Dusty disks around evolved stars

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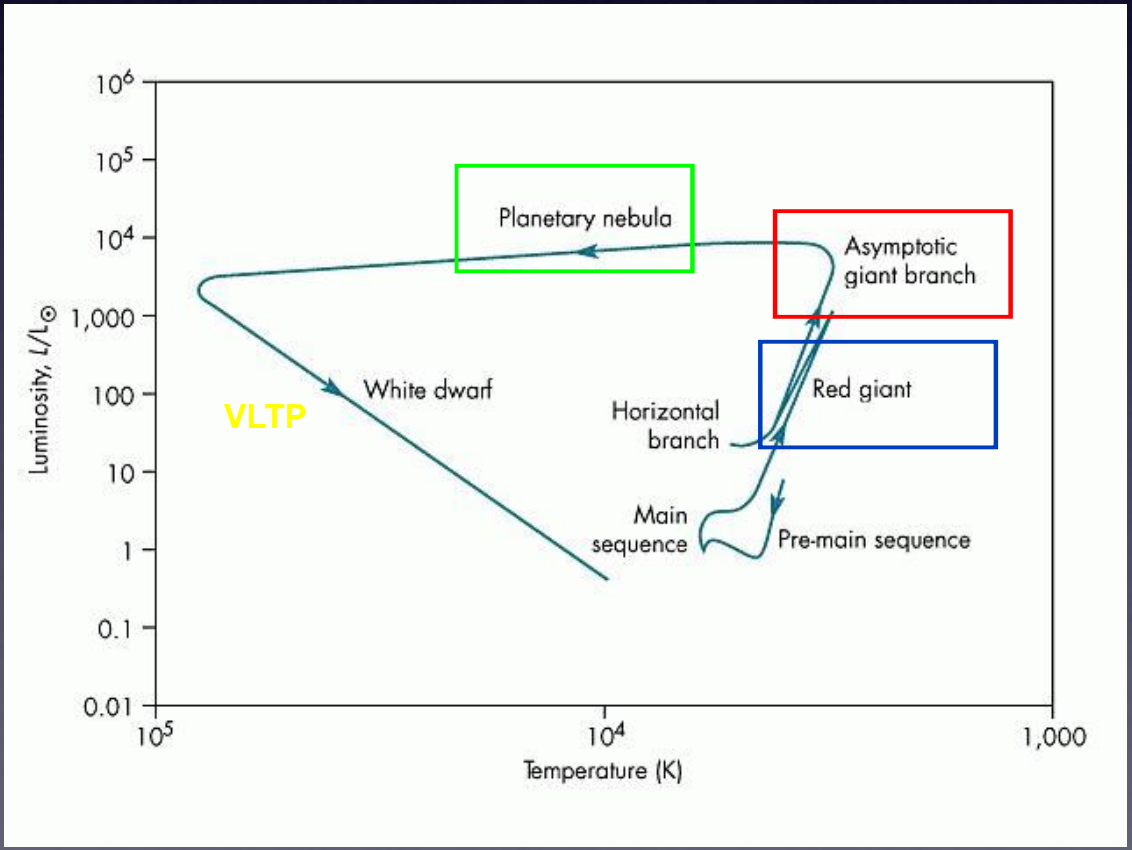
Creating dust

Dust created in the outskirts of the stellar envelope

Intermediate mass stars (1-8 solar masses)



