BD+48 873b - a brown dwarf companion candidate

NICOLAUS COPERNICUS UNIVERSITY IN TORUŃ

Jaros, R.[1], Niedzielski, A.[1], Wolszczan, A.[2], Villaver, E.[3,4].

[1]Institute of Astronomy, Nicolaus Copernicus University, ul. Gagarina 11, 87-100 Toruń, Poland, e-mail: jaros@doktorant.umk.pl

[2] Department of Astronomy and Astrophysics, Pennsylvania State University, 525 Davey Laboratory, University Park, PA 16802, USA

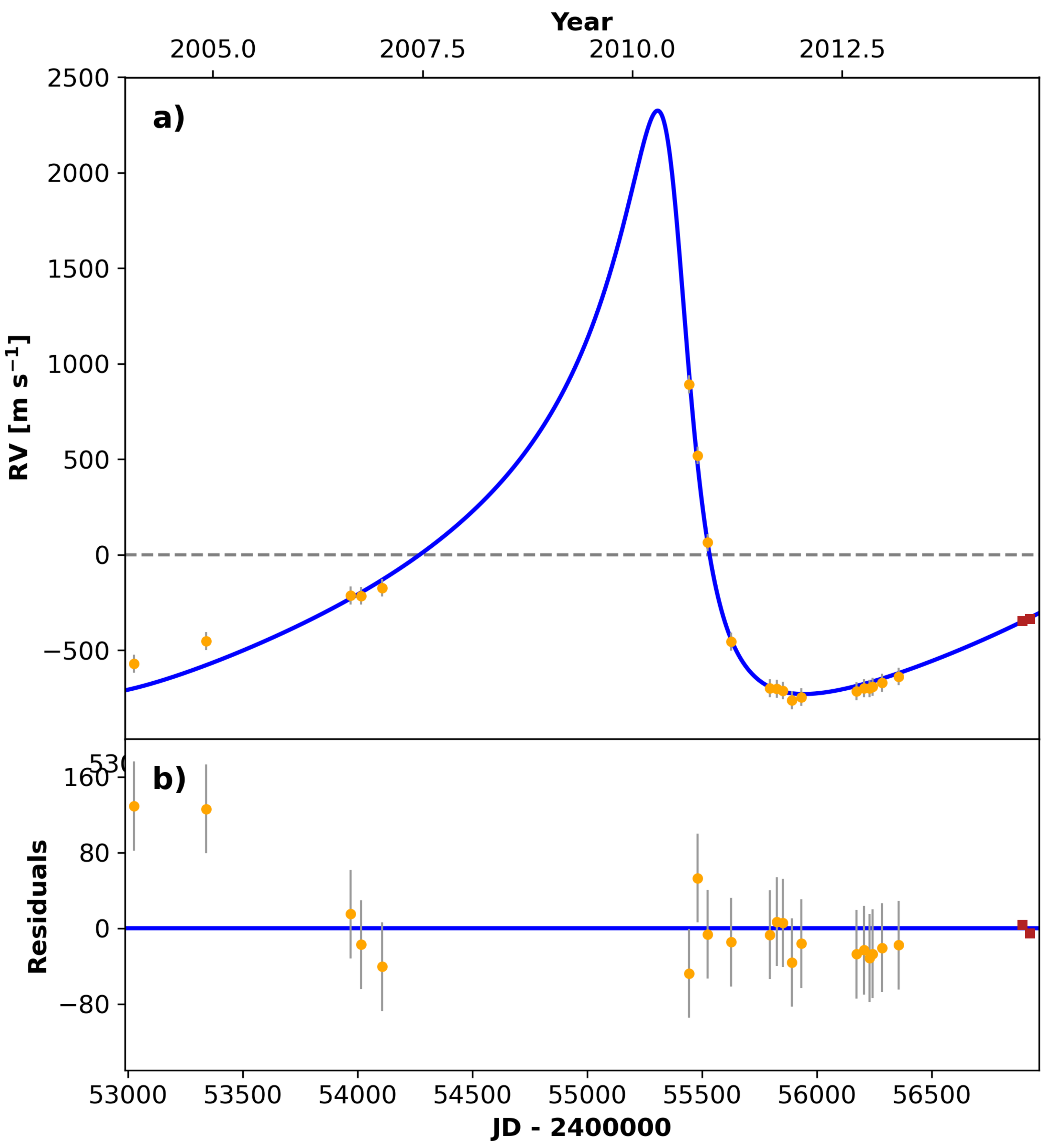
[3] Instituto de Astrofísica de Canarias, 38205 La Laguna, Tenerife, Spain

