SF2A 2006
D. Barret, F. Casoli, T. Contini, G. Lagache, A. Lecavelier, and L. Pagani (eds)

NEW APPROACH TO THE SEARCH FOR COMPANIONS TO EXTRASOLAR PLANETS

J. Cabrera[1] and J. Schneider[1]

Abstract.
At the end of June 2006, 194 planets have been discovered (see the Extrasolar Planets Encyclopedia for a permanent update: http://exoplanet.eu). In our solar system, 7 of the 9 planets have from 1 to several tens of satellites. The search for satellites of extrasolar planets is relevant for the understanding of planetary system's evolution and for the perspective of their habitability (Williams et al. 1997). We have written an article (Cabrera & Schneider 2006) studying possible interactions between satellites and their host planets in extrasolar systems and how these phenomena will affect their detection. Here, we show part of this work: how lightcurves will be affected by mutual phenomena between a planet and its satellite.

1 Introduction

Planets are too faint and are too close to their star to be observed directly for the moment. Indirect techniques are used instead, such as radial velocity measurements (RV), transit detection or astrometric displacement. However, these techniques will have problems characterizing planets with satellites or even binary planetary systems. For example, for a planet-companion system, the RV method gives only the sum of their (minimum) masses, leading to a misassignment of the mass of individual objects. The same consideration holds for astrometric detection. Transits will also be affected both in timing and shape (Sartoretti & Schneider 1999).

Photometrically, the presence of a satellite can be detected as a perturbation of the flux coming from the planet. If the planet and its companion are not resolved, we only measure the sum $F = F_1 + F_2$ of the fluxes from each body:

$$(F_{\rm Refl})_{1,2} = A_{1,2} \times R_{1,2}^2 \qquad (F_{\rm Th})_{1,2} = R_{1,2}^2 \times T_{1,2}^4$$

$F_{\rm Refl}$ stands for "reflected" and $F_{\rm Th}$ for "thermal" flux; A is the albedo (never larger than 1); R is the radius (always smaller than 1.1 $R_{\rm Jup}$; Pont et al. 2005) and T is the effective temperature. The reflected flux is affected by the orbital phase. If the observed normalized flux is larger than the maximum allowed by its size, either there is something wrong with its structure (for example, rings; see Arnold & Schneider 2004) or it is a binary.

2 Lightcurves

We are going to study the reflected flux coming from a planet and how it is affected by the presence of a companion, which can eclipse the planet, transit in front of it (as seen from the observer), being eclipsed or occulted itself by the planet (see Fig. 2). The theory which describes the light reflected by a planet can be found in Lester et al. (1979) and Fairbairn (2002).

The flux reflected by a sphere illuminated uniformly by a source F_* at a distance a, depends on the surface illuminated (its size R^2); the reflecting nature of this surface (for us, lambertian spheres with geometric albedo p) and the angle between the source of illumination and the observer, the so called *phase angle* (α) (see Fig. 1):

$$\frac{F_{pl}}{F_*} = p\,\frac{R^2}{a_{pl}^2}\frac{3}{2\pi}\iint d\theta\, d\phi\, \sin^3(\theta)\, \cos(\phi)\, \cos(\phi+\alpha) \qquad (2.1)$$

We have calculated the flux coming from planet and satellite for different configurations of the system (for further details, please refer to Cabrera & Schneider 2006). In Fig. 2 we present one of these examples.

[1] Observatoire de Paris-Meudon - 5 Place Jules Janssen - 92195 MEUDON

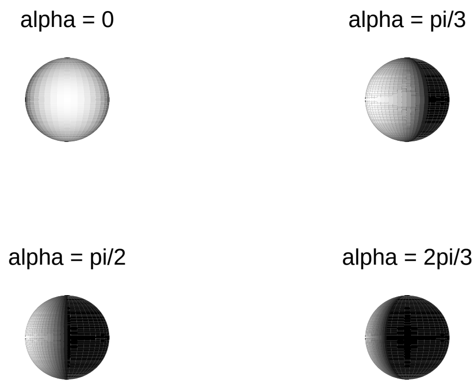

Fig. 1. Illumination of a sphere as seen by the observer for different phase angles.

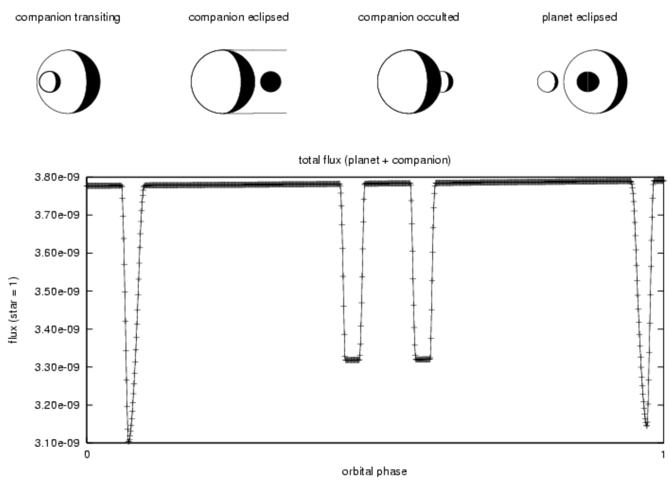

Fig. 2. Mutual phenomena between a planet and its companion, with the resulting flux obtained. The shape of the curves, the relative position of the minima, the depth and the duration of the flux drop... all the parameters depend on the geometry (relative sizes, distances) and the orientation of the orbits with respect to the observer (inclination and phase angle).

References

Arnold, L. & Schneider, J. 2004, A&A, 420, 1153

Fairbairn, M. B. 2002, JRASC, 96, 18

Cabrera, J. & Schneider, J. 2006, A&A, submitted

Lester, T. P., McCall, M. L. & Tatum, J. B. 1979, JRASC, 73, 234

Pont, F., Melo, C., Bouchy, F. et al. 2005, A&A, 433 , L21

Sartoretti, P. & Schneider, J. 1999, A&AS, 134, 553

Williams, D.M., Kasting, J.F. & Wade, R.A. 1997, Nature, 385, 234