RGB (spherical wind)
1st dredge-up: O-rich

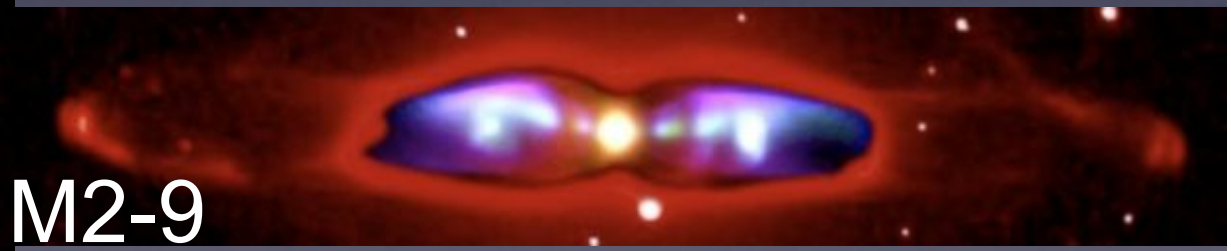
AGB (asymmetric wind)
2nd dredge-up: O-rich
3rd dredge-up: C-rich

post-AGB / PN
CO core, CO envelope
dust envelope
O-rich or C-rich

VLTP
~20% stars to post-WD
re-ascend to AGB
C-rich

Shaping the ejecta

- Angular momentum loss driven by Mass Loss. What shapes the ejecta ?
- Binaries retain angular momentum (magnetic fields?)
- Dust settles in tori / disks (circumbinary or circumstellar)
- Bipolar and Multipolar PNe
- Polar ejections “helped” by disks ? (V. Icke 1981)

