

WHTZ 1: A high excitation Planetary Nebula not a gaseous cocoon from runaway star HD 185806

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ABSTRACT

We present evidence that the nebular cocoon and bow-shock emission nebula putatively and recently reported as deriving from the 9th magnitude "runaway" star HD 185806 is the previously discovered but obscure planetary nebula WHTZ 1 (Ra 7). It has a Gaia DR3 G~16 blue ionizing star at its geometric centre. We present imagery, spectroscopy, other data and arguments to support that this emission source is a high excitation Planetary Nebula not a stellar wind bow shock.

Key words: planetary nebulae: general – techniques: imaging – techniques: spectroscopic – Astronomical data bases: catalogues

1 INTRODUCTION

Miss-identification, false discoveries and re-assignments of celestial objects from one class to another are common as new knowledge and data of higher resolution, sensitivity and wavelength coverage become available. The field of Planetary Nebula (PN) research, history is littered with many examples of objects that have been re-discovered and re-identified as PNe only to later be re-classified as one of the many PN mimics that exist (such as HII regions, Wolf-Rayet shells, Herbig-Haro nebulae, YSO's, reflection nebulae, supernova remnants, nova shells etc). See Frew & Parker (2010) and the recent review by Parker (2022) for further details. Refer also to Ritter et al. (2021) for a PN candidate, Pa 30, re-classified recently as a supernova remnant of the Chinese "guest star" of 1181 AD.

It is much rarer to find examples where a previously reported PN candidate is later ascribed to another source type but then needs to be moved back to its original classification.

One recent case concerns the discovery (*sic*) of a nebula cocoon reported as deriving from runaway star HD 185806 (Spetsieri et al. 2022). The star is a long period variable also designated as V 1279 Aql, where the variability is due to pulsation not binarity (e.g. Smak 1966). We present on-record historical context that shows that the adjacent uncovered gaseous emission region is the previously discovered source WHTZ 1 and observational evidence to re-assign this source back to its original PN status.

1.1 Historical context

The nebulosity was first noticed as a faint emission region on photographic B-band imagery from the POSS-I survey by Weinberger et al. (1999) and given the name WHTZ 1. It was found as a serendipitous by-product when looking for hidden galaxies behind the Milky way. They identified it as a PN candidate with a morphology "typical" of many PNe and with a blue central star (CSPN). The source was never incorporated into the SIMBAD astronomical database (Wenger et al. 2000) at CDS, Strasbourg.

The object was independently "re-found" by French PN amateur astronomer Thierry Raffaelli in 2014 and called "Ra 7" where it was added to the dedicated on-line database created to record and present their work¹ and see Le Dû et al. (in press). The object appears as "Ra 7" in SIMBAD. It was also re-discovered by the Deep Sky Hunters team led by Matthias Kronberger and Dana Patchick (e.g. Kronberger et al. 2016), based in part on assessments of its WISE MIR imagery (Wright et al. 2010). It was ingested into the "HASH" database² as a likely PN in 2015, with unique HASH ID 4418. HASH is the current "gold standard" consolidated on-line catalogue of all known PN in our Galaxy and Magellanic clouds (Parker et al. 2016) having evolved from the previous "MASH" surveys, Parker et al. (2006), Miszalski et al. (2008).

It has also been reported in several editions of the French popular "L'Astronomie" magazine in February 2015, vol. 129, No. 80, p.42³; February 2016, vol. 130, No. 91, p.26⁴ and finally Le Dû (2017).

¹ http://planetarynebulae.net/EN/page_np.php?id=237

² <http://hashpn.space/>

³ <https://ui.adsabs.harvard.edu/abs/2015LAAstr..129b..42A/>

⁴ <https://ui.adsabs.harvard.edu/abs/2016LAAstr..130b..26A/>

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The source has now re-appeared in the literature as a bow-shock cocoon nebula of star HD 185806 in [Spetsieri et al. \(2022\)](#).

2 METHODS AND OBSERVATIONS

We provide accumulated multi-wavelength imagery, new optical spectroscopy, identification of the actual ionising star, associated data, salient characteristics and other evidence to confirm the source as a "True" high excitation PN following the precepts outlined in [Frew & Parker \(2010\)](#) and [Parker \(2022\)](#). The star HD 185806 is merely a chance, closely projected neighbour that is unrelated to the actual emission observed.

2.1 More recent deep amateur narrow-band imagery

Deep, narrow-band, optical imagery of the candidate PN was taken with the Chart32 "Chilean advanced robotic 32inch telescope" in 2017. The resultant 10×8 arcmin RGB composite narrow-band image is shown in Fig 1, taken directly from the Chart32 open-access website: www.chart32.de. This colour image can be directly compared to Figs. 1,2 & 3 in [Spetsieri et al. \(2022\)](#).

The Chart32 RGB colour image was formed from co-adding narrow-band H α images (bandpass 30Å) of 280 minutes total duration (red channel), [OIII] images of 360 minutes total duration (green channel) and then 3 broad-band Astrodon Gen2 RGB filter images (blue channel) for a total of 100 min each respectively. This gave a total on-source exposure time of 15.7 hours. The typical seeing was reported as 0.8-1.2 arcseconds and the data were acquired with an 81cm f/7 Astrooptik Keller Cassegrain telescope with the images processed by Johannes Schedler of the Chart32 team.

