

# The Line Bisectors Of G Type Giant Star HD199719

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## Abstract

We present an analysis of spectral line bisector variations for HD199719, which has been observed at the Turkish National Observatory (TUG) using the Coude Echelle Spectrograph equipped with an iodine absorption cell. We discuss their influence on precise radial velocity measurements in the search for exoplanets. The line bisectors are derived from mean absorption profiles obtained by cross correlation of the stellar spectra using a mask, and by using lines that are located outside the iodine absorption region. No radial velocity variations have been found that are associated with the bisector variations. Finally, the equivalent width (EW) measurements of the  $H\alpha$  were also analysed for stellar activity.

## 1 Introduction

Precise radial velocity (PRV) method is a widely used technique at many observatories to detect the reflex motion of a star due to planetary companion. However, RV variability may be caused not only by such reflex motion, but also by changes in line shapes arising from stellar atmospheric motion (e.g., non-radial pulsations, inhomogeneous convection, and/or rotational modulation due to stellar spots). While the reflex motion of the star leads to the Doppler shift of spectral lines, the atmospheric activity may cause distortions of spectral lines profiles. The true origin of the RV variability can be inferred by the analysis of line profiles or the cross-correlation function (CCF). The simple way for such an analysis is the line bisector technique (Gray, 1983, 2005). Another tool to determine stellar activity is to study equivalent width (EW) variation of  $\text{Ca II}$  and  $H\alpha$  lines. These three lines are frequently used as the chromospheric activity indicator.

In this work, we report line bisector analysis and EW measurements of  $H\alpha$  for HD199719 in order to investigate whether the observed RV curve are caused by a shift of the spectral lines as a whole or by a change in the symmetry of the spectral lines.

## 2 Observations and Data Reduction

Observations of HD199719 were obtained at TÜBİTAK National Observatory (TUG) in Turkey within the scope of precise Doppler survey of 50 G-K type giants (Yılmaz *et al.*, 2013). We acquired 80 spectra for this target from June 2010 to December 2015 using Coude Echelle Spectrograph (CES) attached to the 150 cm Russian-Turkish Telescope (RTT150) at TUG. We used an  $I_2$  (iodine) absorption cell in front of the entrance slit of the spectrograph to obtain PRV measurements. The TUG CES spectra covered a wavelength region from 3500 Å to 8000 Å, with resolving power  $R \sim 55000$ . We obtained signal-to-noise ratios  $S/N = 80$ -150 per pixel with an exposure time of 1800 seconds for all data set.



Figure 1: TÜBİTAK National Observatory (TUG) and 150 cm RTT150 telescope.

Extraction of the spectra from raw CCD images was carried out using the IRAF<sup>1</sup> software packages in the standard way and PRV measurements of target were derived from the observed star +  $I_2$  spectrum using a specific IDL<sup>2</sup> code, which is based on the analysis technique described by Butler *et al.* (1996) and Sato *et al.* (2002). We have achieved a Doppler precision of about  $10 \text{ ms}^{-1}$  over a time span of seven years observations (Yılmaz *et al.*, 2015).

## 3 Analysis

Analysis of the variations of spectral lines was performed via line bisectors based on CCF, which gives an average spectral line of the observed star. However, we used lines that are located outside the  $I_2$  absorption region because  $I_2$  lines affect stellar spectrum. The CCF function was created in two ways; applying a special mask and using no mask. In the mask method, all blended lines were removed from the stellar

<sup>1</sup><http://iraf.noao.edu>

<sup>2</sup>[www.harrisgeospatial.com/productsservices/idl.aspx](http://www.harrisgeospatial.com/productsservices/idl.aspx)

