



Dave Jones

Bipolar PNe

Modelling

The sample

Polar outflows

SFSGSW?

Trends

Summary

Probing close-binary evolution using the morpho-kinematics of planetary nebulae

Dave Jones

European Southern Observatory

Deaths of Stars, Lives of Galaxies
April 8th 2013

Aspherical planetary nebulae

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Bipolar PNe

Modelling

The sample

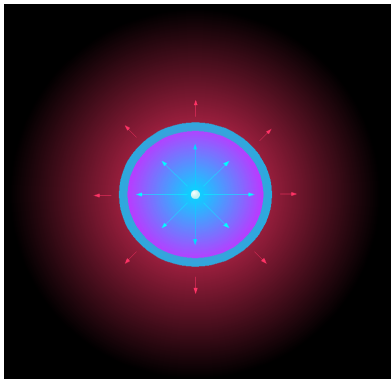
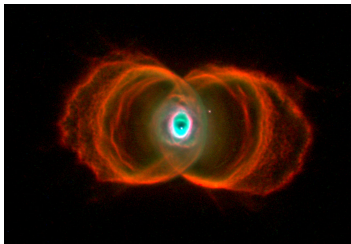
Polar outflows

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- Rapidly rotating stars?
- Magnetic fields?
- BINARIES!



Common envelope ejection

The source of the density contrast

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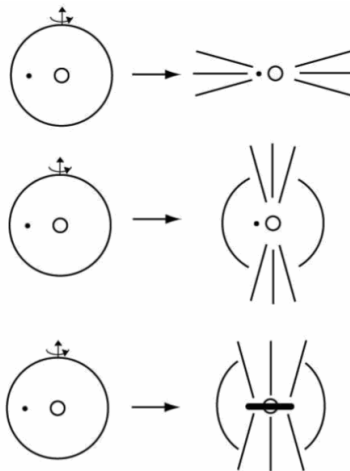
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Nordhaus & Blackman (2006)



Sp 1

The problem!

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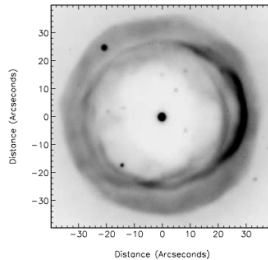
Polar outflows

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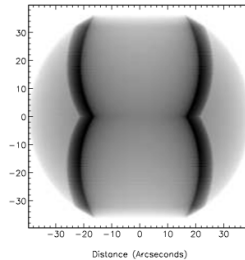
Trends

Summary

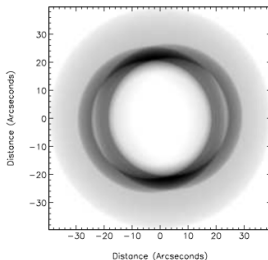




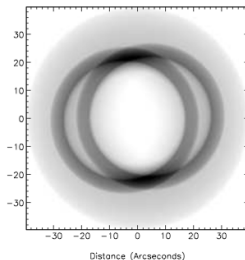
(a) [O III] $\lambda 5007 \text{ \AA}$



(b) 90°



(c) 10°



(d) 15°

Spatio-kinematical modelling

Spectroscopy

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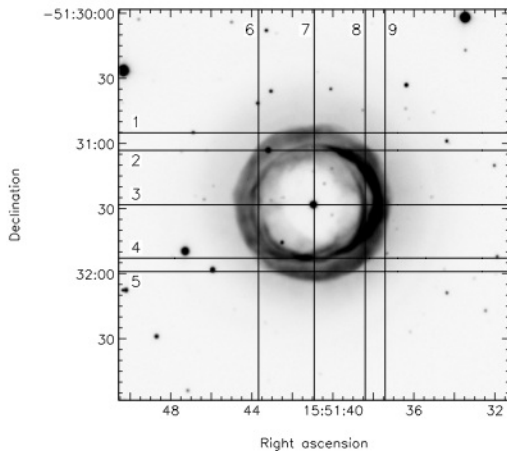
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Spatio-kinematical modelling

