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PN-ISM interaction

RAS National Astronomy Meeting 2007

Tuesday 17th April

Dr Chris Wareing

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Overview

- Simulations of the planetary nebula (PN) – ISM interaction
- The four stages of PN-ISM interaction
- Observations
  - R Hydrae: an AGB-ISM interaction
  - Sh 2-188: a strong PN-ISM interaction
  - Vortices in the wakes of AGB stars

Group: Albert Zijlstra, Tim O'Brien, Myfanwy Bryce, Neil Vaytet

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Our simulation work

- we have performed simulations to investigate the interaction of PNe with the ISM.

- although the interaction has been considered before, the AGB phase of evolution has not been included.

- ~100 3D hydrodynamical simulations employing a fully tested parallel CFD scheme which includes the effect of radiative cooling

- we have varied:
  - mass-loss rate on the AGB: 10^{-7}, 5×10^{-7}, 10^{-6}, 5×10^{-6} $M_\odot$ yr^{-1}
  - local ISM density: n_H = 2, 0.1, 0.01 cm^{-3}
  - relative velocities: 0 to 200 km s^{-1} in 25 km s^{-1} steps

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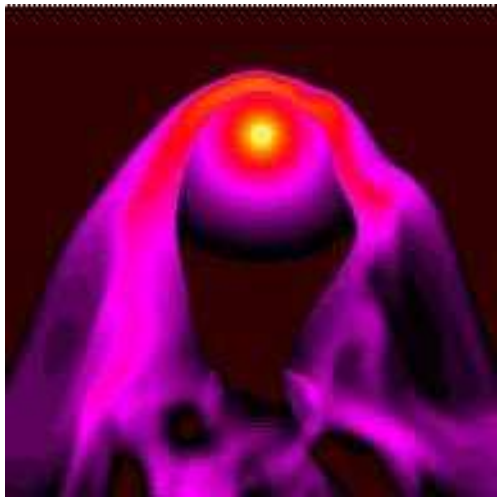
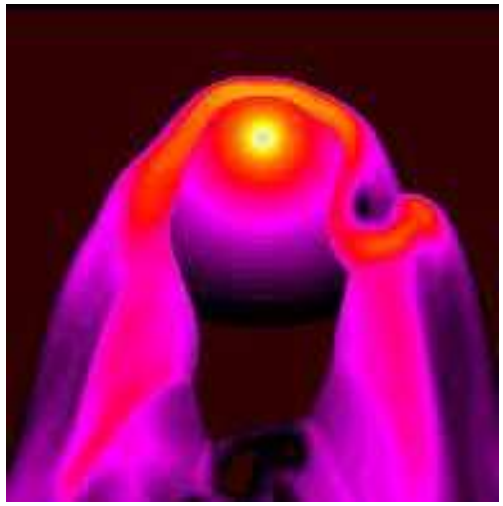
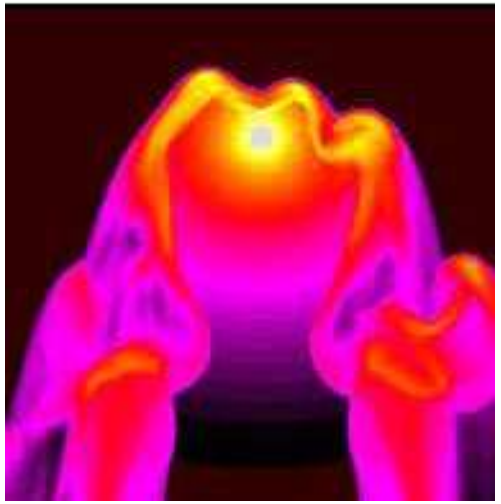
AGB simulations



