

# Close Binary Central Stars and their Planetary Nebulae



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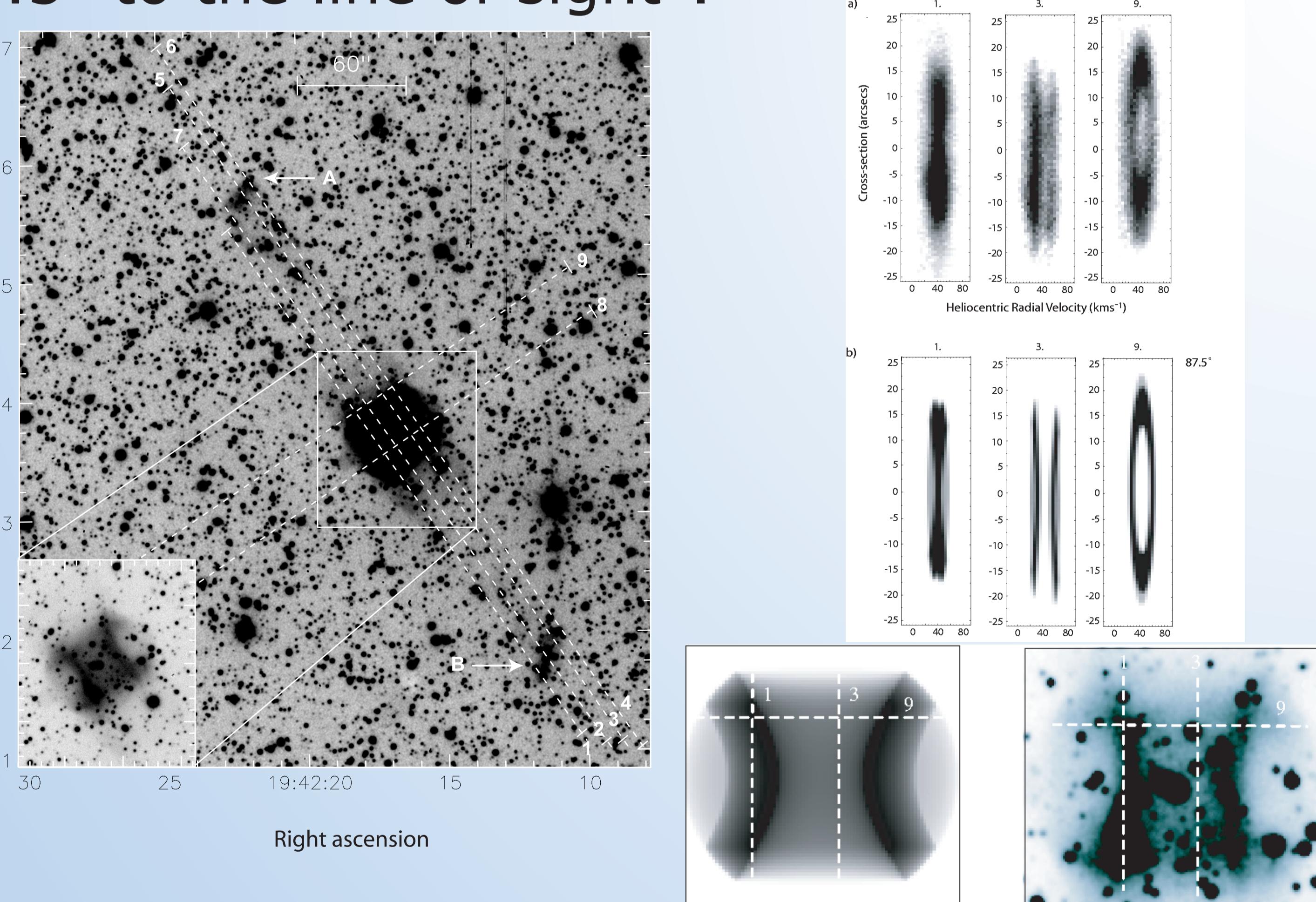
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## Introduction

Binary central stars are widely believed to play an important role in the shaping of Planetary Nebulae (PNe)<sup>1,2</sup>. To date about 10-15% of PNe are believed to have binary central stars<sup>3</sup>, and less than 30 PNe are known to contain close binary systems<sup>2</sup>. In 2004 we began a programme to study the PNe around known close-binary central stars to look for evidence of the effects of the binary systems on the nebular shapes.

## Abell 63

This PNe contains the eclipsing binary UU Sge, which has an orbital period of 11.2 hours and consists of an sdO primary ( $0.9 M_{\odot}$ ) and a dK secondary ( $0.4 M_{\odot}$ ), at a distance of  $2400+/-400$  pc. The orbital plane is inclined at  $87.5^{\circ}$  to the line of sight<sup>4</sup>.