In Fig 2 we also show the 5×5 arcmin Chart32 H α image to show H α emission is present. The overall form of the stronger signal seen in [OIII] is there but is somewhat less distinct in character.

The main body of the WHTZ 1 nebula is oval in shape with a major axis ~193 arcseconds across and a minor axis of ~134 arcseconds. The opposing edges across the minor axes have enhanced intensity and there are internal striations approximately perpendicular to these edges. There is a CSPN located almost exactly at the geometric centre of the nebula, like many typical PNe of elliptical morphology.

We have supplemented these data with very deep narrow-band H α imaging⁵. A combined total of 40 hours and 25 mins H α imaging were combined from observations on August 17th and September 8,9,10,13,15,16th 2022 using two separate automated telescopes in the UK (Celestron C14 EdgeHD telescope with ZWO ADI6200MM Pro camera and a Chroma H α 3 nm bandpass filter for 13 hours and 10 mins observations) and Spain (Twin APM LZOS 152/1200 telescopes with QSI6120 cameras and an Astrodon H α 3 nm bandpass filter for 27 hours and 15mins of observations). In Fig 3 we present the resultant contrast enhanced 20×16 arcmin H α image of WHTZ1 (stars removed for clarity) obtained over these ~40 hours of combined imagery. A faint outer halo can be discerned which is ~10 arcmins across the major axis. Such an extensive, faint halo is difficult to reconcile with any bow-shock scenario.

Deep amateur narrow-band exposures of PN and PN candidates are now providing highly competitive imagery, matching, and in many cases exceeding, the best professional efforts previously available ([Parker 2022](#)).

2.2 Mid Infrared Imagery

In Fig. 4 we show a 9×9 arcmin WISE W4 22 μ m ([Wright et al. 2010](#)) image for WHTZ 1 and HD 185806. The well defined emission region is prominent and has two thick, opposing arc-like structures that follow the enhanced [OIII] edges seen in the optical. The interior is of much lower intensity suggesting a cavity. The Northern MIR emission arc is more prominent. The nebula can also be seen in the W3 12 μ m image, contrary to what was reported by [Spetsieri et al. \(2022\)](#). Annotation indicates the faint MIR emission of the outer oval nebula to the SE and NW reflecting what is also seen in the optical. This compact 3×2 arcmin MIR emission region is isolated. The proper motion vector for HD 185806 (see later) is added, taken from Gaia DR3 data for this star, e.g. [Gaia Collaboration et al. \(2016\)](#). The prominence of HD 185806 in the MIR is also clear.

2.3 Optical Spectroscopy

No low resolution spectroscopy of the nebula was presented by [Spetsieri et al. \(2022\)](#) who obtained high resolution echelle spectroscopy that covered the H α + [NII] lines and [OIII] in two separate spectral windows. These were taken in Mexico with the 2.1 m San Pedro Martir Telescope and Manchester Echelle spectrograph in November 2014. This was supplemented by high dispersion spectra of HD 185806 on the 1.2 m Mercator telescope on La Palma, Canary Islands in July 2021 using the HERMES instrument, confirming it as an M 4 late type star.

We present in Fig. 5 new, low-resolution, optical spectra of the nebula taken with the 2SPOT⁶ Ritchey-Chrétien RC12 12-inch telescope in Chile equipped with the very stable Alpy 600 spectrograph from Shelyak Instruments (resolution 600). The final 1-D spectrum was obtained after combining 5×1200 second exposures from the 12th and 10×1200 second exposures from 15th September 2022. Not only are the [OIII] optical emission lines visible but clearly so is the high excitation He II line at 4686Å. In the red the H α can be seen but is not strong compared to [OIII]. The residual Sodium D (Na D) line is from the night sky. The 2-D spectral images were reduced following the standard pipeline describe in Le Dû et al. (in press). The presence of He II indicates a high excitation nebula. This would be an unprecedented detection for any optical bow-shock, e.g. see [Hartigan \(1999\)](#) for attempts at such detection.

2.4 Proper motion arguments

Gaia ([Gaia Collaboration et al. 2016](#)) DR3 data have now provided reliable proper motion and parallax data for both HD 185806 and the CSPN. This provides the opportunity to examine the proper motion vectors of these stars with respect to the nebula. As has been shown by [Peri et al. \(2012\)](#) with a MIR selected sample of bow-shock candidates, the earlier Hipparchus proper motion vectors of the stars are well aligned with their bow-shocks, i.e. they generally point in the direction of the bow-shock. For HD 185806 no Gaia proper motion vector data were provided by [Spetsieri et al. \(2022\)](#), nor overlaid on their figures. The proper motion vector is added in Fig 4 which points almost directly South and is not aligned with the major symmetry axis of the nebula but is offset by ~50 degrees.

