COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 4838

Konkoly Observatory
Budapest
29 January 2000

HU ISSN 0374 – 0676

THE ROSSITER–MCLAUGHLIN ROTATION EFFECT FOR HD 209458 DUE TO A PLANETARY TRANSIT

WOREK, T.F.

Community College of Allegheny County, Pittsburgh, PA 15212, USA, email: tworek@ccac.edu

The Rossiter–McLaughlin rotation effect is a sinusoidal-like distortion that has been historically observed most frequently in the radial-velocity curves of Algol binaries during their primary eclipses. The amplitude and shape of this distortion depends on the relative radii of the eclipsed and the eclipsing stars, limb darkening, the rotational velocity of the eclipsed star and the inclination of the orbital plane. Other astrophysical and dynamical factors can alter the rotation effect, especially its symmetry. These include bright/dark photospheric spots, non-zero orbital eccentricity, a spin axis not aligned to the orbital plane normal (an obliquity) and differential rotation. The mathematical description of this phenomenon has been elegantly developed by Kopal (1959) and Hosakowa (1953) with additional contributions by Worek (1985, 1996).

Henry et al. (2000) and Charbonneau et al. (2000) have recently reported their successes in photometrically detecting the transit of a planet across the disk of the G0V star HD 209458 (= HIP 108859). An attempt should now be made to observe the corresponding Rossiter–McLaughlin rotation effect in this star's radial-velocity curve. The rotation effect would serve to further confirm the existence of the planet and could help verify and possibly improve its radius and the other parameters which the above researchers have derived.

Using the pertinent HD 209458 transit results published by Charbonneau et al. and an adopted solar value for the star's $v \sin i$ (Table 1), a theoretical rotation effect due to a planetary transit has been computed. The accompanying figure (Fig. 1.) shows the rotation effect as it would appear if it were extracted from the star's radial-velocity curve, i.e. the radial-velocity observations during the transit less the expected orbital velocities. The peak-to-trough amplitude in this plot is almost 40 $\mathrm{m\,s^{-1}}$, a value great enough that this distortion should be observable given that radial-velocity measurements for solar-type stars are currently achieving a precision better than $\pm 10\ \mathrm{m\,s^{-1}}$.

However, some caveats are in order if any attempt is to be made. Namely, the change in the radial velocity happens very quickly during the 3 hour transit so the shortest possible CCD exposures would be required to minimize "phase smearing". Also, an accurate transit ephemeris and a good set of spectroscopic elements are crucial. Lastly, since the star's absorption line profiles are Doppler skewed to the red before mid-transit and to the blue afterwards (Kopal 1959), the photocentric position in these profiles must be measured for the radial velocity.

Table 1: Parameters to calculate the rotation effect

$R_s = 1.1\ R_\odot$
$R_p = 1.27\ R_J$
$i = 87.^\circ1$
$u = 0.50$ (R band)
$a = 0.0467$ AU
$e = 0.0$ (adopted)
$v \sin i = 2000\ \mathrm{m\,s^{-1}}$

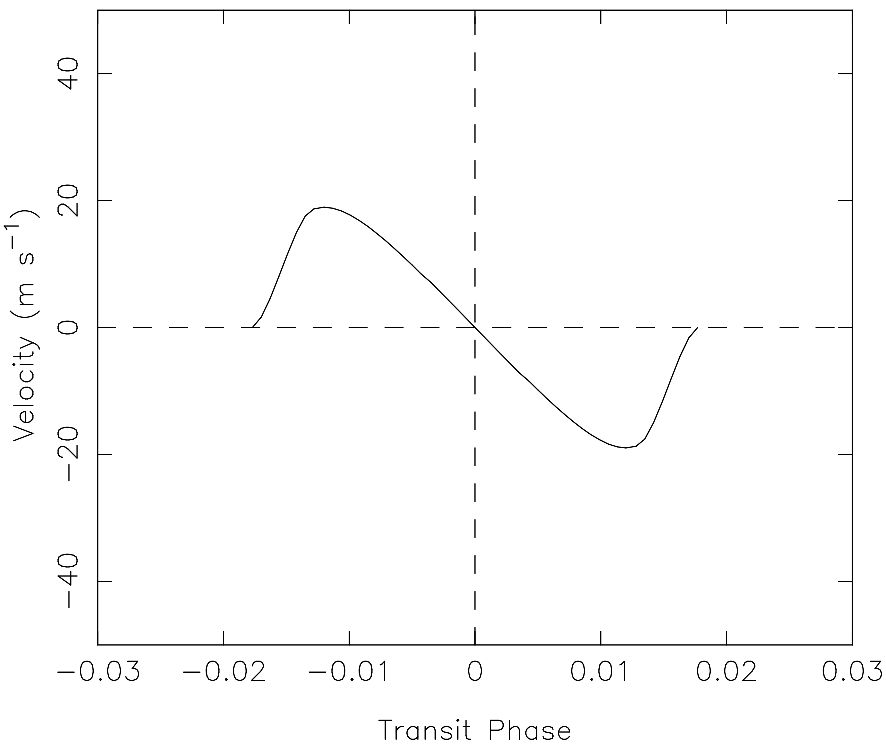

Figure 1. Rotation effect due to a planetary transit

References:

Charbonneau, D., Brown, T.M., Latham, D.W., Mayor, M., 2000, *ApJL*, **529**, L45
Henry, G.W., Marcy, G.W., Butler, R.P., Vogt, S.S., 2000, *ApJL*, **529**, L41
Hosakowa, Y., 1953, *Publ. Astron. Soc. Japan*, **5**, 88
Kopal, Z., 1959, in *Close Binary Systems* (New York, Wiley), pp. 270-274, 280-287
Worek, T.F., 1985, Ph.D. Dissertation, University of Pittsburgh
Worek, T.F., 1996, *PASP*, **108**, 962