The dark lane of the planetary nebula NGC 6302

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Summary

The butterfly-shaped planetary nebula NGC 6302 shows a unique, dense equatorial dark lane, which is presumably a dusty disc. We trace the structure of this disc using Hubble Space Telescope (HST) Hα and NII images. Very Large Telescope (VLT) L- and M-band images at 0.4-arcsec resolution, and a JCMT 450 micron image. Extinction maps are derived from these images. Within the disc, the extinction is A=0.5-7 mag. The 450 micron map shows a north-south elongated central core, tracing the massive dust disc, and extended emission from dust in the bipolar flows. A fit to the SED yields the disc mass of 0.03 Msun. The innermost region shows an extended shell. The orientation of the polar axis shows a marked change between shell, disc and inner and outer outflow. The structures are well described by the warped-disc model of Icke (2003). An infrared source is found close to the expected location of the central star.

Warped disk in NGC 6302

This bipolar nebula shows disc traces by its high extinction. The outflows close to the disc are traced by a striking edge. These features are exactly predicted by the hydrodynamic model by Icke (2003, Fig 3).

The extinction is estimated from Hα and 60 micron emission. The highest extinction is recorded by A(Hα)=6 map.

Fig. 1 The HST WFPC2 image in the F606W band (6064 Å). The scale is log I in Jy arcsec2. The image is dominated by the Hα line.

Fig. 2 Schematic view of NGC 6302. Outer region (left) and the central region (right).

Fig. 3 Warped disc calculated by the hydrodynamic model (Icke 2003).

Far-infrared emission from the disc

NGC6302 was observed with SCUBA/JCMT on 15th April 1998. The bima sizes is about 7 and 13 arcsec at 450 and 850 micron, respectively. At 450 and 850 micron, NGC 6302 was resolved (image at 850 micron is not shown). A large amount of far-infrared excess is detected near the centre of nebula. The excess supposed to be thermal emission from dust grains in the disc.

We model the SED using radiation transfer code (Nomura 2002; Nomura and Miller 2004). A detached dust shell is assumed with an inner and an outer radius, R0 and R1. Two different radial distributions of dust grains are used and . The distance is taken as 1kpc and the luminosity as . The SED is fitted reasonably well with the model parameters , and a dust mass of 0.03 Msun. This suggests gas mass of 3 Msun. The far-infrared to dust ratio is 100. The dust temperature ranges between 50 and 100 K. Below 12 micron, the observed flux is much higher than the model fit, showing that a dust component with a much higher temperature must be present.

Central star or hot ionised gas?

A compact infrared source is present near the centre of symmetry of the PN. It has no counterpart at Hα image, suggesting high optical depth or non-ionised gas. The flux of compact source using 0.4-arcsec aperture photometry is 10.4, 11.4, and 13.8 in magnitudes in M_NB, NB_4.07, and NB_3.21.

We have obtained L-band spectra of NGC 6302 with ISAAC. Across the central bob, we detect hydrogen recombination lines and a 3.94 micron emission line, while the other regions along the slit do not show a 3.94 micron line at all. There is a clear difference in the spectra towards the central object. The 3.94 micron line is identified as [SIII] by Cassen et al. (2003), although it could be [FeII] line which is of photometric origin in O-type stars (Lenzner et al. 2002). The nature of this central object is an open question.