Solar Rotation Inferred from Radial Velocities of the Sun-as-a-Star during the 2012 May 21 Eclipse

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With an aim to examine how much information of solar rotation can be obtained purely spectroscopically by observing the Sun-as-a-star during the 2012 May 21 eclipse (Fig. 1) at Okayama Astrophysical Observatory, we studied the variation of radial velocities (V_r), which were derived by using the iodine-cell technique based on a set of 184 high-dispersion spectra consecutively obtained over the time span of ~ 4 hours.

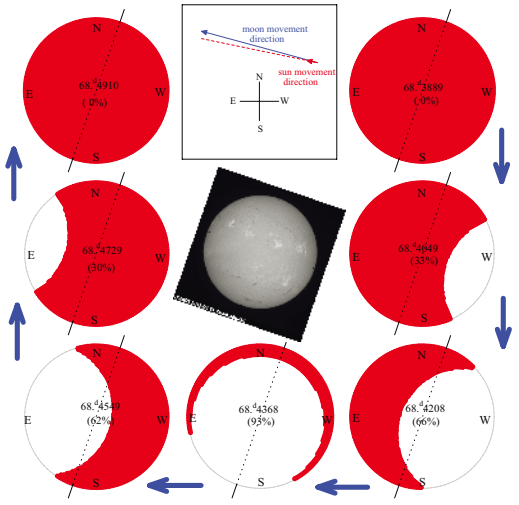

Figure 1: Solar eclipse on 2012 May 21 at Okayama Astrophysical Observatory.

The resulting $V_r(t)$ was confirmed to show the characteristic variation (Rossiter–McLaughlin effect) caused by time-varying visibility of the solar disk. By comparing the observed $V_r(t)$ curve with the theoretical ones, which were simulated with the latitude (ψ) dependent solar rotation law $\omega_{\rm sidereal}(\psi) = A + B\sin^2\psi$(deg day^{-1}), we found that the relation $B \simeq -5.5A + 77$ gives the best fit as seen from the minimum trough of $\sigma(A, B)$ (O−C standard deviation in the A–B plane; cf. Fig. 2), though separate determinations of A and B were not possible. This relationship is consistent with the real values known for the Sun ($A \simeq 14.5$, $B \simeq -2.8$), as can be confirmed in Fig. 3 where the theoretical curve corresponding to (A = 14.5, B = −2.75) case is compared with the observation. This consequence may provide a prospect of getting useful information on stellar rotation of eclipsing binaries from radial-velocity studies during eclipse, if many spectra of sufficiently high time-resolution are available. See [1] for more details of this study.

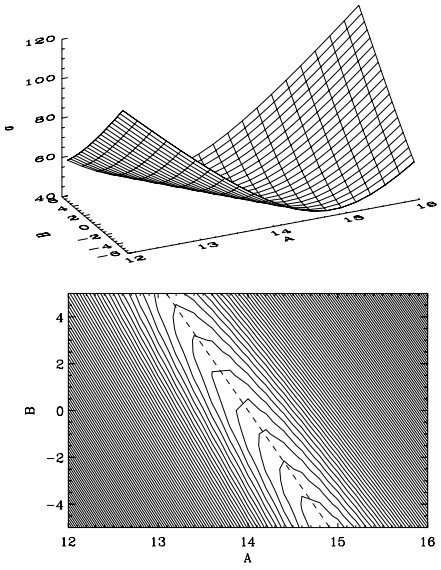

Figure 2: Behavior of $\sigma(A, B)$ (standard deviation in fitting the simulated $V_r(t)$ with the observed $V_r(t)$).

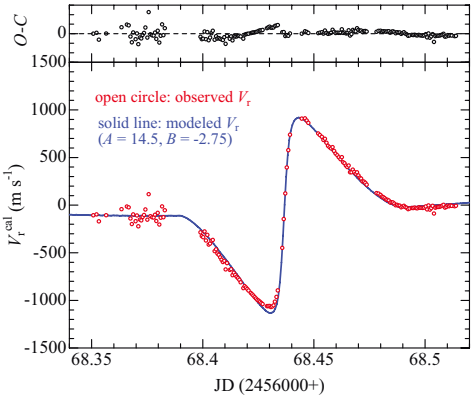

Figure 3: Comparison of the theoretical $V_r(t)$ coresponding to (A = 14.5, B = −2.75) with the observed $V_r(t)$.

Reference

[1] Takeda, Y., et al.: 2015, *PASJ*, **67**, 10.