Jet launching revealed in post-AGB binaries

D. Bollen, *H. Van Winckel, D. Kamath, O. De Marco*

Contact:
dylanbollendb@gmail.com

Background

Binary interaction processes are believed to induce the main shaping agent for asymmetric Planetary Nebulae (PNe). The interaction between the central stars results in outflows or jets, which are suggested to be the origin for the bipolar or asymmetric structures we observe in PNe [1].

Why study jet formation in post-AGB stars?

Probing the inner regions of PNe is difficult, which makes that the origin and launching mechanisms of the jets in PNe are poorly understood. In order to acquire more knowledge in these fundamental physical mechanisms, it is interesting to study post-AGB stars that also show the presence of a jet. We provide a quantitative analysis on the origin and properties of jet formation in post-AGB binaries.

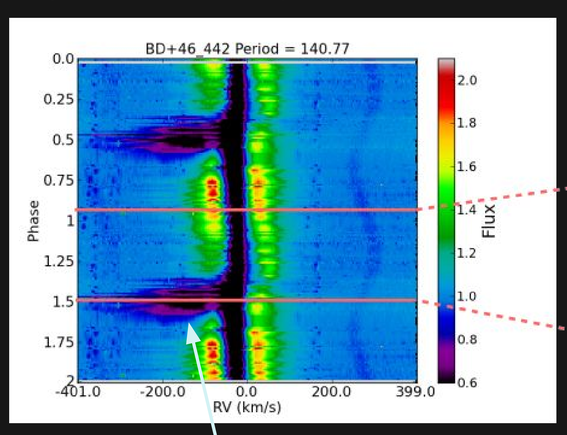
BD+46°442: a post-AGB binary

- F-giant
- Orbital period: P = 140.80 ± 0.03 d
- T_{eff} = 6250±250K
- Main-sequence companion
- Circumbinary Keplerian disk

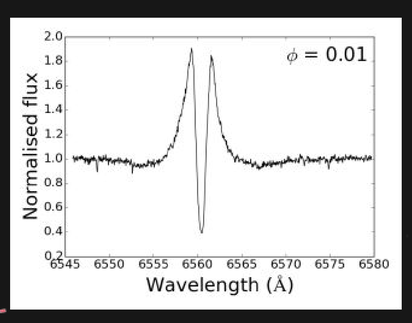
Time-series analysis

Dynamic spectra of H-alpha profile

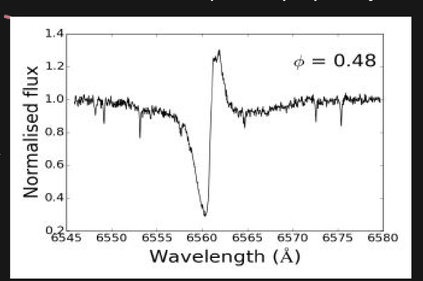
- Time-resolved spectroscopic monitoring with HERMES spectrograph.
- Orbital phase-dependent variations in H-alpha profile reveal the presence of the jet and circumcompanion accretion disk.



