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A dam around the Water Fountain Nebula?

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Water fountain sources are proto-planetary nebulae with bipolar high-velocity molecular outflows, including water. They show reflection lobes at optical wavelengths with evidence for a precessing jet, and these are separated by a dark lane hitherto explained as obscuration by a dense dusty torus. Indeed, the central star is not directly observable, and the objects have extremely red SEDs. We present spatially resolved mid-IR imaging and spectroscopy on the class-defining Water Fountain Nebula, obtained with VISIR on the VLT. Surprisingly, we find that the observations are best matched with a very dense dusty superwind (as occurs at the tip of the AGB) which is essentially spherically symmetry. It shows no other peculiar structure than the biconical cavities corresponding to the optical reflection lobes. We must conclude that the jet driving engine and any disc-like structure (e.g for accretion) are entirely hidden from view, but it is interesting to consider that the star underwent a relatively ”unaffected superwind”.

A dam around the Water Fountain Nebula?

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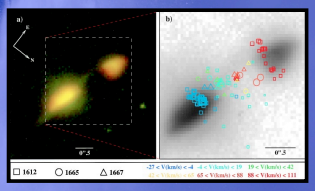
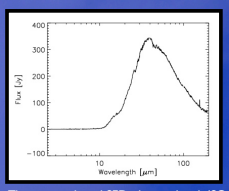
What is IRAS16342-3814? One of the reddest evolved objects observed with ISO, with evidence for pre-cessing jets in the optical/near-IR reflection lobes, and named after its fast bipolar H_2O (and OH) outflow.

The near-IR reflection lobes, with corkscrew structure due to a precessing jet (Sahai et al. 2005, 2007)



The high-velocity bipolar outflow of H2O and OH observed at radio wavelengths (Claussen et al. 2009)

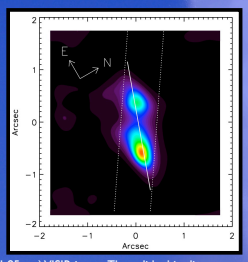


The extremely red SED observed with ISO. The silicate features are seen in absorption (Dijkstra et al. 2003)

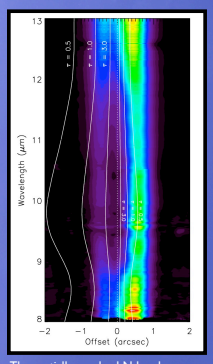
The question tackled here: what is the origin and role of the dark dust structure obscuring the central region?

Our approach: mid-IR imaging and 2D spectroscopy using the VISIR instrument on the VLT

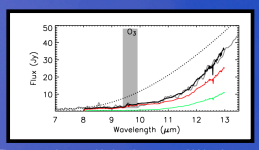
Results 1: even at 12 μm, only the bipolar lobes appear, but now most probably in thermal emission from dust rather than reflected light.



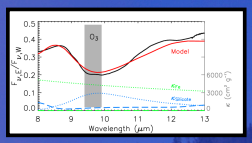
Mid-IR (11.85 μm) VISIR image. The solid white line represents the PA of the optical/near-IR reflection lobes. The dashed lines represent the slit used for the spectroscopy.



The spatially resolved N-band spectrum. The solid white lines represent constant opacity along the line-of-sight of the model (see the dedicated box "Model")

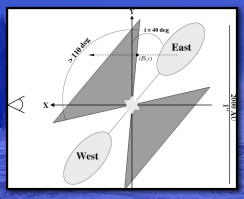


The extracted spectra: black is the integrated N-band spectrum, red the Western lobe, Green the Eastern lobe, grey the ISO spectrum as reference, and the dotted line the continuum estimated from a spline fit to the ISO SED.



Observed flux ratio between the Eastern and Western Lobes (black solid line), and the different opacity contributions to the modelled flux ratio (dotted = absorption, dashed = scattering)

Model: constraining the dust distribution by matching the mid-IR observations.



Assumptions: outflow with limited opening angle, lobes with 160K temperature, i = 40° (from maser observations)
Parameters: mass-loss rate, filling angle, dust composition
Constraints: SED, flux ratio, spatial effects

Results 2:

- filling angle of the dust torus: ~ 145°
- mass-loss rate: ~ 1 x 10^{-3} Msun/yr
- dust composition: silicates and iron, large and small grains

Conclusions:

- the N-band flux originates in the 2 lobes with T~160K
- the dark dust structure is not a disc, and probably not even an outflowing torus: the filling angle is very large
- it resembles more a regular, strong superwind as seen in OH/IR stars, but with cavities blown by the jets
- So which kind of (binary) interaction is taking place behind that wall of dust?

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