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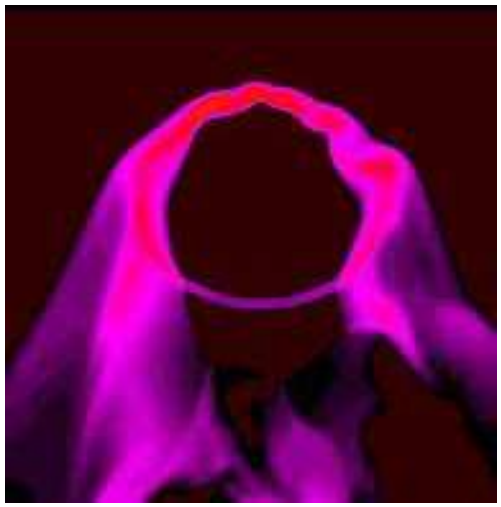
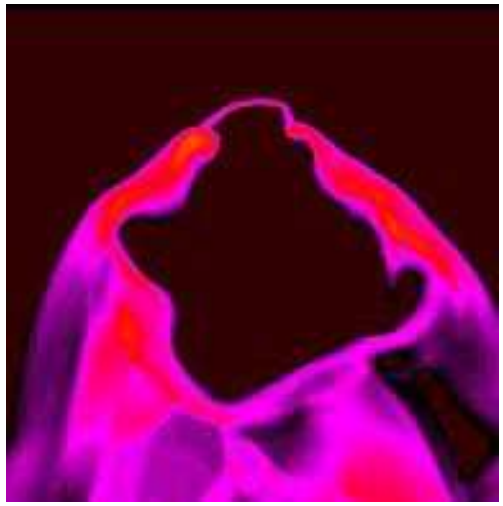
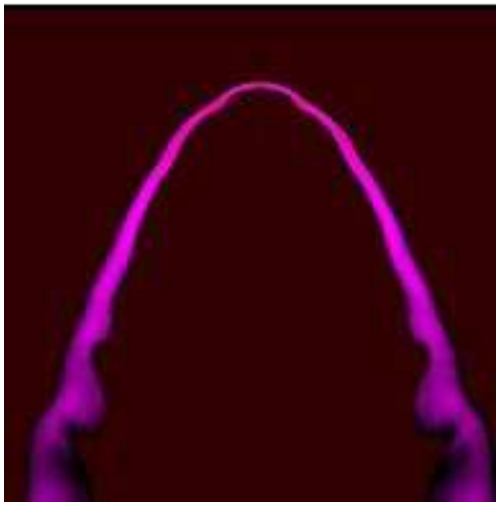
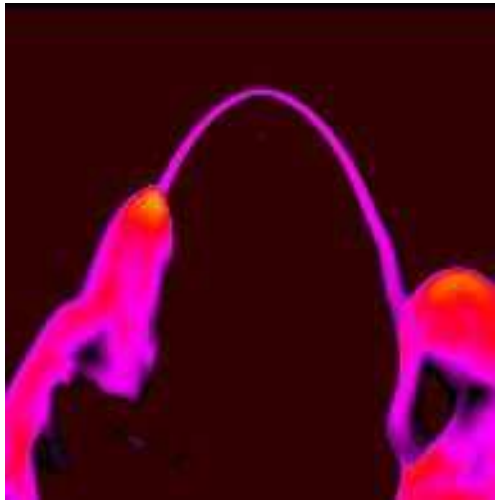
post-AGB / PN Simulations

