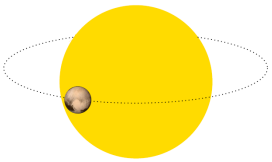
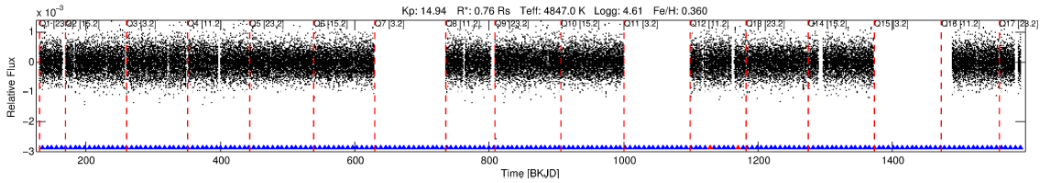
Exploring the limits of exoplanet detection
Minimax bounds for detecting short periodic signals

Are there other habitable Earth-like planets? If so, how can we (best) discover them? These and related questions have made people wonder and marvel for ages. Mathematics is an integral part of the quest of finding answers and unraveling the secrets of the Universe.



Figuratively speaking, in this project, we are concerned with the question of how to best find a needle in a haystack, as, at first glance, recovery of a signal from data as displayed below seems like a hopeless task. There is hope, however, whenever signals of interest are sufficiently strong, sufficiently long, or if they have additional structure that helps facilitate the search. In the endeavor of discovering exoplanets via their transits from photometric data collected by telescopes, signal comes in small clusters that reappear periodically. In fact, repeated dips in starlight are measured as a planet passes in front of its host star at a fixed frequency, which makes the detection problem tractable.



From a statistical viewpoint, the quest of finding transiting exoplanets translates to the issue of optimal detection of sparse, periodic signals of fixed length in noisy data. Based on knowledge on empirical methods for detection (Karlashchuk, 2020) and setting detection thresholds (Jenkins et al., 2002), we will develop the required theory to make previous findings more rigorous and, based on this, derive optimal data driven methods that we will apply to search the data base from NASA's Kepler mission[1] for exoplanets.

This project is suited for students with basic knowledge and interest in mathematical as well as applied statistics, probability theory and programming in `R`.

References

Jenkins, J. M., Caldwell, D. A., and Borucki, W. J. (2002). Some tests to establish confidence in planets discovered by transit photometry. *The Astrophysical Journal*, 564(1):495.

Karlashchuk, M. (2020). Detection of exoplanets by means of the bump detection method. `http://essay.utwente.nl/80503/`.

[1] `https://science.nasa.gov/mission/kepler/`