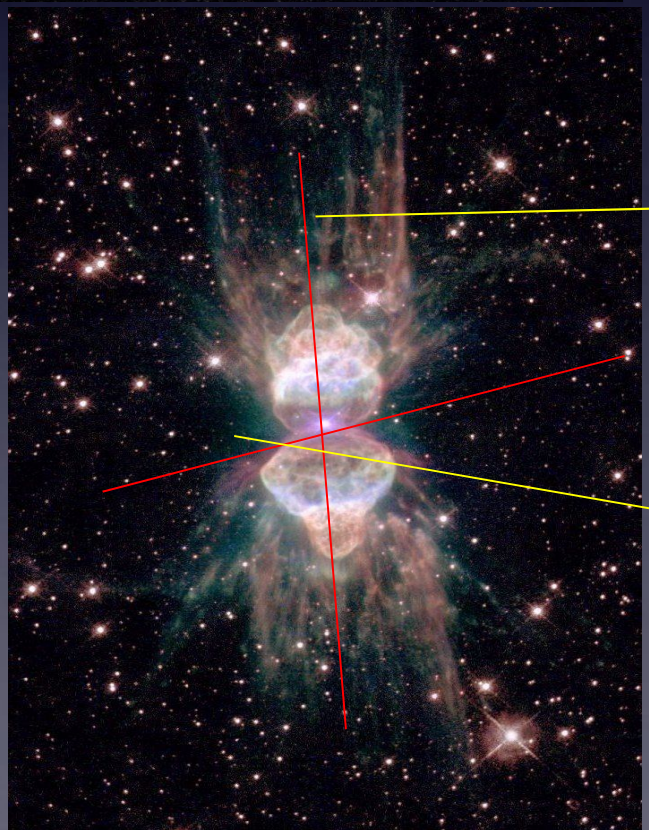


M2-9

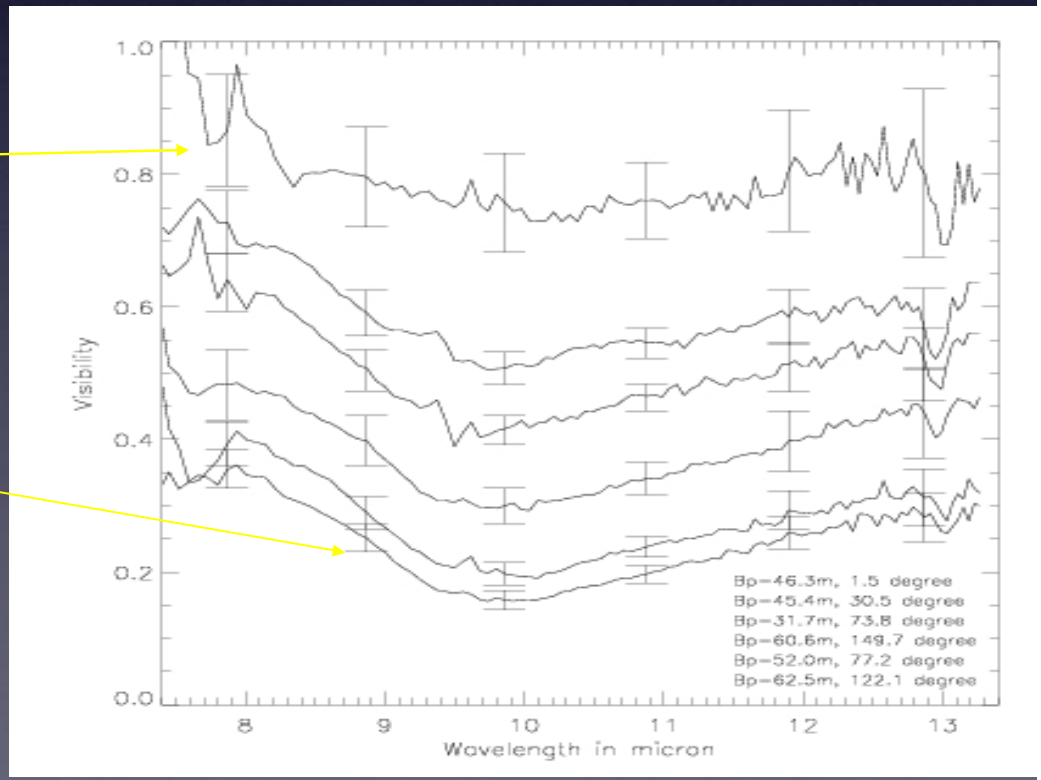
Infrared interferometry

VLTI / ESO

- Optical telescopes resolution up to 0.1 arcsec
- Infrared interferometry (it's dust!) MIDI/VLTI is 2 beam recombiner, baseline < 200m, resolution ~20 mas @ 10micron, N-band (8-13.5 micron) spectrally dispersed visibilities
- Visibility = FT(Brightness) = complex function (amplitude and phase)
- For MIDI phase signal corrupted by atmosphere; use amplitudes and RT code to reconstruct images (MC3D)