[4] Agencia Espacial Española (AEE), 41015 Sevilla, Spain

Introduction

Pennsylvania Toruń Planet Search (PTPS) project monitored about 1000 objects in the northern hemisphere sky. Focused mostly on evolved stars, the sample contains a wide range of stars at various evolutionary stages. Here, we present one of the detected potential brown dwarf candidates orbiting BD+48 873, a giant star in a 5 AU orbit, placing it at the edge of the brown dwarf desert. Radial velocity (RV) observations were mostly collected within the PTPS project, using the High-Resolution Spectrograph (HRS, Tull et al. 1998) at the Hobby-Eberly Telescope (HET, Ramsey et al. 1998) with later additional follow-up with HARPS-N spectrograph at Telescopio Nazionale Galileo. Keplerian orbital fit parameters were modeled and posterior parameters determined with the RadVel PYTHON package (Fulton, Petigura, Blunt & Sinukoff (2018)).

The star, observations, and the keplerian model



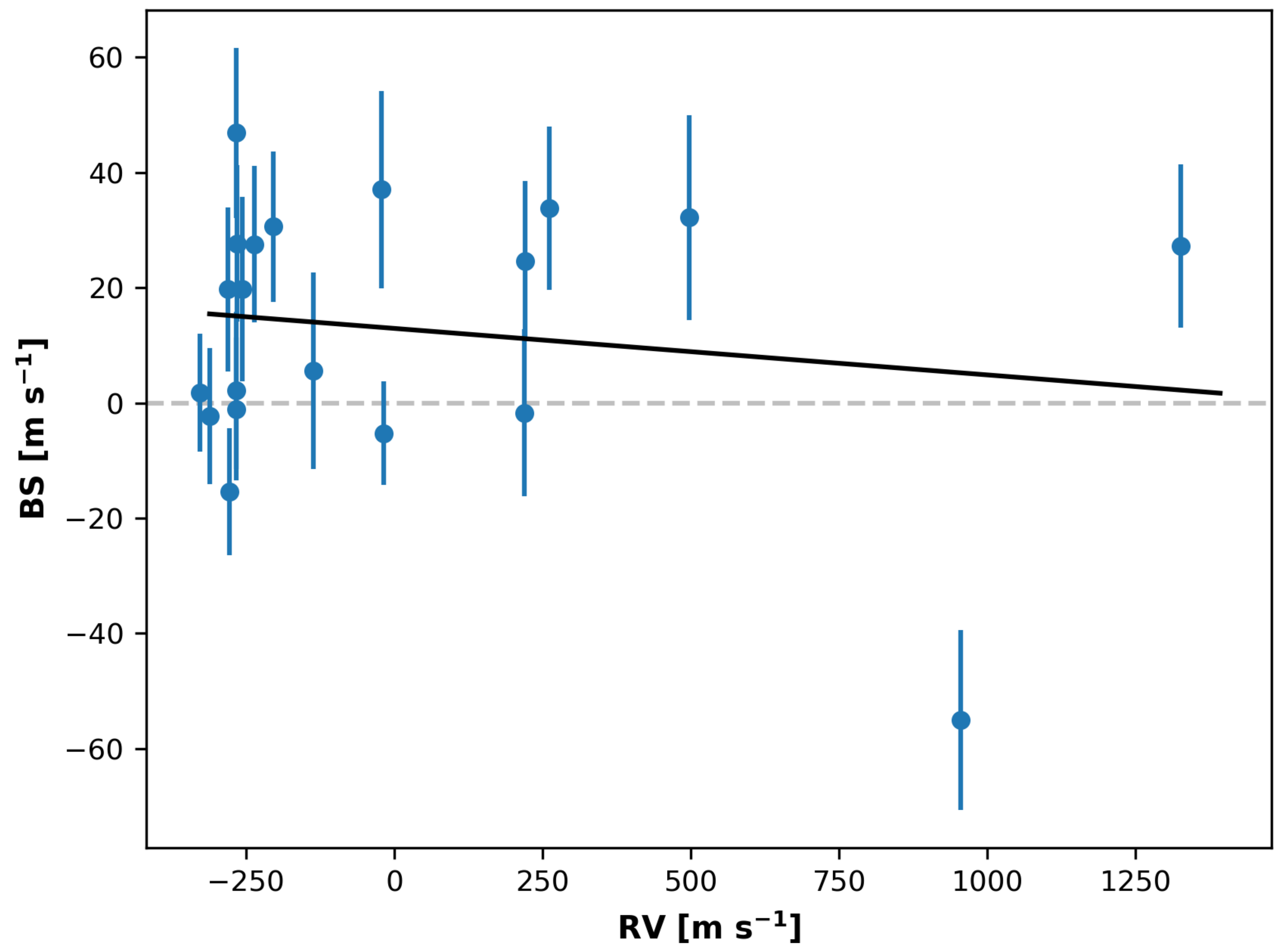
BD+48 873 is a T_{eff}= 4830± 10 and logg=2.70±0.03 [Fe/H]=-0.12±0.06 intermediate-mass giant star with $\log L/L_{\odot}$ = 1.81±0.16 and M= 1.65±0.21 It belongs to the sample of twelve BD candidates with minimum masses of m sin i < 100 M_J that have been identified in the PTPS sample (Niedzielski et al. 2013).

