Education and Heritage in the era of Big Data in Astronomy
Proceedings IAU Symposium No. 367, 2020
R. M. Ros, B. Garcia, S. R. Gullberg, J. Moldon & P. Rojo, eds.
doi:10.1017/S1743921321000983

Discovering exoplanets in the classroom

Margarita Metaxa[1,2] and Anastasios Dapergolas[2]

[1]Arsakeio High School, 1 L. Marathonos, 14565, Athens, Greece
email: marmetaxa@gmail.com

[2]National Observatory of Athens, Institute for Astronomy, Astrophysics,
Space Applications and Remote Sensing,
Ioannou Metaxa and Vasileos Pavlou, GR-15236, Athens, Greece
email: adaperg@noa.gr

Abstract. This resource was developed to help bring this exciting area of research into the classroom. It consists of two practical activities appropriate for the *K12 curriculum.*
Each of the activities is standalone, takes around 60 minutes to complete and can be used either during lessons or as part of a science club. Each offers plenty of opportunity for extension work and includes a taking it further section to allow students to build on what they have learnt through independent research. The activities can be used individually, or in combination. We have already implemented them during the astrophysics summer courses we offer to school students at the National Observatory of Athens, with great success.

Keywords. Pbl exercise, exoplanets, transit method, spectral type.

1. Introduction

The discovery of planets outside our solar system, has been at the forefront of astronomical research since 1995, when Michel Mayor and Didier Queloz announced the first discovery of a planet outside our Solar System. Since then over 4600 exoplanets have been found in our home galaxy. More exoplanets are still being discovered, with different sizes, types and orbits that are piecing together the puzzle that can teach us about planet formation and our own origins. But the biggest payoff is yet to come: capturing evidence of a distant world hospitable to life. To find another planet like Earth, astronomers are focusing on the 'habitable zone' Heller (2015) around stars–where it's not too hot and not too cold for liquid water to exist on the surface. All these information and discussions are worth to come to education[1] in a figurative way since as groundbreaking as exoplanet science is, the basic physics is quite accessible to K12 level physics students. To further illustrate this point, we developed this exercise that generates real exoplanet data taken from a simple telescope[2], to provide students and teachers with interactive learning activities. Using introductory physics concepts, with the data taken we check:

a. the existence of an exoplanet with the transit method
b. the spectral type of the host star, so that the hosted exoplanet to have chances to belong to the habitable zone. We have created a student's fact sheet, task sheet, and an information sheet about exoplanets.

1 https://www.stem.org.uk/resources/elibrary/resource/31030/exoplanets
2 https://www.cfa.harvard.edu/smgphp/otherworlds/ExoLab/teachers/pdfs/Activity1WelcomeV5.pdf

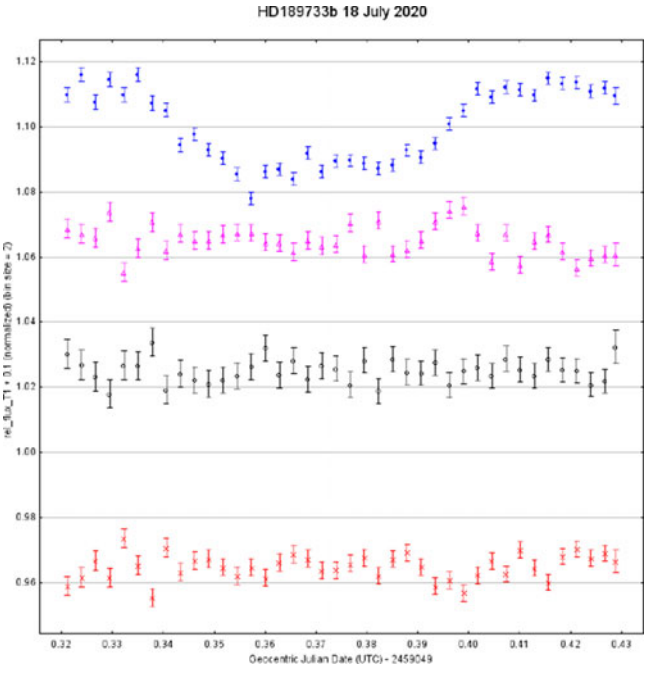

Figure 1. The uppermost light curve refer to the transit of the exoplanet, while the other curves refer to the comparison stars.