MIDI visibilities for different baselines orientations

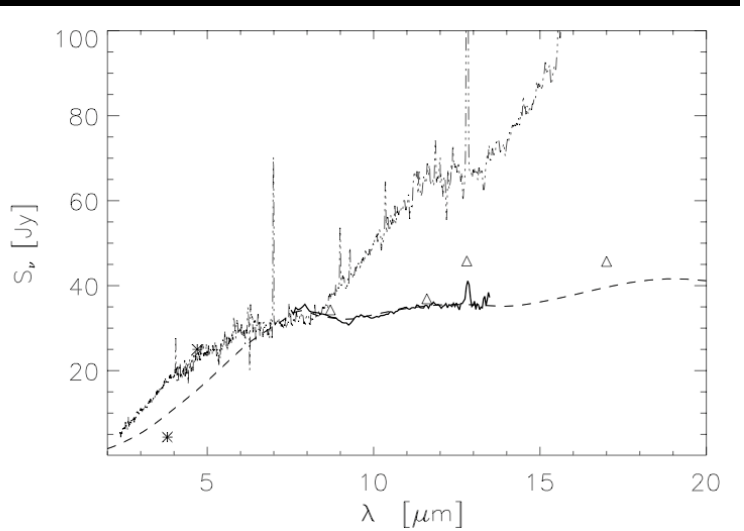


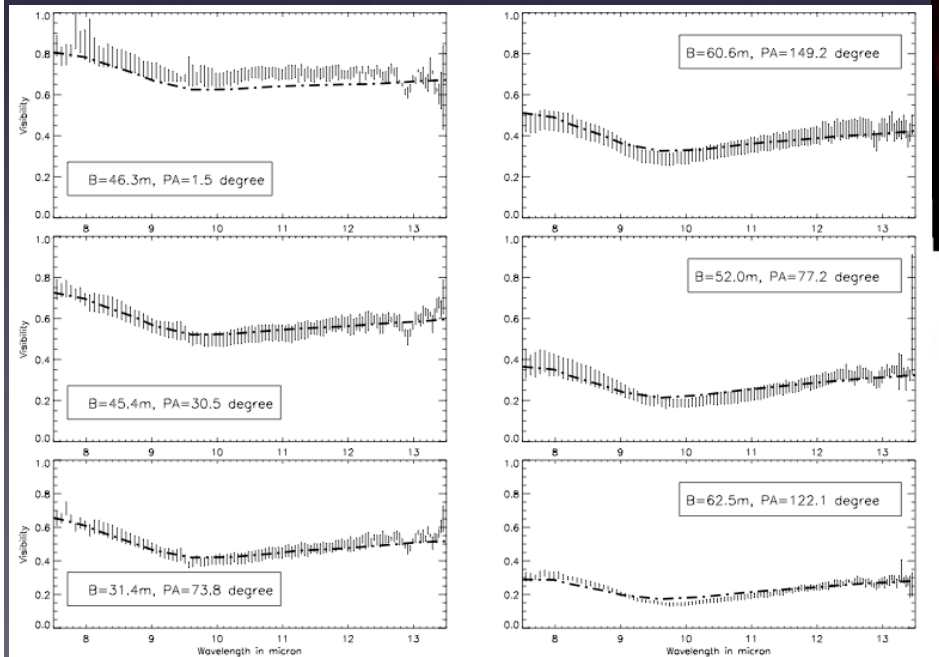
Menzel 3

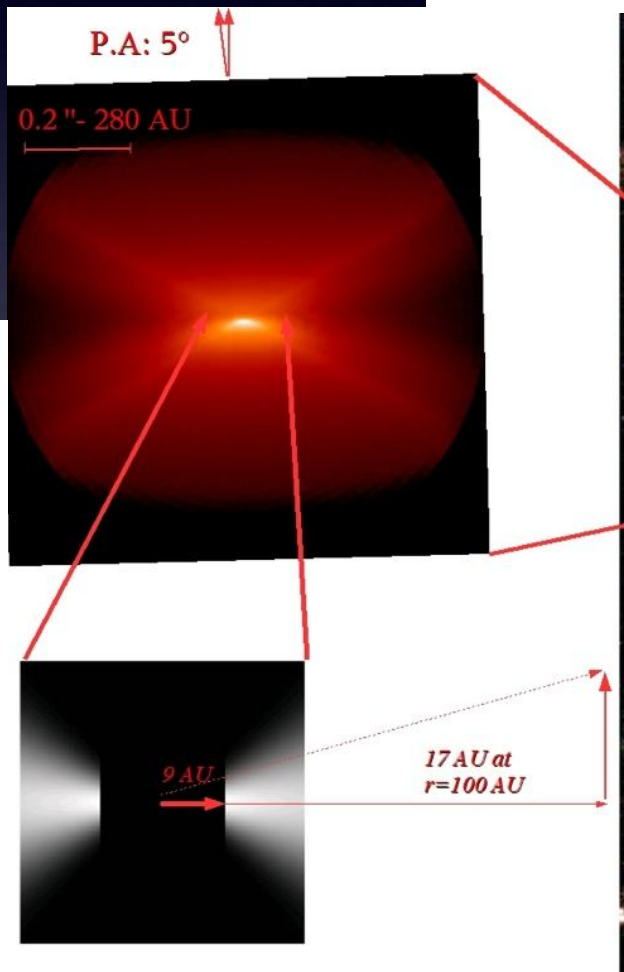
Detection of an edge-on disk in an extremely bipolar nebula with IR interferometry.

