Boletim da Sociedade Astronômica Brasileira, **30**, no. 1, 50-51

Planetary transit model and light curve analysis

N. Vinicius Santos, Israel Florentino, Adriana Valio

[1] Universidade Presbiteriana Mackenzie, São Paulo, SP. e-mail: 41486501@mackenzista.com.br

Abstract. The analysis of light curve based on planetary transit is directly associated to the variation of the light emitted by a star when an exoplanet eclipses its orbit. Each system involves exoplanets (they may have moons, rings, etc.) and stars with numerous features. These variables together generate the light curve, and from it, its possible to calculate the planet radius, orbit slope angle, and the larger semi-axis.

Resumo. A análise de curva de luz baseada no trânsito planetário está diretamente associada á variação da luz emitida por uma estrela quando um exoplaneta movimenta-se por sua órbita. Cada sistema envolve exoplanetas (podem ter luas, aneis, e etc) e estrelas com inúmeras caracteristicas. Estas variáveis em conjunto geram a curva de luz, e a partir dela, pode-se calcular o raio do planeta, ângulo inclinação da órbita e semieixo maior.

Keywords. light curve – planetary systems – model

1. Introduction

More than 3600 planets have been discovered orbiting around other stars. Of these, 75% were detected by the planetary transits method, when the planet eclipses its host star. Given this favorable percentage, this project aims to organize in a single tool the calculations, variables, functions, constants and so on. in a documented way, in order to consolidate the concepts used to calculate the transit of planets based on light curve analysis. Such a model will be implemented and made available in the python language, and will allow the user to perform partial calculations or simulations with analytical results, graphical animations and navigable 3D displays as well as graphs related to the light curve. The Python language was agreed because of the high utilization rate by the academic community. It will also be using a Python branch named Visual Python (VPython). The tool used for the development and eventual compilation of codes that use graphic resources is the Jupyter Notebook. Jupyter is a client-server application that allows the execution of VPython documents through the browser. The development of the tool will be under the paradigm of object oriented programming respecting the design patterns.

2. Light Curve Model

The first step in light curve analysis is when the planet eclipses its host star. During a transit the brightness of the star is diminished by a few hours of less than 1% periodically depending on the orbital period of the planet. This decrease in the amount of light allows the extraction of the data needed to construct the relative light flux as a function of time, as exemplified in Figure 1 (1). The light curve generated by traffic is not always uniform. The light flux may undergo minor changes due to the chemical-physical characteristics of the stars involved in the analysis. Planets may have moons and rings, stars usually have spots, and these characteristics are directly linked to the results generated. When these factors are involved, we can visualize the perturbations in the graph according to Figure 2 (1). Once these variables are parameterized, we are able to infer relevant results, such as the planet radius, the larger semi-axis and the inclination angle of the planet orbit.

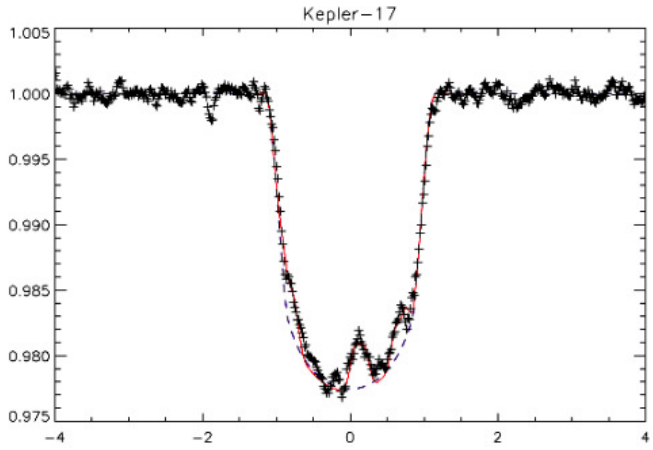

Figure 1. Light curve model without disturbance

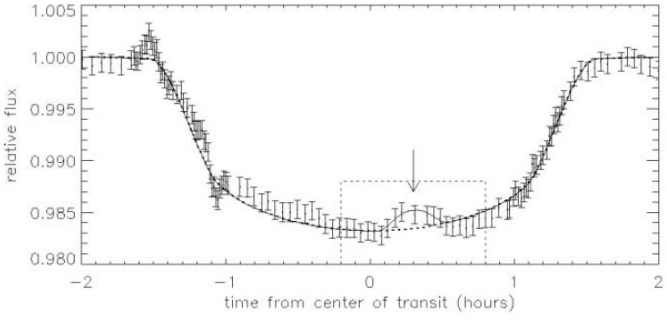

Figure 2. Light curve model with disturbance of a spot light

3. Model, Documentation and Methodology

The application documentation provides all the necessary objects for the best representation of the problems involving the model. Objects such as Magnetic Field, Types of Spots, Flake and Rotation are properly associated so that there is total control and manipulation of the classes. For use of functions, all calls will be properly documented (Figure 3), informing who uses them, what are the arguments that should be passed as a