⁵ see <https://www.imagingdeepspace.com/observatories.html>

⁶ for details on the 2SPOT amateur spectroscopy consortium see: <https://2spot.org/EN/>

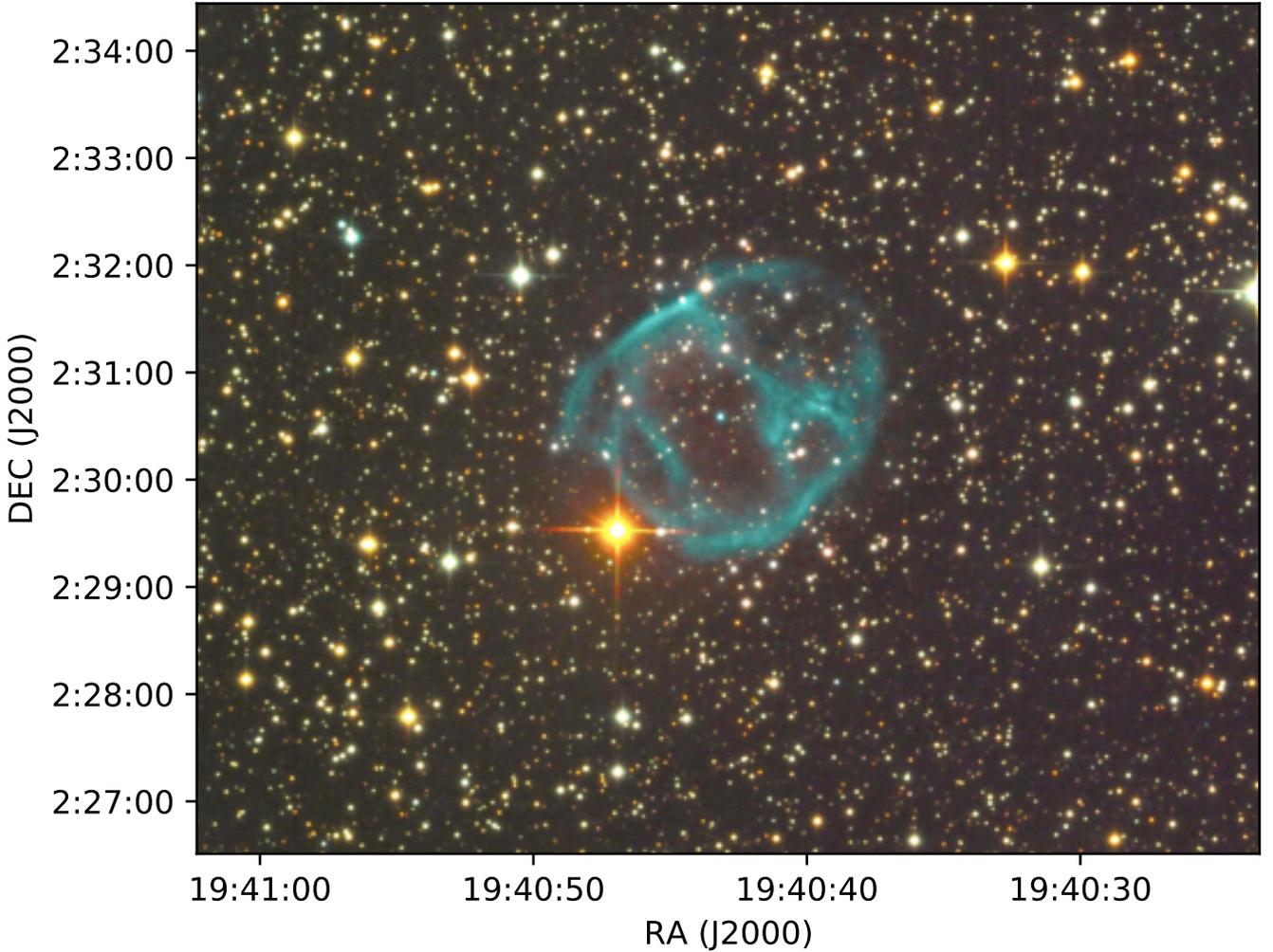


Figure 1. Combined 10×8 arcmin narrow-band (30\AA) image of WHTZ 1 comprising combined $H\alpha$ images of 280 minutes (red-channel), combined [OIII] images of 360 minutes (green channel) and then 3 broad-band Astrodon Gen2 RGB filter images for 100 min each respectively (blue channel). This gave a total on-source exposure time of 15.7 hours. In the figure North is up and East to the left. The typical seeing was reported as 0.8-1.2 arcseconds. The blue CSPN is clear at the nebula's geometric centre.

3 BROADER GEOMETRIC CONSIDERATIONS

Visual inspection of the available, deep, narrow band imagery indicates the proposed blue CSPN is the actual ionising source for the nebula. It is located within 5 arcseconds of the intersection of the major and minor axis best fit by eye to the nebula's overall oval shape as would be expected for any true CSPN. This is also the case for the WISE MIR imagery where the optical enhancements on the NE and SW sides are reflected in a two component but uneven MIR intensity arc structure and hollow interior in the $22\mu\text{m}$ band-4 WISE data where the CSPN resides. The 9×9 arcmin band-4 WISE image in Fig 4 is dominated by HD 185806. This makes it difficult to assess the MIR emission component from the nebula as it is so close to the bright star, at least in a projected sense. Apart from the compact WISE nebula there is no other obvious MIR emission across the 9×9 arcmin field shown. Contour fits (as also done by Spetsieri et al. 2022) can give a false impression of the actual nebula emission close to such a bright star so examination of the MIR imagery itself is needed. There is a hint of W4 WISE emission beyond the star to the

SE. We believe this shows the faint nebula extension expected here, assuming it reflects the faint outer envelope of the oval nebula seen to the NW in the optical and MIR imagery.