Double-peaked emission profile
➔ Accretion disk around companion



Pcygni-like profile
➔ Occultation of primary by the jet

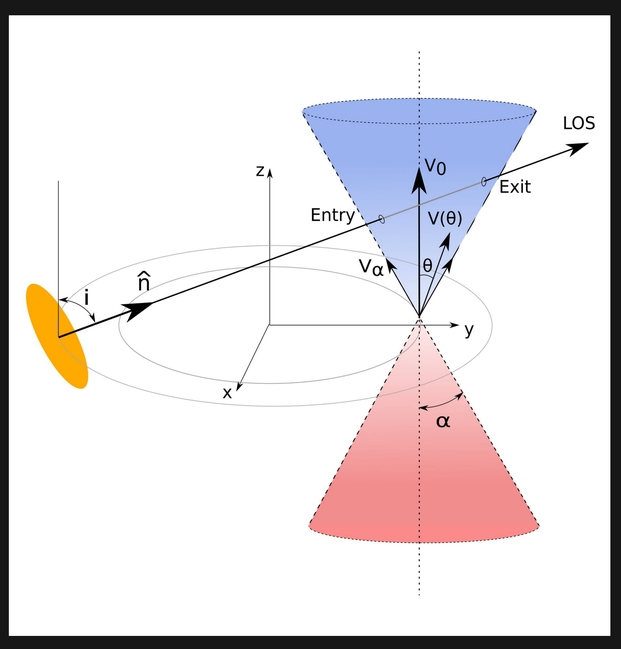


The observed blueshifted absorption wing is caused by the scattering of continuum photons by the H-gas in the high-velocity outflow or jet.

Photons scattered by H-atoms in jet → primary seen in absorption

Modelling the system

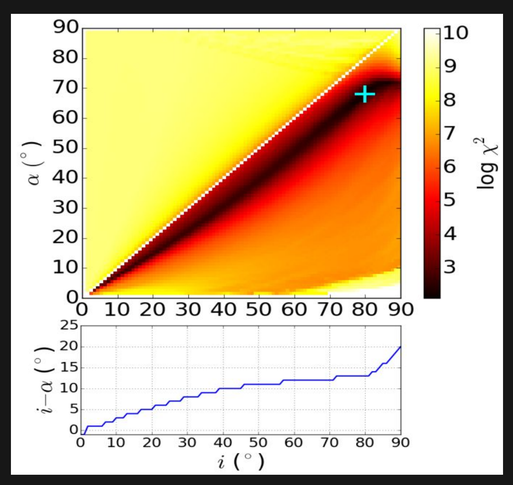
- We correlate the path length through the jet in the model with the amount of absorption by the jet (equivalent width of H-alpha profile).
- Free parameters:
  - Inclination *i*
  - Jet angle *α*



Results

Jet with wide opening angle

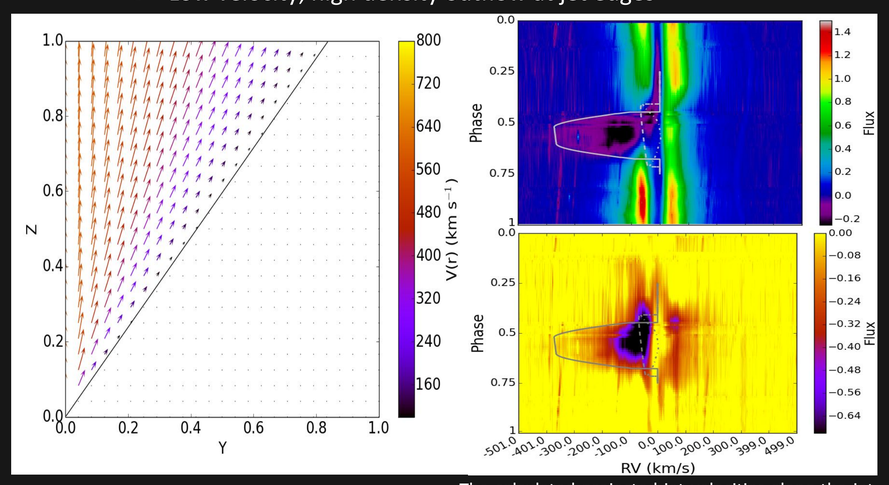
Strong correlation between inclination and jet angle



Chi-squared goodness of fit result for the inclination and jet angle.

Latitudinally dependent velocity profile in jet

➔ High velocity, low density outflow along jet axis (~ 600 km s^{-1})
➔ Low velocity, high density outflow at jet edges