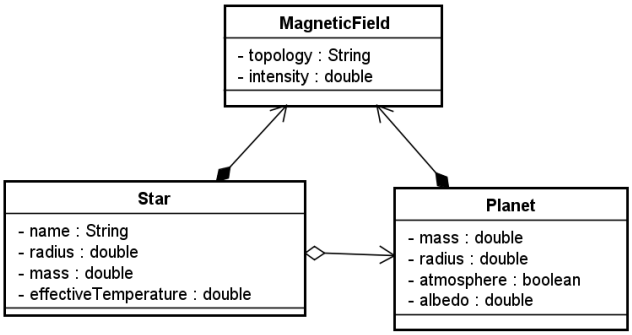

Figure 3. Part of Class Diagram

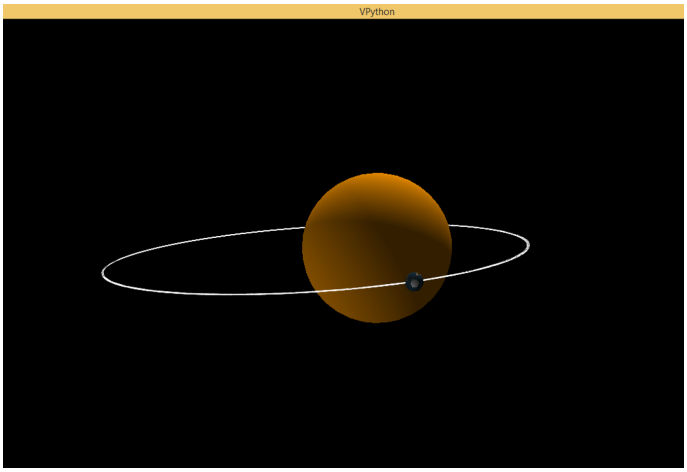

Figure 4. Transit Representation

parameter, as well as what the return of the function and a brief summary of what was done. The animation generated involving 3D (Figure 4) objects will be given dynamically, where the colors, shapes and characteristics of the objects will be defined from the inputs made by those who call the function. The animations will not fit into perfect scales, since such a property would make it difficult to see the planet in front of the star, given its dimensions. The methodology to be used to consolidate all the needs of the application on a single scope will be the analysis and transcription of codes already existing in programming languages, mostly oriented to the work involving astronomy and astrophysics The library will be available to the entire community downloading by Github

4. Expected results

All the asymmetric and mathematical models used were designed through the work by researchers very concepts. Given this, it is intended to consolidate these adaptation models of a use and propagation of the light curve model, using a technology as allied in the process. The largest object and scope is related to the expansion of the planetary transit model under the light curve to be created by users of simple and functional formats, from undergraduate to postdoctoral students. The major difficulties and those faced are associated with the workflow of processes and documentation, since it is a physical and mathematical involved are not trivial. Nevertheless, assuming that future projects involving planetary transit will save precious developing time when the library proposed here is completed, it is sufficient motivation to move forward.

Acknowledgements. Thanks to all friends and teachers for help, time, affection, and especially patience.

References

Silva, A.V.R (2003). Method For Spot Detection On Solar-Like Stars, The Astrophysical Journal.
Tusnski, L. R. M. (2011). Modelo para simulação de trânsitos de planetas com luas e anéis. page 56.
Gamma, E. Helm, R. Johnson, R. Vlissudes, J. Design patterns: elements of reusable object-oriented software
Boss, A. P. (2002). Stellar metallicity and the formation of extrasolar gas giant. pages 50–55.
Ghezzi, C., Jazayeri, M., and Mandrioli, D. (2002). Fundamentals of software engineering.
Marcus, A. and Gould, E. W. (2000). Crosscurrents: cultural dimensions and global web user-interface design. interactions, 7(4):32–46.