Through almost 9 years of spectroscopic observations, 22 epochs have been gathered in total with HET/HRS and two additional epochs with HARPS-N/TNG. Typical uncertainty of HET/HRS data is ~6 ms^{-1} and ~3 ms^{-1} in the case of HARPS-N/TNG.

These data show radial velocity amplitude of 1650 ms^{-1} which is >250 times the HET/HRS uncertainty, and a long-term variation.

We modeled these combined data with RadVel and obtained a keplerian orbit of 3686±83 days with a large eccentricity of 0.67±0.01 and semi-amplitude of 1052±43 ms^{-1}. The results are presented in the figure above. The upper panel (a) presents the timeseries of the collected data with modeled keplerian orbit. Yellow dots represent observations made by Hobby-Eberly Telescope. Red squares represent the follow-up observations made with HARPS-N. The lower panel (b) presents the radial velocity post-fit residuals showing the model fit quality.

Stellar activity



The figure presents the relation between spectral line bisector and radial velocity. Black line represents linear fit resulting in Pearson r coefficient at level of r=-0.008, showing that there is no corelation present. According to this we can assume that radial velocity signal is not caused by any surface phenomena on the host star.

Discussion

Parameter	Value
P [d]	3686±83
T_c [d]	55498.7±5.3
e	0.67±0.01
ω [rad]	0.86±0.03
K [ms^{-1}]	1052±43
msin i [M_J]	83±10
a [AU]	5.52±0.32
σ_{jitter} [ms^{-1}]	16.8±4.3

Presented posterior value results were acquired in the first stage by using the Keplerian model fitting through the likelihood function. The fit was optimized with *scipy* package function *optimize.minimize* for finding the local minimum using Powell's method. For second stage of analysis to extract posterior values and uncertainties, *emcee* package's Affine Invariant Markov chain Monte Carlo (MCMC) Ensemble sampler algorithm was used (Goodman, J. ; Weare, J. 2010).

From the current estimate of parameters, we can conclude that this object can be categorized as sitting at the edge of a brown dwarf desert. Within the estimated mass uncertainties, the object appears to be a brown dwarf. The Keplerian model presented is obviously based on a limited set of data points, not covering evenly the postulated orbit. This adds uncertainty to our detection. It is, therefore, important to collect more observation epochs, specifically around the peak of the RV signal, to straighten the case.

Acknowledgements

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