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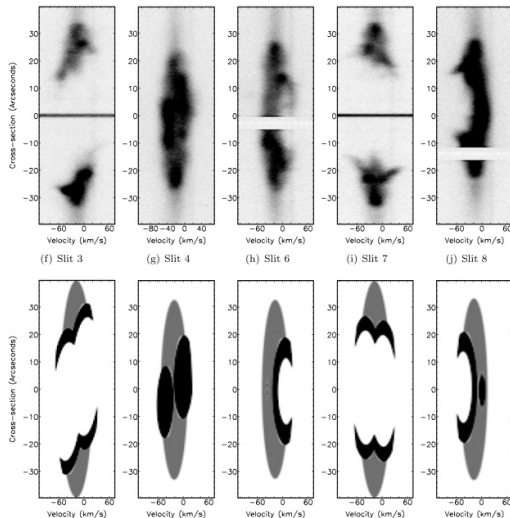
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The sample and other associated PN

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PN	Period (days)
A 41	0.226
A 63	0.456
NGC 6337	0.538
A 65	1
HaTr 4	1.74
Sp 1	2.91
NGC 6778	0.15
Hen 2-428	0.18
ETHOS 1	0.53
The Necklace	1.16
Fg 1	1.19

Abell 41

Jones et al. (2010)

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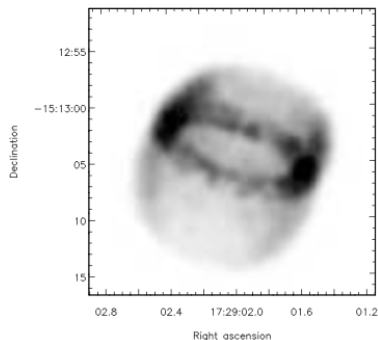
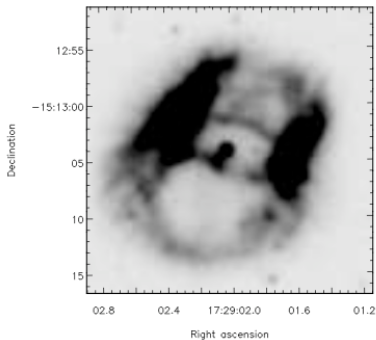
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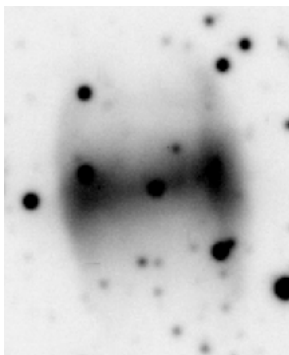
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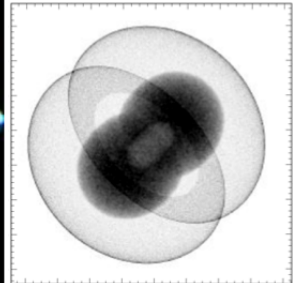
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Polar outflows

The PNe

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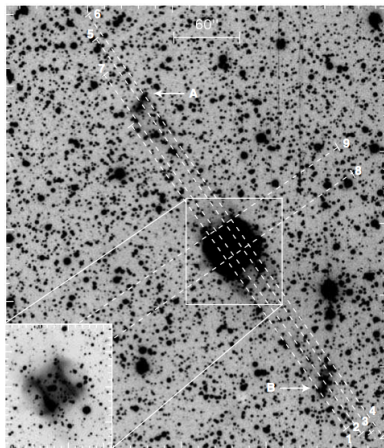
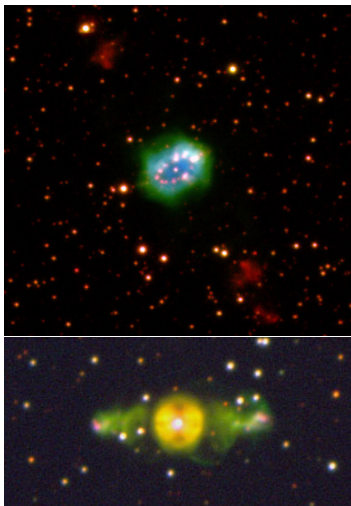
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Polar outflows

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Polar outflows

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Trends

Summary





Polar Outflows

Ages?