A further piece of contrary evidence to a bow-shock interpretation can be seen in Fig. 3 of Spetsieri et al. (2022) where, at the extreme Northern corner of the [OIII] emission mosaic, there appears to be a faint emission arc parallel to the enhanced Northern edge of the main nebula but 3 arcminutes away from the CSPN. This could be [OIII] emission associated with a possible AGB halo of the PN given its geometry and alignment. In Fig 3 we show that indeed there is a faint outer 10 arcmin dimension halo visible, in this case in $H\alpha$.

3.1 The bow-shock interpretation

Bow-shocks can form both around hot, young stars where strong stellar winds slam into the surrounding interstellar medium or more commonly where runaway typically O/B stars are ploughing into a dense ISM. Examination of the best extant image examples of bow-shocks around mostly runaway stars have little in common with the

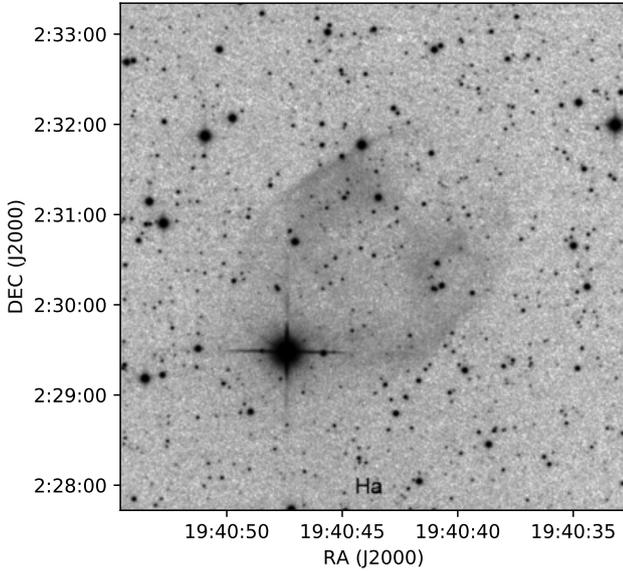


Figure 2. Chart32 $H\alpha$ 5×5 arcmin image for WHTZ 1 showing that the $H\alpha$ closely follows that of the [OIII] but is fainter and less distinct in character for the equivalent exposure time. North is up and East to the left.

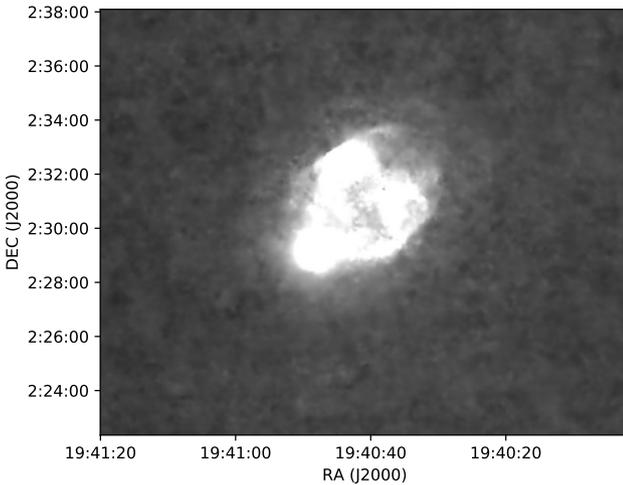


Figure 3. Large area, contrast enhanced, deep $H\alpha$ 20×16 arcmin image for WHTZ 1, with stars removed for clarity. Clear evidence of a faint $\sim 10\times 7$ arcmin $H\alpha$ halo is seen surrounding the main nebula. North is up and East to the left. The image derives from 40 hours and 25 mins of combined narrow-band exposures.

observed nebular features seen here. See the compilations, discoveries and imagery reported by [Peri et al. \(2012\)](#) and later by [Kobulnicky et al. \(2016\)](#) and [Kobulnicky et al. \(2017\)](#). These show major, new samples of Galactic candidate stellar bow shocks found on Spitzer and WISE MIR data for runaway stars. All 244 examples listed by [Peri et al. \(2012\)](#) were from O and B type stars and no M-type stars, like HD 185806, were found in their entire sample. However, [Cox et al. \(2012\)](#) provide a catalogue of “wind-ISM” bow shocks and “wind-wind” interactions detected around AGB stars but only as seen in the far infrared with Herschel/PACSs imagery ([Pilbratt 2001](#)) and not at these shorter wavelengths.