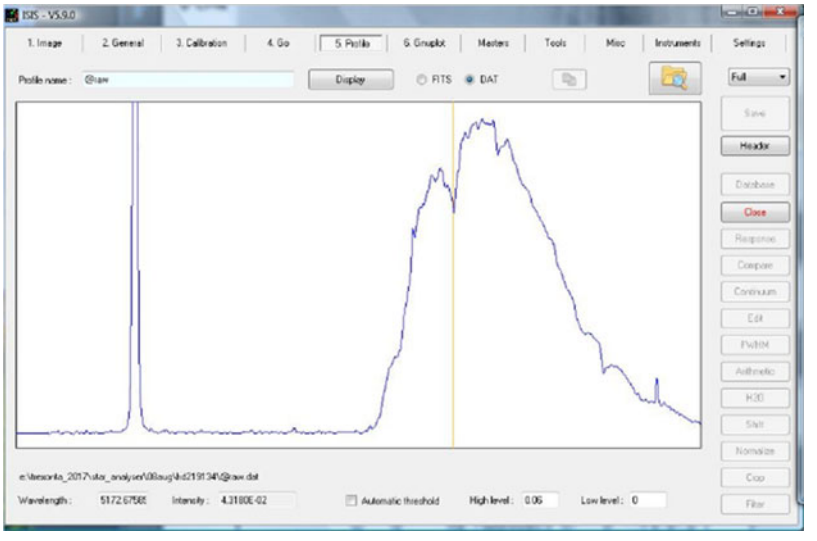

Figure 2. The trace of the star HD219134. We see on the left the trace of the undispersed star (order 0) and right the dispersed spectrum. The indicated strong absorbtion is a blend of MgI, FeI etc.

2. The case of exoplanets of the star HD189733b

We used images of the exoplanet HD189733b, taken with a 8inch f/4 newtonian telescope with an detector DSLR canon 40D. In order to increase the signal the images were defocused and the exposure time was increased to 60sec. Then with the software *a.* Muniwin we extracted and used the green (G) colour of the RGB images and reducted

https://doi.org/10.1017/S1743921321000983 Published online by Cambridge University Press

the data for the dark and flat corrections and *b.* with the software Astroimagej we conducted the photometry (Fig. 1). In the diagram orizontal axis is Julian Date in UTC and the vertical relative flux. The plotted points has bin size equal to 2.

3. The case of the star HD219134

HD 219134, is a main-sequence star in the constellation of Cassiopeia with at least five exoplanets orbiting around. Using the same telescope we took the spectra images of the mother star with the star analyser 100 transmission grating and a CMOS camera ASI120M. We analysed the spectra using the ISIS software to extract the spectral trace were we can identify the metal lines eg of Mg which is a strong indicator that the star is of spectral type between F to K, and thus the star can host exoplanets at the hapitable zone (Fig. 2).

4. Conclusion

It is a totally hands-on exercise, with an additional observational experience for the students. Through the proposed exercise on "discovering exoplanets" in the classroom, we effectively teach students to develop the skills of Problem based Learning ie Critical thinking, Team Work, Independent thinking, Communication and Digital Literacy. This method of teaching requires a high level of thinking. The students analyse, create and evaluate a challenging problem posed. This problem is open-ended and might not have solutions. Additionally the use of a telescope, as a mean for the students to obtain their own data, is an extremely challenging opportunity beyond the ordinary process, leading them to exciting exploration.

Reference

Heller, R. 2015, "Better than Earth", *Scientific American* (January 2015), 32–39.

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