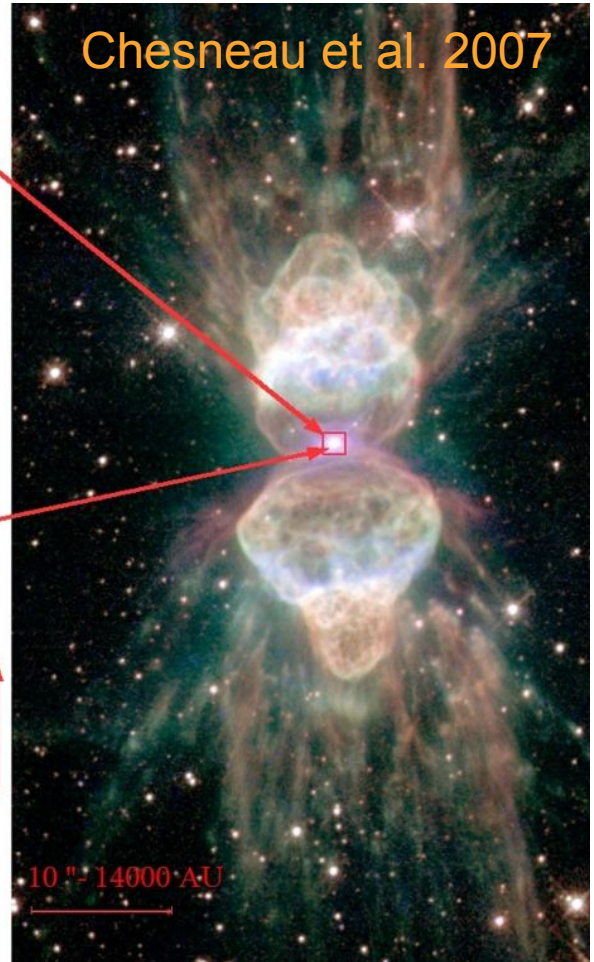
Disk: Silicate chemistry; survived gas expansion + stellar UV; radius: 9-500 AU, mass: 9×10^{-6} Msun

X-ray jet (Kastner et al., APN4)