Most bow-shocks exhibit very open angles on the forward curve

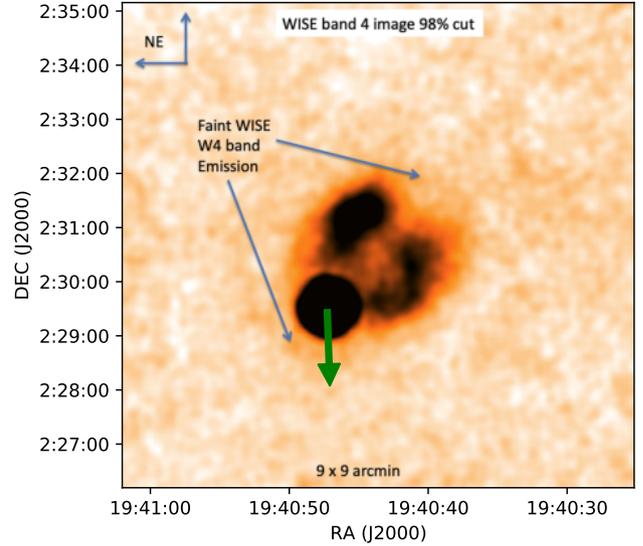


Figure 4. A 9×9 arcmin WISE W4 $22\mu\text{m}$ image for WHTZ 1 and HD 185806. It shows the main opposing arc like structures and hollow interior. Annotation indicates the faint MIR emission of the outer oval nebula to the SE and NW reflecting what is also seen in the optical. The green arrow marks the almost directly Southern direction of the Gaia proper motion vector for HD 185806.

and are well separated and in front of the associated star. The only example found that even remotely resembles the case here is associated with the binary star BZ Cam but the prominent striations seen are lacking in that case and there is a prominent, if faint, more forward bow-shock too.

The 3 main arguments to support a bow-shock interpretation made by [Spetsieri et al. \(2022\)](#) while seemingly plausible, lack firm observational evidence and are more descriptive than numerical. The claim of a bow-shock structure being “clearly depicted” in the WISE imagery is based on contour fits to the WISE w4 $22\mu\text{m}$ data that are affected by the intensity and close proximity of HD 185806 in the MIR. Close examination of the actual MIR imagery does not bear this out while they themselves admit to no evidence of a bow shock in the optical band as might be expected. They multiply claim that HD 185806 is “surrounded” by the nebula when there is clearly almost no projected overlap between the star and the main body of the nebula region.

The star HD 185806 is not aligned with the major axis of the fitted ellipse that best describes the nebula but is ~ 15 degrees off, while the star itself is also located ~ 1.5 arcmin to the SE of the nebula centre. The expected faint SE extension of the nebula to match that seen to the NW is largely obscured by the brightness of HD 185806 but can just be discerned at the edges. The Gaia proper motion vector is poorly aligned with the major axis of the nebula.

4 DISTANCE ESTIMATES AND KINEMATIC AGE FOR THE NEBULA

PN WHTZ 1 was included in the calculated Surface Brightness radius (SB-r) relation PN distances paper of [Frew et al. \(2016\)](#) as entry 307. The published distance from this robust PN statistical distance indicator is 2.49 ± 0.71 kpc. This compares with a Gaia DR3 parallax based distance for the assumed CSPN of 1.83 kpc ([Bailer-Jones et al. 2021](#)). This just agrees to within the admittedly large 20-30%