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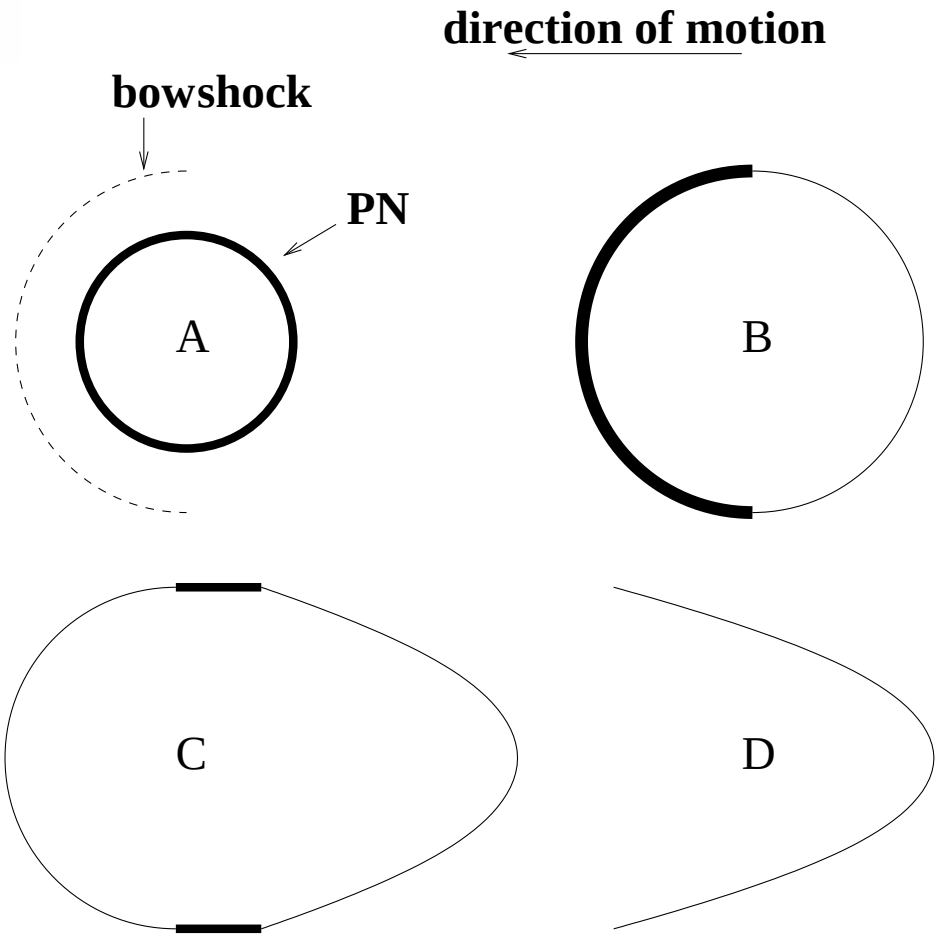
Generalisation of the interaction



Stage 1 – PN as yet unaffected by the interaction but a faint bow shock may be observable.

Stage 2 – PN shell is brightened in the direction of motion.

Stage 3 – the geometric centre of the nebula shifts downstream away from the central star.

Stage 4 – the PN is completely disrupted; central star can now appear outside its nebula

