Asymmetric Planetary Nebulae 5
(Ebrary, Cambridge, USA),
A.A Zijlstra, I. McDonald, eds.

Understanding the Etched Hourglass Nebula — MyCn 18

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Understanding the Etched Hourglass Nebula - MyCn 18

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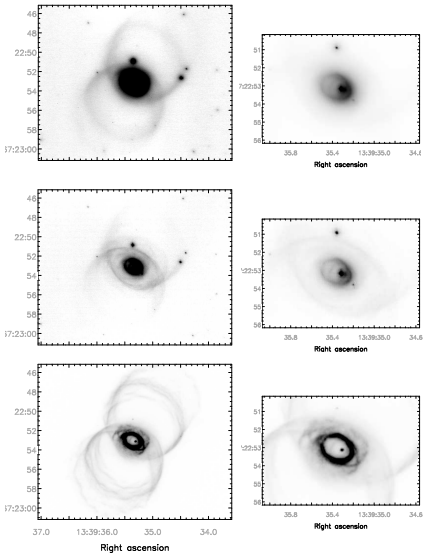
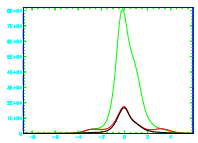
Abstract

The Etched Hourglass Nebula is typical of many wasp-waisted PNe. Here we consider near infra-red imagery and spectroscopy with a view to understanding the structure of the nebula in terms of its ionisation along different directions, the origins of the extreme bipolar shaping and the effect of the off-centre central star.

Images

VLT NACO images at Ks (top) and narrowband H2 2.122 μm (centre) are shown, together with the WFPC2 [NII] optical image of Sahai et al.,([1] bottom). The left hand images show the full extent of the main hourglass shell. The right hand images show the central region, at high contrast. The H2 image shows finely detailed features, similar to those seen in the [NII] optical image, whereas the continuum Ks band is dominated by emission from a compact, central region. Sahai et al. [1] showed that the optical continuum emission is similarly concentrated and is due to nebular continuum rather than scattered starlight.





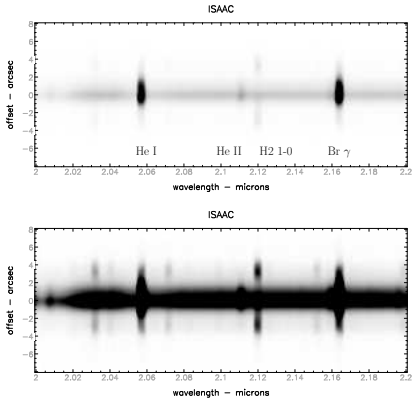
Spatial cuts through 0.01 μm wide sections of the ISAAC spectrum show the relative contributions of the different emission components: Brackett gamma - green, H2 1-0 S(1) - red, continuum - black.

It is clear that the Br γ and He emission lines originate in the compact, ionised zone around the star. Bumps at ±3 arcsec in the H2 profile indicate H2 emission from the lobes. The central region of the H2 profile is almost identical to the continuum profile, indicating that there is no significant H2 from the inner region of the nebula. The continuum contribution can be well fitted by two Gaussian components of similar height, one of width equivalent to the seeing and the other $\sim$ 3 times wider; in other words the narrower component represents the stellar emission and the broader component the free-free continuum emission from the compact, ionised region around the star.

MyCn 18 is a beautiful example of a wasp-waisted hourglass nebula; combining a well defined overall bipolar shape with a host of intriguing features such as the hyper-sonic bullets, the tendrils extending from the edges of the open-ended lobes, the arcs etched on the lobes, and the inner hourglass and ring structures close to the centre of the nebula. Finally, there is also the puzzle of the obviously offset central star. The hourglass is known to be oriented such that its axis is at about 35deg from the plane of the sky, with the southeastern lobe towards the observer [1,2,3]. Radio observations indicate that the emission is optically thick close to the centre of the nebula but optically thin in the lobes.[4] Optical line emission images also show the bipolar lobes of the nebula to be density bounded but the central region to be ionisation bounded.[1] The morphological and ionisation structures all point towards a binary central star but as yet there is no direct observational evidence that this is the case.

Spectra

A spatially resolved ISAAC spectrum, taken across the minor axis of the main hourglass nebula, is shown at low and high contrasts, with the most prominent atomic and molecular emission lines indicated. The spectrum clearly shows a broad nebular continuum, about 2 arcsec in extent, and slightly offset with respect to the central star. There are also prominent atomic recombination lines from the central region, extending outwards beyond the main continuum band. The H2 emission lines are clearly different in spatial extent, these peak at about ±3 arcsec from the star. Comparing this spatial cut to the images, it can be seen that the H2 emission comes from the cusps of the lenticular H2 feature which is most likely the line-of-sight overlap of the two lobes of the Hourglass.



Sahai et al. [1] noted that the expected K-band flux (from the star) is about half what was observed by Whitelock [5], and suggested this may indicate the presence of hot dust in the equatorial region. Our spectra show that this excess emission can be explained by the strong free-free and atomic line emission from the compact ionised zone.

References

1. Sahai et al., 1999, AJ, 118, 468
2. Bryce et al., 1997, ApJ, 487, L161
3. Corradi & Schwartz, 1993, AA, 268, 714
4. Bains et al., 2002, MNRAS, 337, 401
5. Whitelock, 1985, MNRAS, 213, 59

Based on observations obtained at the European Southern Observatory, Paranal, proposal numbers 071.D-0698 and 073.D-0359.