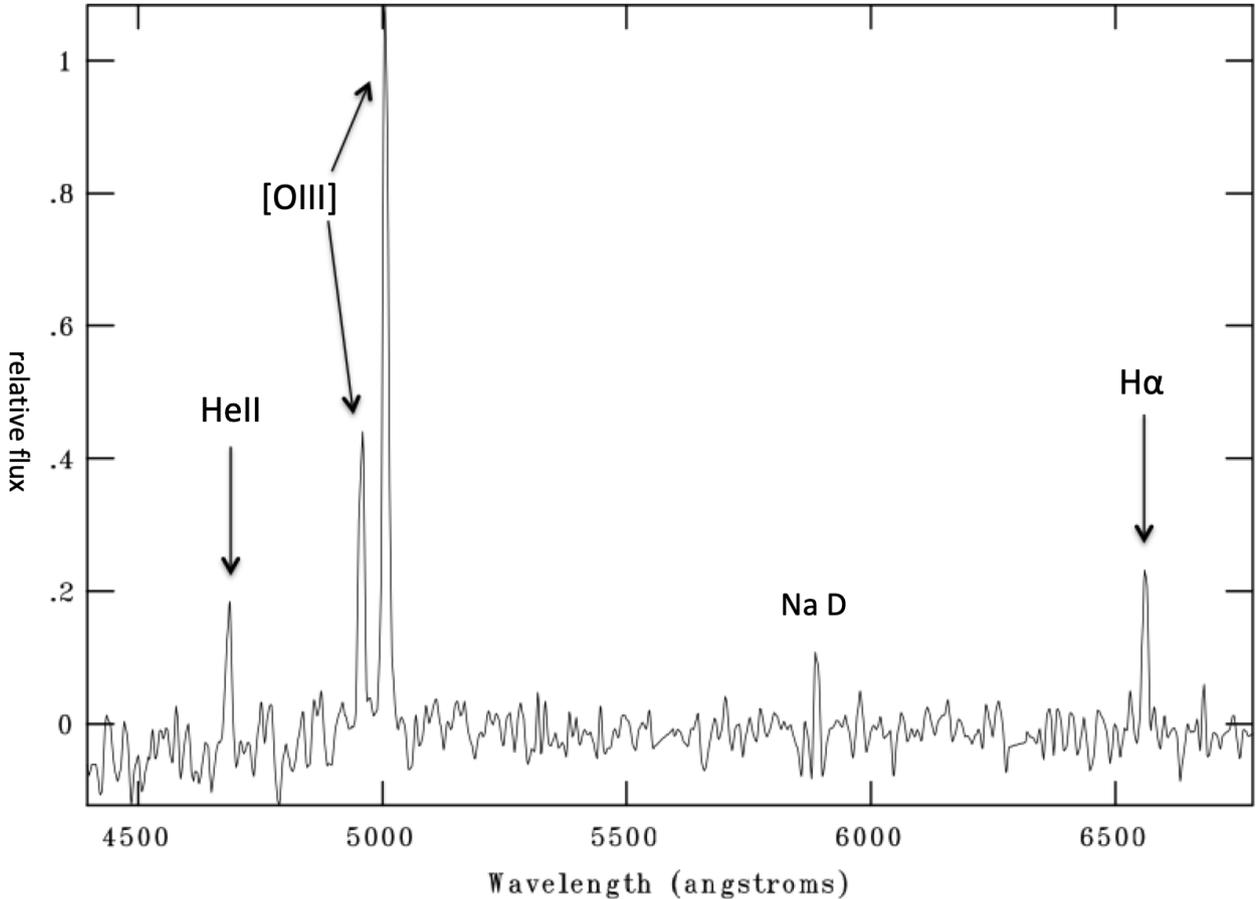


Figure 5. Low resolution 1-D optical spectra of WHTZ 1 taken with the dedicated 2SPOT System in Chile. The [OIII] and high excitation He II 4686Å emission lines are seen in the blue, indicating it is a high excitation PN. Weaker H α is evident in the red. The not fully cancelled bright Sodium-D night sky emission line is also indicated.

errors typically reported for the SB-r technique so the PN and CSPN distances are compatible. The robust Gaia distance for HD 185806 is 910 pc (Bailer-Jones et al. 2021).

The expansion velocity of the gas inferred from the data reported by Spetsieri et al. (2022) is taken as $\sim 57 \pm 10 \text{ km s}^{-1}$ based on an average of the positive and negative velocity components reported at multiple points across the nebula and from the H α , [NII] and [OIII] emission lines sampled. This is in the accepted range for a PN. Assuming this has been effectively constant since the envelope ejection from the progenitor star that created the PN and taking the physical size of the PN to be $1.7 \times 1.2 \text{ pc}$, as estimated by taking the PN angular size in radians and the Gaia DR3 distance for the assumed CSPN of 1.8 kpc, yields a kinematic age of the nebula of $\sim 25,000$ years (see Tab. 1). This is within the range of PN kinematic ages, if at the higher end, but certainly not without precedent for such a faint and evolved PN (Fragkou et al. 2022).

5 DUST AND EXTINCTION IN THE LOCAL ENVIRONMENT

The WISE data shows there is no further MIR emission in a large 9×9 arcmin area around WHTZ 1 - it is an isolated 3×2 arcmin MIR emission region. Even on one degree scales there is very little MIR emission at this Galactic location and what there is is extremely

faint and very diffuse. Likewise, the Schlegel, Finkbeiner and Davis dust maps (Schlegel et al. 1998) show little dust in this zone while the large-scale SHASSA (Gaustad et al. 2001) H α gaseous emission maps show no significant ionised regions in the vicinity. This is not surprising given the nebula is 10 degrees latitude above the Galactic mid-plane. The ISM is not significant here and the extinction is assumed modest.

The 3D dust map by Green et al. (2019) gives a low E(B-V) value of 0.33, quantitatively confirming the impressions of a relatively low extinction environment. This explains why the [OIII] narrow-band images and spectroscopic emission lines are strong as these data are not significantly extinguished. In low extinction environments the [OIII] lines can be much stronger than H α emission in PNe. This is seen in many higher Galactic latitude examples such as Abell 78 and as is the case for this emission object.

6 COROLLARIES WITH OTHER KNOWN PNE

The morphological structure of the nebula is typical of many elliptical shaped PNe. There are many known PN corollaries, including a recently discovered PN found by the French Amateur group, StDr 47 (HASH ID 32596), LTNF 1 (HASH ID 677) reported by Liebert et al. (1995), Kn 121 (HASH ID 23344) and Abell 36 (HASH ID 988) where all their positions, sizes, imagery etc can be located.

Deep, narrow band amateur imagery of all of these PNe corollaries can also be found here: <https://www.imagingdeepspace.com/peter-goodhew-planetary-nebulae-images.html>.

These PNe share many of the features of WHTZ 1. They have an elliptical morphology, enhanced opposing edges, similar internal structure, a faint blue CSPN at the geometric centre and even, in the cases of StDr 47 and Kn 121, unrelated nearby bright stars. Two examples are shown for comparison purposes in Fig 6 and are extracted from deep narrow-band H α and [OIII] amateur images⁷. There are many examples of PNe being in close projected proximity to unrelated bright stars as might be expected given the majority of PNe are located in the Galactic plane. Perhaps the best known example is Abell 12 the so-called "hidden planetary", a small PN in the constellation of Orion heavily obscured by the glare of 4th magnitude star Mu Orionis in the optical but nicely seen in the WISE MIR imagery.

