metals that have very short settling times (e.g., Farihi et al. 2010). The composition of this accreted material has compositions that resemble that of asteroids and the bulk Earth (Xu et al. 2014). Kepler could possibly detect the debris from the breakup of a small body, as in the case of KIC 12557548 (Rappaport et al. 2012). The fact that we do not have a detection of a transiting object around a white dwarf seems not due to the intrinsic physical properties of the white dwarf star and its formation, but the small numbers of searched systems. Therefore, including the relatively small number of targets in the K2 target list is worth doing.

While a ground-based search is possible, because the interesting habitable zone orbital periods range from 4–32 hours, such a search is severely limited by the aliasing of Earth's rotation. Despite this, at Wesleyan University, we are conducting a ground-based search with our 0.6-meter telescope, and have monitored about 25 targets over the last 6 months. However, the observations are limited to 1–2 8-hour epochs, making it difficult to definitively rule-out a transiting signal with periods in the habitable zone range.

Due to the shortness of any transit, these observations should be taken in short cadence. Note that many of these have high proper motions, which may enter into the pointing calculations. I would be happy to assist in the further refinement of the observational details. While I have only touched on the value of these targets in terms of transiting object detections, there are other research programs that this data would facilitate, even if no transits were found, including stellar pulsations (e.g., Greiss et al. 2014).

References

Agol 2011, ApJ, 731, L31
Di Stefano et al. 2010, ApJ, 712, 142
Farihi et al. 2010, MNRAS, 404, 2123
Greiss et al. 2014, MNRAS, in press
Jensen, Redfield, et al. 2012, ApJ, 571, 86
Kilic & Redfield 2007, ApJ, 660, 641
Loeb & Moaz 2013, MNRAS, 432, L11
Rappaport et al. 2012, ApJ, 752, 1
Redfield, et al. 2008, ApJ, 673, L87
Wolszczan & Frail 1992, Nature, 355, 145
Xu et al. 2014, arXiv 1401.4252