CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Isaac A. Broudy

Project Number

38286

Project Title

Testing Special Relativity with High Resolution Differential Photometry of Eclipsing Binary Systems

Abstract

Objectives/Goals

This study used multi bandpass differential photometry of variable star eclipses to investigate potential variations in the speed of light (c), offering a test of special relativity.

Methods/Materials

Three eclipsing binary star systems (W Uma, UV Leo, and U Cep) were measured with four bandpass filters (luminance, red, green, and blue) in order to compare potential shifts between eclipse timings, signifying a shift in the speed of light.

To do so, I built an automated observatory for this study, featuring a 90mm refractor telescope with fully automated target and image acquisition. I developed and used a semi-automated image processing and analysis pipeline for photometric analysis.

All measurements were made over a 12 night period. Measurements were converted from instrumental magnitude to apparent magnitude through the use of AAVSO reference stars. Apparent magnitudes were then folded into a complete light curve representing a single period. Curve fits and first derivatives were used to calculate timing of each eclipse and confidence intervals for statistical analyses.

Results

This study did not measure any significant differences in the speed of light of different wavelength. All eclipsing minima, in all bandpass filters, occurred at the same time, within the resolving power of the system. This observation was found to be true across each of the three eclipsing binary star systems.

Conclusions/Discussion

It was predicted that light of differing wavelength could travel at differing speeds--potential explanations including interstellar medium or quantum permeability. This study; however, did not observe any such differences.

After analysis, it is not surprising that I failed to detect changes in c, given this system was determined to reach a 10^-7 level of precision, and the speed of light has been well-measured to 10^-9 . The automated system and analysis workflow; however, can be extended to stars orders of magnitude further away, readily enabling higher precision measurement beyond 10^-9. This offers the possibility of observing changes to c and potential violations of special relativity. For now; however, this study adds further evidence that the speed of light is indeed constant.

Summary Statement

I used differential photometry of eclipsing binary systems to determine that all wavelengths of visible light travel at the same speed, providing support towards the second postulate of special relativity.

Help Received

I received help from Dr. Brian Keating, Dr. Andrew Friedman, Dr. David Tytler, and Mr. Delwin Johnson of UCSD, Center for Astrophysics & Space Sciences; they provided valuable insight for planning and analysis of this research project. I also received help from Dr. Arijit Chakravarty with statistical analysis.