7 SUMMARY OF OBSERVED PROPERTIES AND ASSESSMENT

We provide below the main accumulated arguments against the bow-shock interpretation and supporting the PN nature of the observed nebula emission.

7.1 Arguments against the bow-shock scenario

A brief summary of points concerning the bow-shock interpretation are as follows:

- The morphology of the nebula is unlike other extant examples in the literature of bow-shock nebulae in the optical
- The host star is not an O or B type star as found for most other examples in the optical and MIR as reported by [Peri et al. \(2012\)](#) but is an M 4 late type star. This would be very unusual at these wavelengths, although some are found around AGB stars in the far infrared with Herschel
- The presence of an faint outer nebular halo fits a PN AGB halo interpretation but not a bow-shock
- The star's location is not aligned with the major axis of the elliptical nebula with a ~ 15 degree offset
- The strength of [OIII] relative to H α can be explained by shocks but can also easily be explained in a PN interpretation and by the Galactic location out of the mid-plane so the blue emission lines are not heavily extinguished
- The low extinction and lack of gas and dust in the general area means the ISM does not provide a dense medium for bow shocks to develop easily
- The stellar and nebula systemic velocities do not agree
- The Gaia proper motion vector of the star is not aligned with the supposedly trailing nebula (see Fig. 4) but is off by ~ 50 degrees

7.2 Factors supporting a PN identification

A brief summary of points supporting a PN classification is as follows:

⁷ see http://planetarynebulae.net/EN/page_np.php?id=845 for StDr 47 and <https://www.imagingdeepspace.com/ltnf1.html> for LTNF 1)



Figure 6. Deep, narrow-band H α and [OIII] amateur images of PN StDr 47 (HASH ID 32596, top with PN major axis 270 arcsec) and LTNF 1 (HASH ID 677, bottom - with PN major axis 230 arcsec) as examples of excellent morphological PNe corollaries to WHTZ 1. This includes the presence of faint blue CSPNe at their geometric centres and even, in the case of StDr 47, a bright, unrelated star nearby.

- The morphology is PN like with many corollaries with known PNe (see Fig. 6)
- There is a plausible blue, ionising star at almost the exact geometric centre of the nebula. This is a compelling argument for a PN origin for the nebula emission
- the optical spectrum is also compelling given the spectrum has a clear detection of He II 4686Å emission which requires a CSPN with a T_{eff} of at least 50,000 K, implying a high excitation PN identification
- The SB-r distance to the nebula and the CSPN parallax distance from Gaia are compatible within the errors

- The expansion velocity, kinematic age and physical size are all within accepted ranges for PNe
- The presence of a faint 10 arcmin outer halo - shown in our deep $H\alpha$ image (Fig 3), is a feature also seen in many PNe

Based on all these combined observed characteristics and also applying the decision tree for PNe to the key observations provided in Fig.11 of Parker (2022) leads us to a straightforward identification of WHTZ 1 as a high excitation PN.

In Tab. 1 we present the combined summary of all the observed and estimated parameters for the PN, proposed CSPN and for HD 185806.

8 CONCLUSIONS

We have shown that the recently reported cocoon "bow-shock" nebula, supposedly trailing the bright, 9.4^{th} magnitude star HD 185806 is actually a previously identified, faint, evolved, high excitation PN WHTZ 1 (Ra 7). This is confirmed by new, low resolution optical spectroscopy and multiple other pieces of evidence. The blue, ionizing CSPN, detected in Gaia DR3 (Gaia Collaboration et al. 2022) as star 4289684146940013184, has a reported parallax of 0.5548 mas from which Bailer-Jones et al. (2021) infer a distance of ~ 1.8 kpc. This gives the PN a physical extent across the major axis of ~ 1.7 pc, well within the range of known PNe. The expansion velocity and kinematic age are also compatible with a PN origin. The elliptical morphology is also typical of many evolved PNe with LTNF 1, KN 121, Abell 36 and the recent discovery of PN StDr 47 being particularly apt corollaries. They all have faint blue CSPNe with very similar morphological structures and, in the case of StDr 47 and KN 1212, bright, unrelated close stellar projected neighbours. The bright star HD 185806 is merely a chance line-of-site projected neighbour situated in the foreground at 910 pc.

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DATA AVAILABILITY

The data underlying this article are available in the article itself and in its associated online material freely accessible from the HASH database found here: <http://hashpn.space> by simply entering the unique HASH ID number for each source as provided.