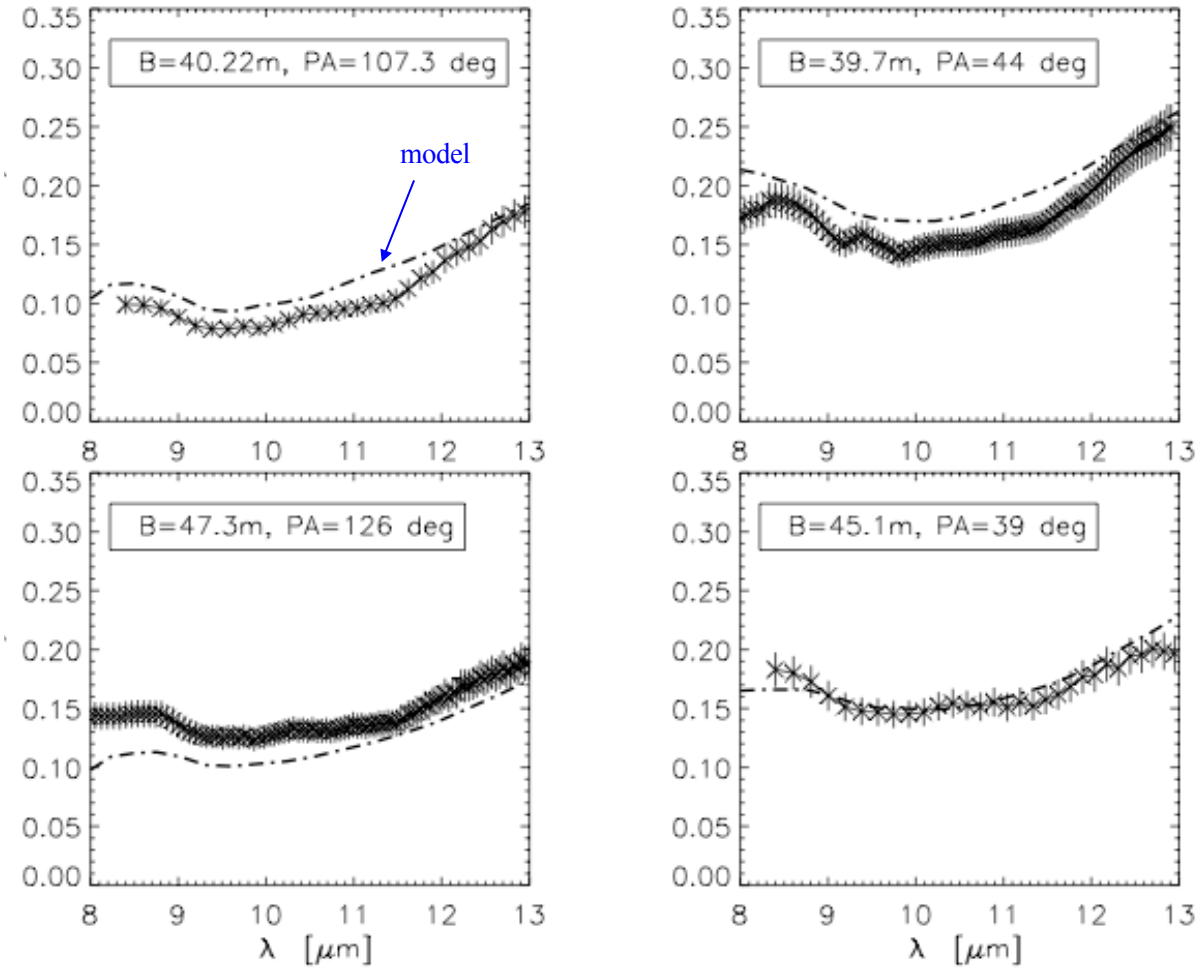


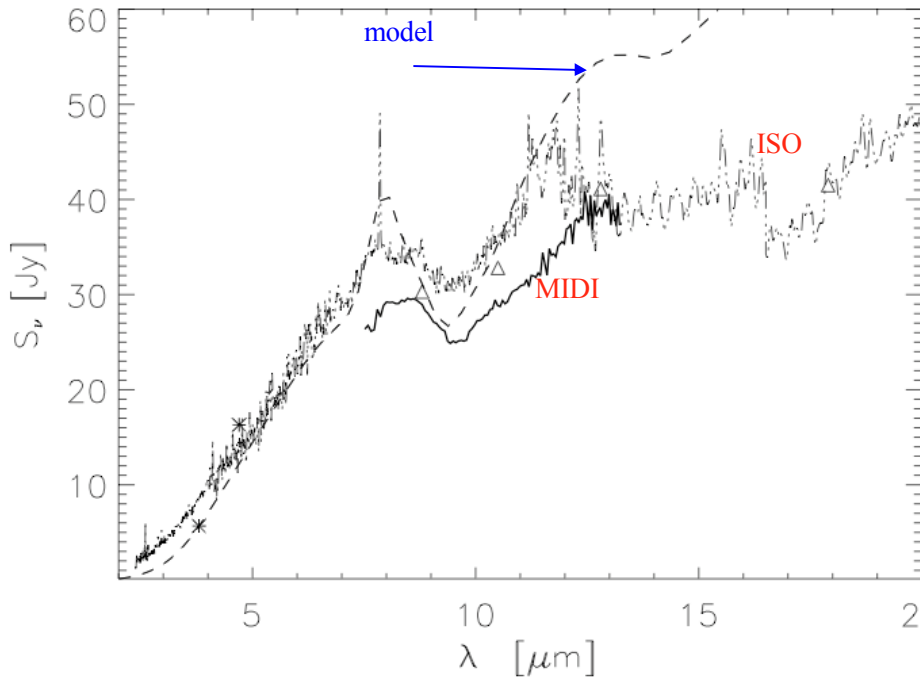


M2-9

Spectrophotometric *twin* of Menzel 3
Early PN with precessing jet (~18 yrs) → BINARY (separation~10AU)
MIDI found a circumbinary disk at radius: 15-900AU of silicates (1.5×10^{-5} Msun)

Halpha emission by HST, accretion disk around the primary?