Modelling of the AGB phase of evolution is crucial

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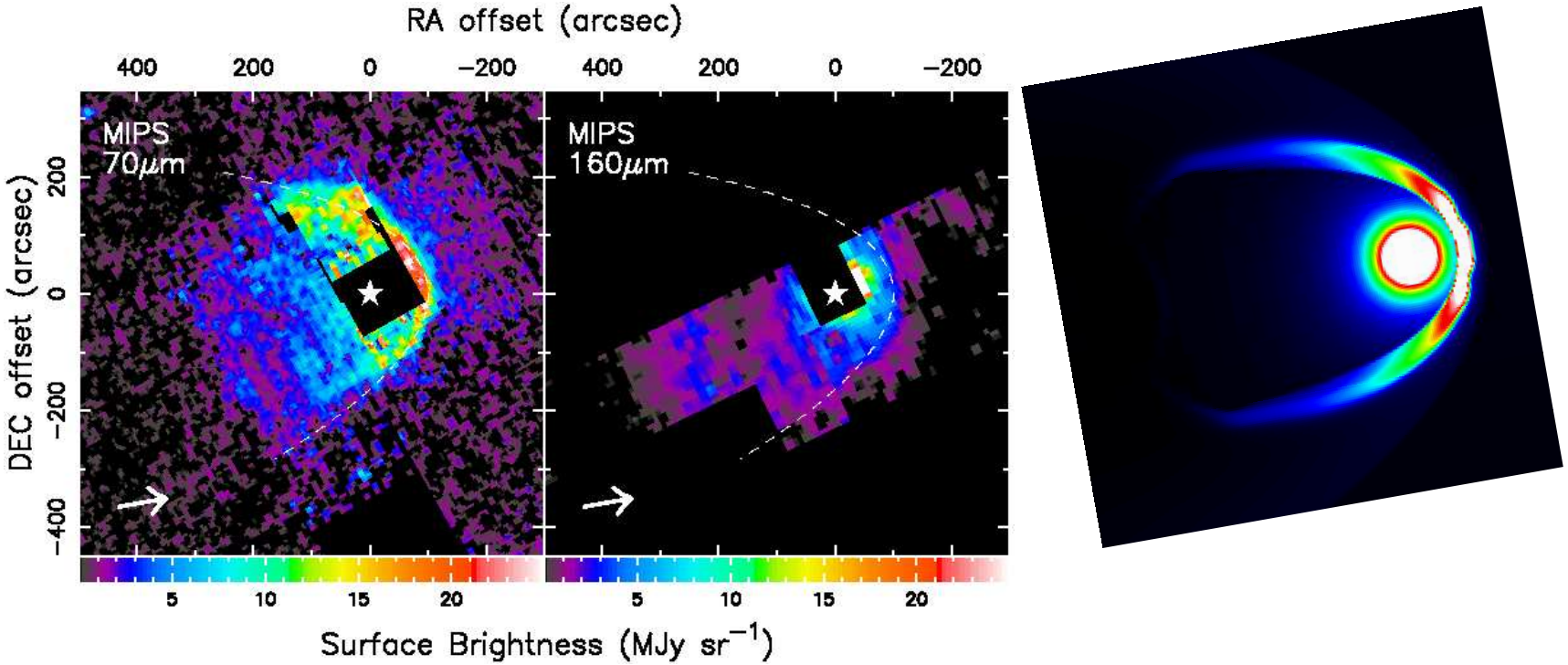
R Hydrae

An alternative explanation of detached shells around AGB stars – shells are in fact AGB-ISM walls.



A comparison of MIRIAD images (left & middle) and an AGB simulation (right).

Instant confirmation of this result!

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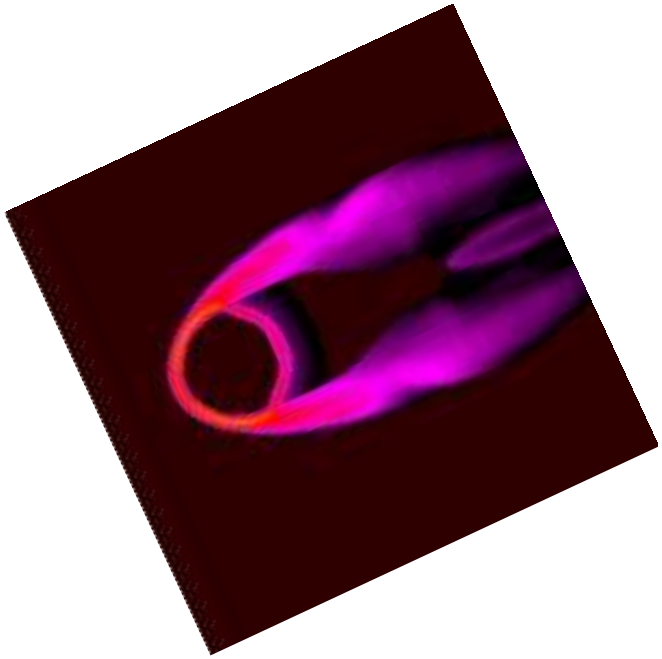
Sh 2-188

Initially thought to be a bright one-sided arc-like PN



IPHAS images revealed faint structure – a circular completion of the arc and a tail

Sh 2-188 is a case of strong PN-ISM interaction

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Vortices in the wakes of AGB stars

Vortex generating instabilities at the head of the bow shock

- first discovery of such vortices coming off stars

- enhanced mixing of stellar material
- turbulence in the ISM

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The End!

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Sh 2-188 reference -- MNRAS **366** 387 (2006)
R Hya reference – MNRAS **372** L63 (2006)
Vortices in the wakes of AGB stars – ApJ L accepted (astro-ph/0703732)
& RAS NAM 2007 press release