REFERENCES

Bailer-Jones C. A. L., Rybizki J., Foesneau M., Demleitner M., Andrae R., 2021, *AJ*, 161, 147

- Cox N. L. J., et al., 2012, *A&A*, 537, A35
- Fragkou V., Parker Q. A., Zijlstra A. A., Vázquez R., Sabin L., Rechy-García J. S., 2022, *ApJ*, 935, L35
- Frew D. J., Parker Q. A., 2010, *Publ. Astron. Soc. Australia*, 27, 129
- Frew D. J., Parker Q. A., Bojičić I. S., 2016, *MNRAS*, 455, 1459
- Gaia Collaboration et al., 2016, *A&A*, 595, A1
- Gaia Collaboration et al., 2022, arXiv e-prints, p. arXiv:2208.00211
- Gaustad J. E., McCullough P. R., Rosing W., Van Buren D., 2001, *PASP*, 113, 1326
- Green G. M., Schlafly E., Zucker C., Speagle J. S., Finkbeiner D., 2019, *ApJ*, 887, 93
- Hambly N. C., et al., 2001, *MNRAS*, 326, 1279
- Hartigan P., 1999, *ApJ*, 526, 274
- Kobulnicky H. A., et al., 2016, *ApJS*, 227, 18
- Kobulnicky H. A., Schurhammer D. P., Baldwin D. J., Chick W. T., Dixon D. M., Lee D., Povich M. S., 2017, *AJ*, 154, 201
- Kronberger M., et al., 2016, in *Journal of Physics Conference Series*. p. 072012, doi:10.1088/1742-6596/728/7/072012
- Le Dû P., 2017, *L'Astronomie*, 131, 46
- Liebert J., Tweedy R. W., Napiwotzki R., Fulbright M. S., 1995, *ApJ*, 441, 424
- Miszalski B., Parker Q. A., Acker A., Birkby J. L., Frew D. J., Kovacevic A., 2008, *MNRAS*, 384, 525
- Parker Q. A., 2022, *Frontiers in Astronomy and Space Sciences*, 9, 895287
- Parker Q. A., et al., 2006, *MNRAS*, 373, 79
- Parker Q. A., Bojičić I. S., Frew D. J., 2016, in *Journal of Physics Conference Series*. p. 032008 (arXiv:1603.07042), doi:10.1088/1742-6596/728/3/032008
- Peri C. S., Benaglia P., Brookes D. P., Stevens I. R., Isequilla N. L., 2012, *A&A*, 538, A108
- Pilbratt G. L., 2001, in Pilbratt G. L., Cernicharo J., Heras A. M., Prusti T., Harris R., eds, *ESA Special Publication Vol. 460, The Promise of the Herschel Space Observatory*. p. 13
- Ritter A., Parker Q. A., Lykou F., Zijlstra A. A., Guerrero M. A., Le Dû P., 2021, *ApJ*, 918, L33
- Schlegel D. J., Finkbeiner D. P., Davis M., 1998, *ApJ*, 500, 525
- Smak J. I., 1966, *ARA&A*, 4, 19
- Spetsieri Z. T., et al., 2022, *MNRAS*, 515, 1544
- Weinberger R., Hartl H., Temporin S., Zanin C., 1999, in Taylor A. R., Landecker T. L., Joncas G., eds, *Astronomical Society of the Pacific Conference Series Vol. 168, New Perspectives on the Interstellar Medium*. p. 142
- Wenger M., et al., 2000, *A&AS*, 143, 9
- Wright E. L., et al., 2010, *AJ*, 140, 1868

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Table 1. Summary Table of all observed and determined PN, CSPN and star HD 185806 parameters from this work and from the literature.

Parameter	PN	CSPN	HD 185806
RA (J2000)	19:40:43.84	19:40:43.840 [∇]	19:40:47.56 [∇]
DEC (J2000)	02:30:31.80	02:30:31.928 [∇]	02:29:28.64 [∇]
Galactic longitude	40.875	40.87508	40.86675
Galactic latitude	-9.7764	-9.77643	-9.79839
Gaia stellar ID: 428968+	-	4146940013184	3322306283904
Gaia G-band (mag)	-	16.887	7.606
B_j (mag) [◇]	-	~16.94	~10.37
R-band (mag) [◇]	-	17.42	8.00
$E(B - V)$ [△]	0.33	-	-
μ_δ (masyr ⁻¹) [∇]	-	-7.78 ± 0.06	-10.28 ± 0.03
$\mu_\alpha \cos \delta$ (masyr ⁻¹) [∇]	-	-5.03 ± 0.08	-0.36 ± 0.04
Distance (kpc)	2.49 ± 0.71*	1.83 ^{+0.27} _{-0.21} [•]	0.91 ^{+0.04} _{-0.02} [•]
Velocity (km s ⁻¹)	-34 ± 13 (systemic) [#] 57 ± 10 (expansion) [#]	-	13.76 ± 0.37 (heliocentric) [∇]
Physical size major axis (pc)	1.72 ^{+0.24} _{-0.21}	-	-
Physical size minor axis (pc)	1.19 ^{+0.17} _{-0.12}	-	-
Nebula outer H α halo (arcmin)	~10	-	-
Kinematic age (yr)	25000 ⁺¹⁵⁰⁰⁰ ₋₁₀₀₀₀	-	-

[∇] from Gaia DR3 (Gaia Collaboration et al. 2022)

* from SB-r relation of Frew et al. (2016)

estimated from data in Spetsieri et al. (2022)

◇ taken from SuperCOSMOS photometry, see Hambly et al. (2001)

△ taken from Green et al. (2019)

• taken from Bailer-Jones et al. (2021)