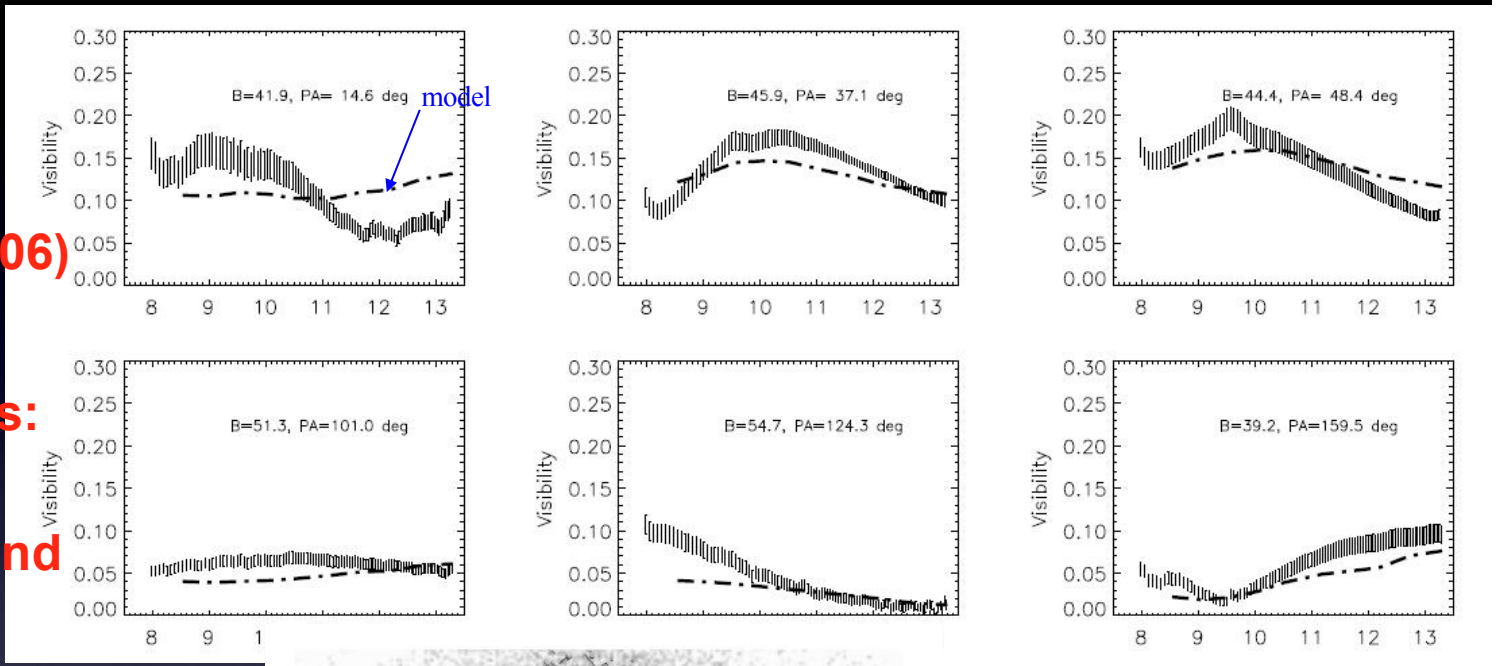
Lykou et al. *in prep*

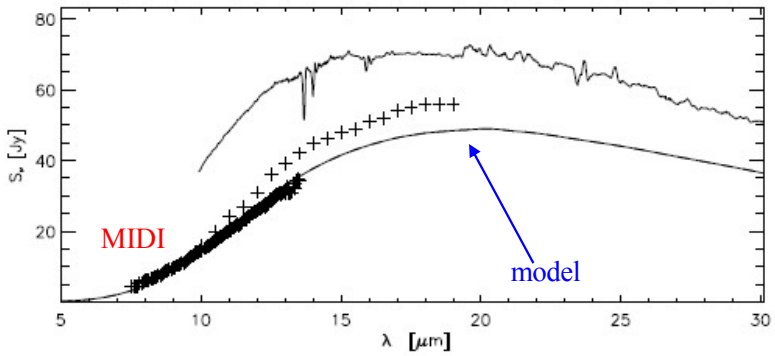
Sakurai's Object

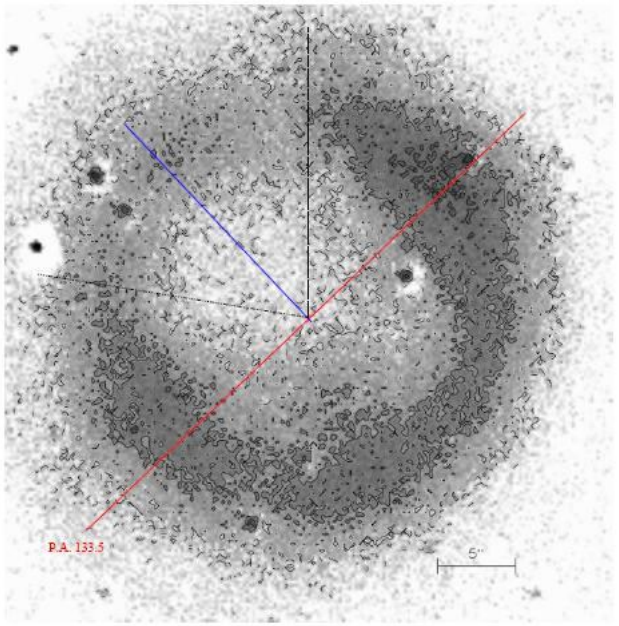
- VLTP event in 1996; dust cloud 2002-now
- H-poor, 13C-rich (Evans '06)
- disk amor. C

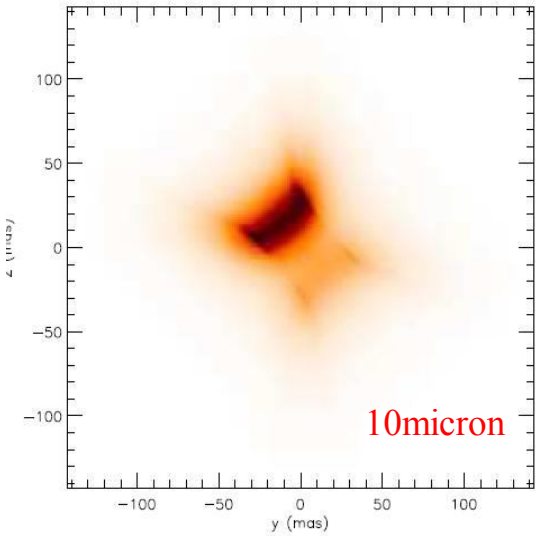
(mass: 6×10^{-5} Msun; radius: 65-500 AU)

- observed by MIDI 2007 (and Spitzer 2006)
- P.A. ~132deg aligned with PN
- binary? fast-rotating core?









Chesneau et al. 2009

Conclusions

- From symmetric AGB wind to asymmetric ejecta.
- Binarity seems to be the solution in angular momentum loss.
- Dust of different composition, survives and evolves near the stars.
- Sakurai's object : first detection of newly formed dust in H-poor, 13C-rich environment