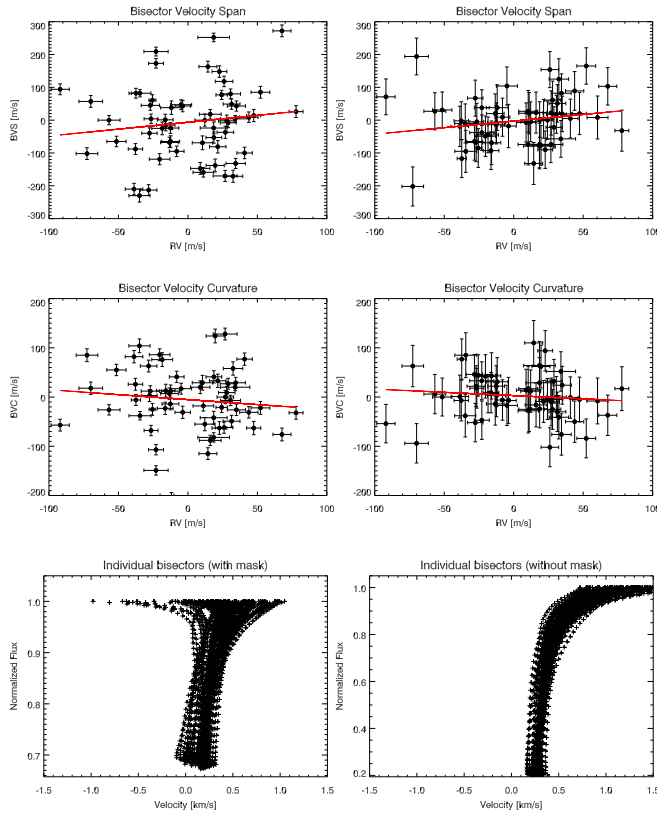


Figure 2: *Upper panel:* plot of RV vs BVS for HD199719 using a mask (left) and without a mask (right) and best linear fit. *Mid panel:* plot of RV vs BVC. *Lower panel:* line bisectors for individual spectra.

spectrum and we identified special lines that were relatively deep. In without a mask method, all spectral lines were used in the construction of the CCF profile. The bisector line was obtained by combining bisector points ranging from the core toward the wings of the CCF profile. We defined three regions to study velocity span of the bisector,  $V_T$  top (between 65% and 85% of the line depth from top),  $V_C$  central (35-55%) and  $V_B$  bottom zones (5-25%). The bisector velocity span (BVS) measurements were performed using velocity difference between  $V_T$  and  $V_B$  ( $BVS = V_T - V_B$ ), and bisector curvature (BC) were derived using the difference of the velocity span of the upper half of the bisector and the lower half ( $BC = (V_T - V_C) - (V_C - V_B)$ ).

We also measured variations of  $H\alpha$  EW in order to understand whether or not HD199719 is chromospherically active. We measured the EW using a window of only 1.0 Å centered on  $H\alpha$  and a Gaussian fit to the profile.

## 4 Results and Conclusions

The G-type giant HD199719 shows RV variations of 50  $\text{ms}^{-1}$ . Its variability could be due to stellar intrinsic variability, rotational modulation, or unseen companions. In order to understand the origin of this variation we examined the behavior of the observed spectral lines. In Figure 2 and 3, we presented BVS and BVC curves and their periodograms for of

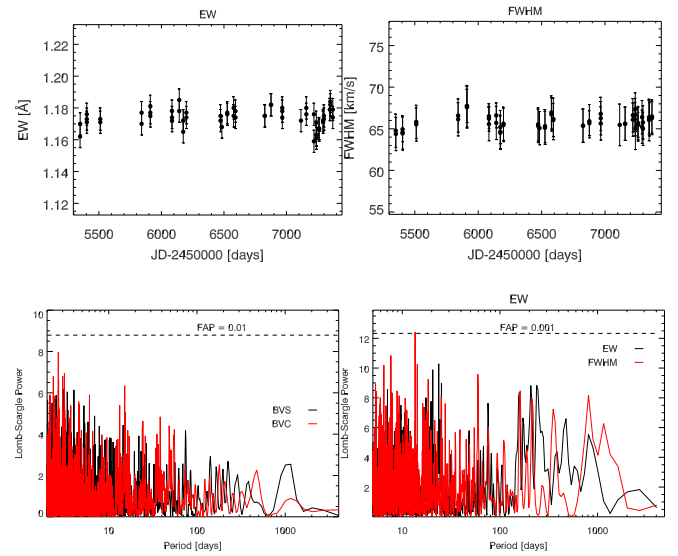


Figure 3: *Upper panel:* EW (left) and FWHM (right) of the  $H\alpha$  line for HD199719. *Lower panel:* The Lomb-Scargle periodogram for the BVS and BVC (left), and the  $H\alpha$  EW and FWHM (right) variations.

the star. No radial velocity variations have been found that are associated with the bisector variations and no significant periods have been obtained; all trial periods have extremely small significance levels. We also measured EW and FWHM of the  $H\alpha$  line for stellar activity and we could not see any important variations of the  $H\alpha$  line. Neither BVS and BVC nor EW and FWHM show correlation with radial velocity. This implies that RV variations observed in HD199719 are not attributable to an intrinsic stellar process, but to an unseen companion.

## Acknowledgments

This work was supported by The Scientific and Technological Research Council of Turkey (TÜBİTAK), the project number of 114F099. This work has been partially supported by RFBR projects 13-02-00351, 12-02-00185, 12-02-97006-r-povolzhie. Authors would like to thank TUBITAK National Observatory (TUG) and KFU for supports in using RTT150.

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