*Winds of Stars and Exoplanets*
*Proceedings IAU Symposium No. 370, 2023*
*A. A. Vidotto, L. Fossati & J. S. Vink, eds.*
doi:10.1017/S1743921322003477

# Signatures of wind formation in optical spectra of precursors of planetary nebulae

**Kārlis Puķītis and Laimons Začs**

Laser Center, Faculty of Physics, Mathematics, and Optometry, University of Latvia, Raiņa bulvāris 19, LV-1586 Rīga, Latvia

**Abstract.**
Generally it is thought that shaping of planetary nebula from initially spherical envelope of asymptotic giant branch stars into non-spherical morphologies is a consequence of binary interactions. However, post asymptotic giant branch stars HD 235858 and HD 161796 seem to be at odds with this idea and perhaps the non-spherical nebulae surrounding them arose from intrinsic change in the nature of the stellar wind which is poorly understood for this evolutionary phase. Spectroscopic monitoring of these two stars has revealed signatures in the spectra that point to variable outflow. This indicates the prospect of spectroscopic monitoring to advance the knowledge of wind launching mechanism in post asymptotic giant branch stars and other dynamical processes in their extended atmospheres.

**Keywords.** stars: AGB and post-AGB, stars: atmospheres, stars: winds, outflows, stars: individual (HD 235858, HD 161796)

## 1. Introduction

The role of different processes in shaping of planetary nebula (PN) around post-asymptotic giant branch (post-AGB) stars is not fully understood. It is known that formation of PN begins in AGB stage when intense stellar winds expel outer layers of the star. Virtually all AGB stars are observed to have spherically symmetric wind-created envelopes; however, only around 20% of PN are found with such symmetry with the rest showing mostly elliptical or bipolar morphologies. It is known that the rapid transition to non-spherical morphology and a change in the nature of stellar wind occurs near the end of AGB and beginning of post-AGB phases. Recently, binary interactions have been thought of as the main shapers of PN; however, cases of non-spherical envelopes around unlikely binaries are known. It is possible that an intrinsic change in the nature of stellar wind during the post-AGB phase plays an important role in the formation of the PN. While there is poor knowledge of wind launching mechanism in post-AGB stage, it is more or less understood in AGB stars with the current paradigm being that molecule interaction with shock waves in the extended atmosphere produce dust grains which, by the pressure of stellar radiation, drive the stellar wind.

## 2. Observations and analysis

We have carried out spectroscopic monitoring of HD 235858 and HD 161796. Former is a carbon rich G type star and the latter - oxygen rich F type star. Both are pulsationally variable post-AGB supergiants in early stage - they are relatively cool and likely to have winds that share similarities with the ones operating in AGB stars. Both have aspherical wind-created envelopes; however, there is no evidence for binarity. It was neither revealed

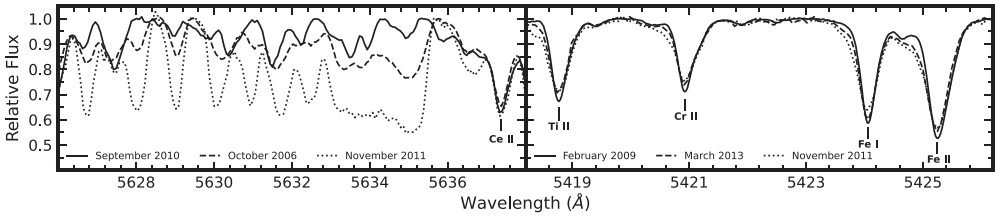


**Figure 1.** Left panel: intensity changes in the spectra of HD 235858 blueward of 5636 $\mathring{A}$ ($C_2$ Swan system bandhead). Right panel: typical variation of absorption lines in HD 161796.

in long term radial velocity monitoring (Hrivnak et al. 2017) nor latest Gaia data seems to support it (Parthasarathy 2022).

For HD 235858 time-domain spectroscopic observations have revealed pulsation induced cool outflow (Začs et al. 2016). This was inferred from intensity variations of blueshifted $C_2$ Swan system and CN Red system absorption lines, although such molecular features of significant strength are not normally expected in G type stellar spectrum.

In case of HD 161796 spectra acquired at multiple epochs point to an variable outflow of warm matter from the stellar surface (Puķītis et al. 2022). This follows from the specific variation of absorption line profiles - blue wings are variable, most often being extended while red wings remain virtually unchanged. Such variation is seen for both atomic and ionic lines, and for both low- and high-excitation lines of different chemical elements. Additionally, the specific shape of H$\alpha$ profile in HD 161796 - variable narrow central absorption dip showing emission components which is superposed on a normal broad absorption without any significant variation - as interpreted by Sánchez Contreras et al. (2008), is a consequence of incipient mass loss and therefore support the conclusion of an outflow from HD 161796. For both stars splitting of intense absorption lines can be observed which is a manifestation of shocks which, in turn, are an integral part of wind launching for related stars.

## 3. Prospects

Spectroscopic monitoring of these and other similar post-AGB stars has a potential to advance the knowledge of stellar wind in this evolutionary phase and to uncover variety of dynamical processes in the atmospheres of such objects. The latter is corroborated by the study of Začs & Puķītis (2021) in which, based on interday variability of molecular and low-excitation metallic lines, it was shown that the star experienced an episode of infall of matter. Recently we have embarked on spectroscopic monitoring of HD 235858 and other similar objects in the near-infrared. Additional spectral lines of different species and excitation energies including bands of the abundant CO molecule will allow to probe dynamic phenomena over larger range of depths of the extended atmospheres of post-AGB stars.

## References

Hrivnak, B. J., Van de Steene, G., Van Winckel, H., et al. 2017, ApJ, 846, 96
Parthasarathy, M. 2022, RNAAS, 6, 33
Puķītis, K., Začs, L., & Grankina, A. 2022, ApJ, 928, 29
Sánchez Contreras, C., Sahai, R., Gil de Paz, A., et al. 2008, ApJS, 179, 166
Začs, L., Musaev, F., Kaminsky, B., et al. 2016, ApJ, 816, 3
Začs, L. & Puķītis, K. 2021, ApJ, 920, 17

https://doi.org/10.1017/S1743921322003477 Published online by Cambridge University Press