CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

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Project Number

36748

Project Title

A Search and Exploration of Multi-Exoplanet Systems Using Novel Photometric and TTV Algorithms for the K2 Mission

Abstract

Objectives/Goals

To date, over 5000 exoplanet candidates have been discovered orbiting around stars other than our Sun. However, the vast majority of planet systems discovered are considered to be single planet systems. Our own Solar System is a multi-planet system, which is thought to have been necessary for the formation of life on Earth. Yet it is poorly understood whether multi-planet systems are commonplace or rare elsewhere in the universe. In this project, we use the K2 mission to search for and analyze multi-planet systems with the goal of finding out what types of multi-planet systems exist. We hypothesized that we would only find multi-planet systems with short period planets smaller than Neptune because the formation processes of larger planets would gravitationally clear out their orbits.

Methods/Materials

The two most successful methods for discovering planets by far-the transit method and radial velocity-are both optimized for finding single planet systems, which explains the apparent dearth of multi-planet systems. However, the TTV method, which searches for gravitational "tugging" on transiting planets by unseen planets in a system, allows for the unbiased detection of multi-planet systems. We developed a novel algorithm in Python which uses the TTV method to perform a scalable search for multi-planet systems. Our algorithm starts with images taken by the K2 mission and creates light curves, graphs of brightness over time, for each star. Our algorithm then times each "lap" of known, transiting planets as they orbit their host stars. Variations in these "lap times" indicate the presence of other planets in the system.

Results

We found 4 potential multi-planet systems of which 3 are new discoveries. One of the systems has multiple transiting planets and exhibits TTVs consistent with theoretical TTVs from n-body simulations. Another multi-planet system likely has two hot-Jupiters, which could be an unprecedented finding.

Conclusions/Discussion

Our results indicate that multi-planet systems are highly diverse, and confirm the need to revise current theories of exoplanet formation. The method used in this project is also particularly important because it is the only method that can be used with current instruments to find habitable planets around Sun-like stars. In the near future, we will continue to use our algorithm to perform one of the first large-scale surveys for multi-planet systems.

Summary Statement

We create and use a novel algorithm to search for multi-exoplanet systems using the "crippled" Kepler mission, and find 4 potential multi-planet systems, 3 of which are new discoveries.

Help Received

We developed all of the algorithm, came up with the idea for our project, and analyzed our results. Dr. Ann Marie Cody at the Kepler building at NASA Ames Research Center provided helpful tips and advice on certain reduction techniques, as well as gave opportunities for follow up observations with ground