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PN	t_{nebula} (yrs/kpc)	t_{jets} (yrs/kpc)
A 63	3500 ± 200	5200 ± 1200
The Necklace	1100 ± 100	2350 ± 450
ETHOS 1	900 ± 100	1750 ± 250
Fg 1	5000	6000-16000
NGC 6337	~ 9200	~ 1000

NGC 6337

García-Díaz et al. (2009)

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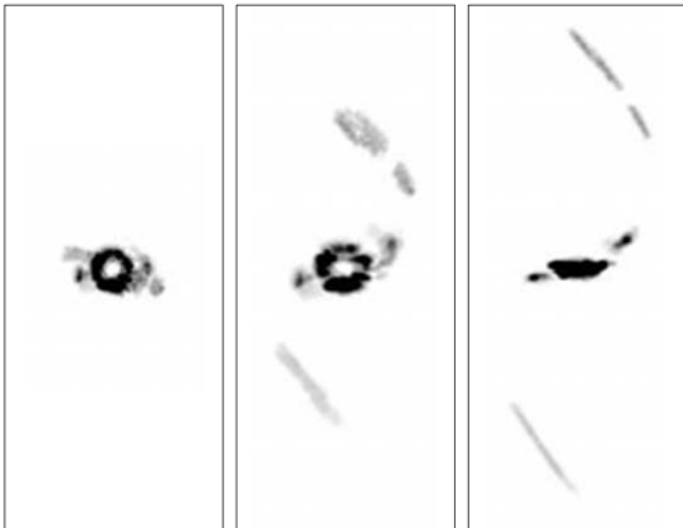
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So far, so good, so what?

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- CE shaping model fits
 - pre-CE mass transfer episodes!
- Still small numbers
 - Time for less detailed but multi-object investigation?
- Speculation time?





Morphology linked to period?

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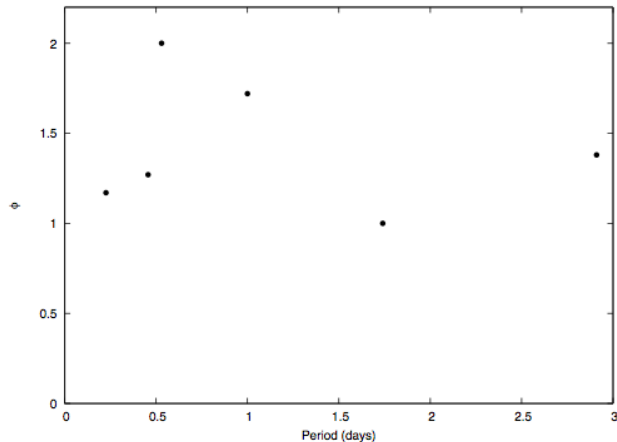
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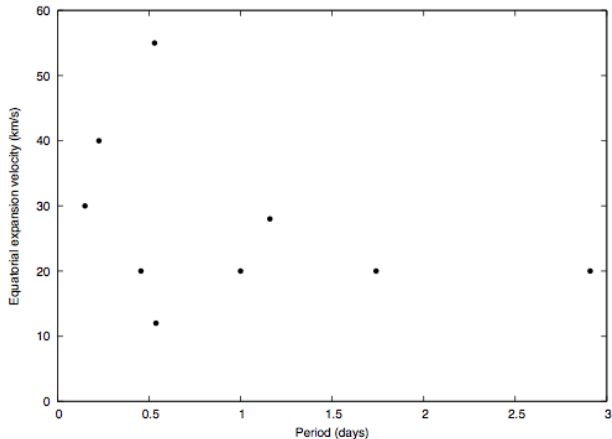
Expansion velocity linked to period?

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- PNe are *definitely* shaped by binary stars
 - But too soon to link parameters
- Morphologically disparate
- Polar outflows before CE phase?