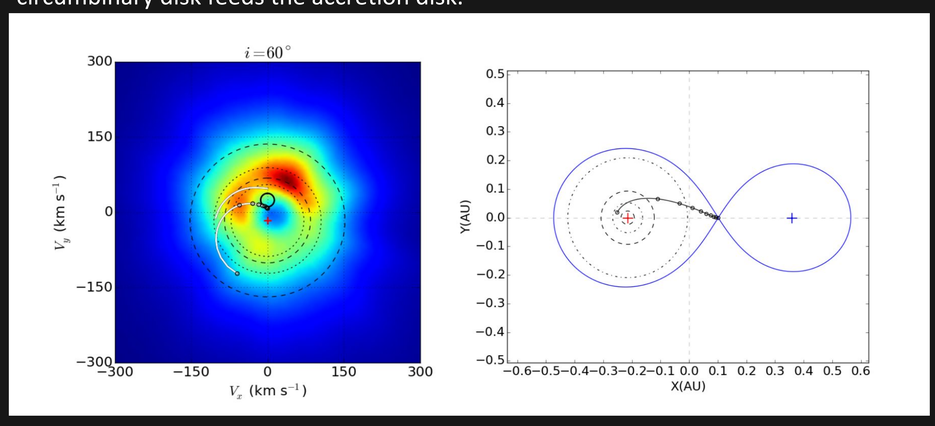


Velocity profile in the jet. The z-axis corresponds to the jet-axis.

The calculated projected jet velocities along the jet axis (full line) and jet edges (dashed lines) are plotted over the dynamic spectra. The lower figure only shows the absorption by the jet.

Hot spot in circumcompanion accretion disk

The emission peak in the Doppler map might reveal the presence of a hot spot at the location where a putative gas stream from the evolved component or the circumbinary disk feeds the accretion disk.

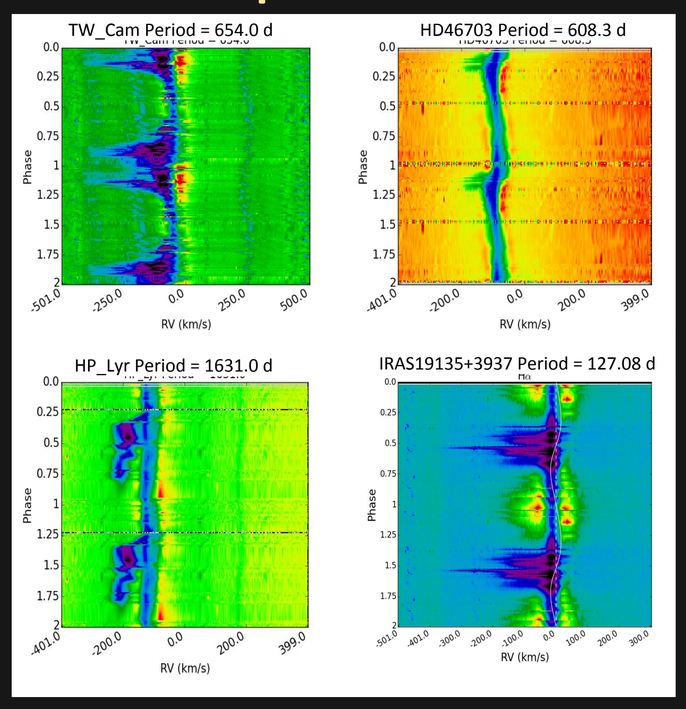


Doppler map of BD+46°442 in H-alpha, resolving the circumcompanion accretion disk in velocity space.

Accretion geometry of BD+46°442.

Jet formation is commonly observed in post-AGB binaries

We show that the mechanism of jet production is more commonly observed among post-AGB binaries [2,3,4]. Hence, these quantitative analyses of jets in the different post-AGB systems will allow us to study the jet formation mechanisms in a wide variety of conditions.



Conclusions

- Jet formation is a result of a binary interaction channel, in which the gaseous circumcompanion disk is the origin of the fast outflow.
- The jets are **not** strongly collimated but are rather wide with a latitudinally dependent velocity profile.
- Our current observations show that jet formation is also common in post-AGB binaries.

References

[1] De Marco, O. 2009, PASP, 121, 316
[2] Gorlova, N., Van Winckel, H., Gielen, C., et al. 2012, A&A, 542, A27
[3] Gorlova, N., Van Winckel, H., Vos, J., et al. 2014, ArXiv e-prints
[4] Witt, A. N., Vijh, U. P., Hobbs, L. M., et al. 2009, ApJ, 693, 1946