New radial velocity measurements for orbital parameter analysis of the gamma-ray binary HESS J0632+057

N. Matchett,[1] B. van Soelen,[1] R.O. Gray[2]

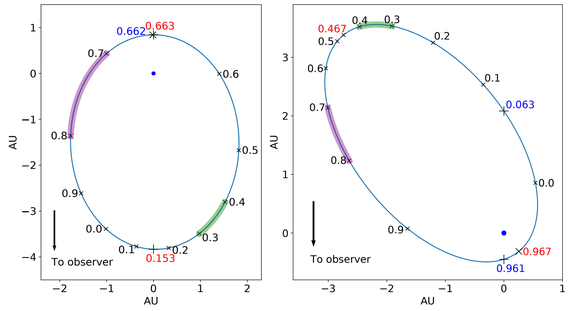
1. Department of Physics, University of the Free State, Bloemfontein, South Africa. 2. Department of Physics and Astronomy, Appalachian State University, Boone, North Carolina, United States of America

Introduction

Gamma-ray binaries are a small subclass (<10) of high-mass binary systems wherein the non-thermal emission peaks at energies greater than 1MeV. These systems consist of O/Oe or B/Be type stars and a compact object in the mass range of a neutron star or black hole [1,2].

The gamma-ray binary HESS J0632+057 consists of a Be type star and an unidentified compact object. The X-ray and TeV lightcurve shows two maxima, at orbital phases 0.3-0.4 and 0.7-0.8 [3]. In order to interpret the VHE emission, two incompatible orbital solutions were proposed by Casares et al. 2012 [4] – through radial velocity measurements of the absorption lines arising from the photosphere of the Be star – and Moritani et al. 2018 [5] – through radial velocity measurements of the wings of the Hα Balmer emission line. Moritani et al. suggested that the maxima in the VHE lightcurves could be attributed to the compact object passing through the circumstellar disc of the Be star.

In order to determine a clear solution for this system, independent radial velocity measurements of both the absorption and Balmer emission lines are being undertaken. We present the preliminary results.



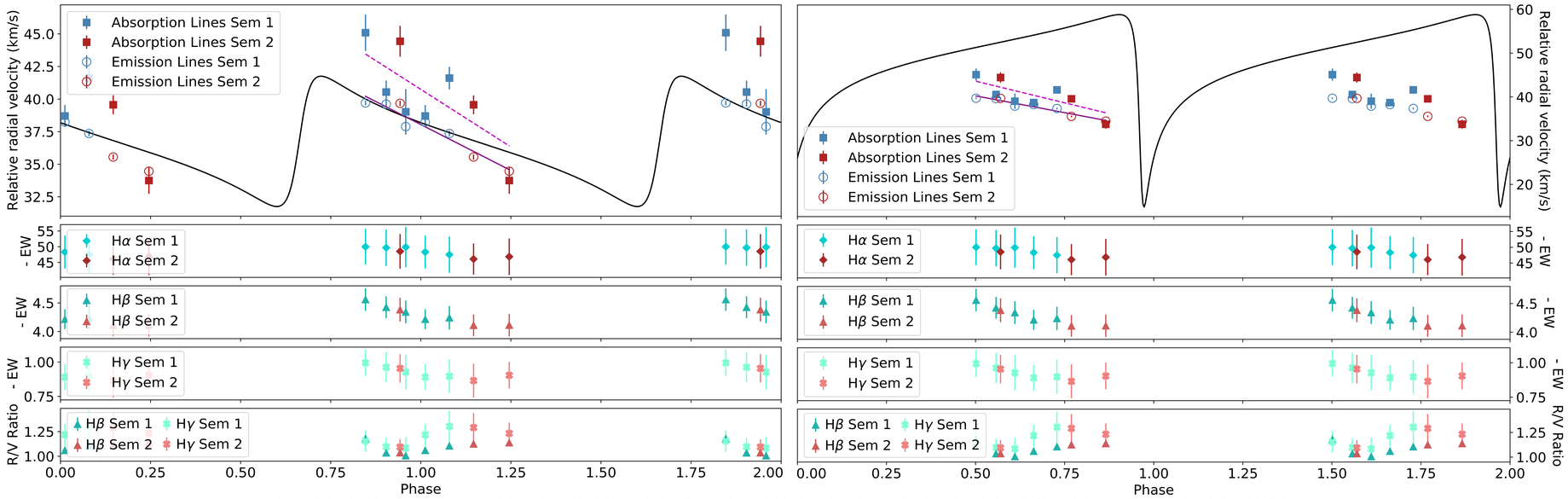
*The binary orbits for the Moritani et al. 2018 (**left**) and the Casares et al. 2012 (**right**) solutions. The phases where the maxima in the VHE occur are indicated by the **broad- green** and **purple** lines. The orbital phases for periastron and apastron are given in **red** and superior- and inferior-conjunction are given in **blue**.*

Analysis and Discussion

Spectroscopic observations have been undertaken with the High Resolution Spectrograph (HRS) [6] on the Southern African Large Telescope (SALT) [7] over two semesters. Eight echelle spectral observations were obtained between December 2020 and February 2022. The spectra were reduced and wavelength calibrated through the HRS-pipeline, and the 1D spectral orders were merged, normalized and corrected to the barycentre.

The radial velocities of the Hα, Hβ and Hγ emission lines were measured by fitting Voigt profiles to the wings of the emission profiles – emitted from the innermost region of the circumstellar disc. The radial velocities of He I (λ4120Å, λ4143Å, λ4387Å, λ4471Å, λ5047Å) and S II (λ4648Å) absorption lines were measured by cross-correlating against a median template in the rvsao.xcsao package. The radial velocity of the template has been measured using the emission lines. The average radial velocities of the absorption and emission lines are shown in the figure below.

The characteristics of the emission lines – the equivalent width (EW) and the ratio between the red and violet peaks (V/R) for the double peaked profile of the emission lines – was measured by a monte-carlo processs of integrating under the line profiles and fitting a double voigt profile – one for each peak, respectively. The preliminary results are shown in the figure below.



*The radial velocities, and the EW and the R/V ratio of the emission lines, phase-folded against the Moritani et al. solution (**left**) and the Casares et al. solution (**right**).*

We can see that the trend of the radial velocity data for both the emission and absorption lines is more consistent to the Moritani et al. solution, though further observations are required to fill in the missing orbital phases.

References

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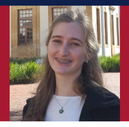

matchettn@ufs.ac.za | **www.ufs.ac.za**
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