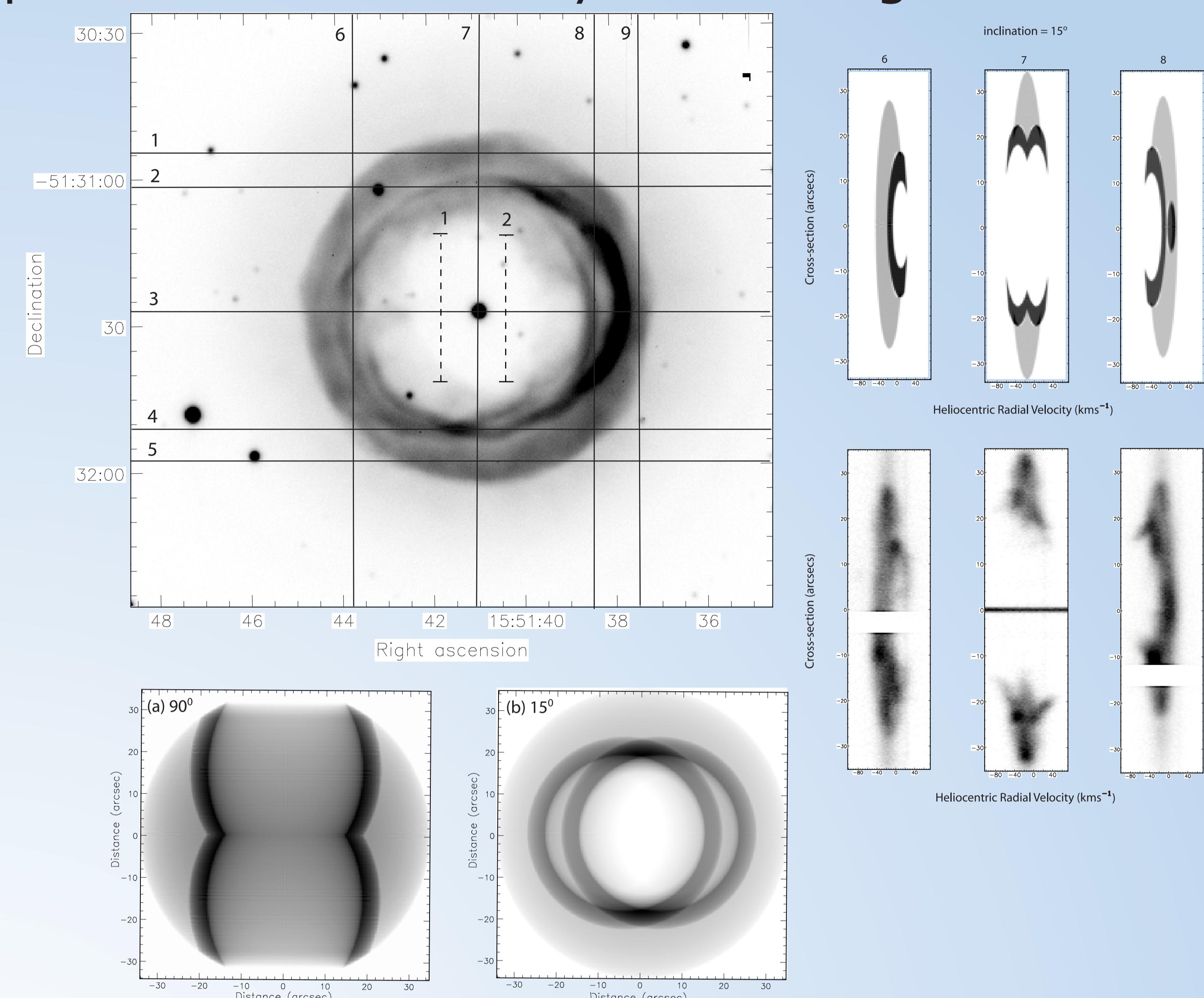


The H $\alpha$ +[N $_{\text{II}}$ ] image of A63 shows a barrel-shaped nebula ([O $_{\text{III}}$ ] image inset) and two end-caps (A and B), bright in [N $_{\text{II}}$ ] emission. Examples of longslit spectra from some of the marked slit positions are shown, together with synthetic spectra obtained from a model nebula inclined at the same angle to the sky as the binary central system<sup>5</sup>.

These results show, for the first time, a direct connection between the orientation of the binary system and the surrounding PN.

## Sp 1

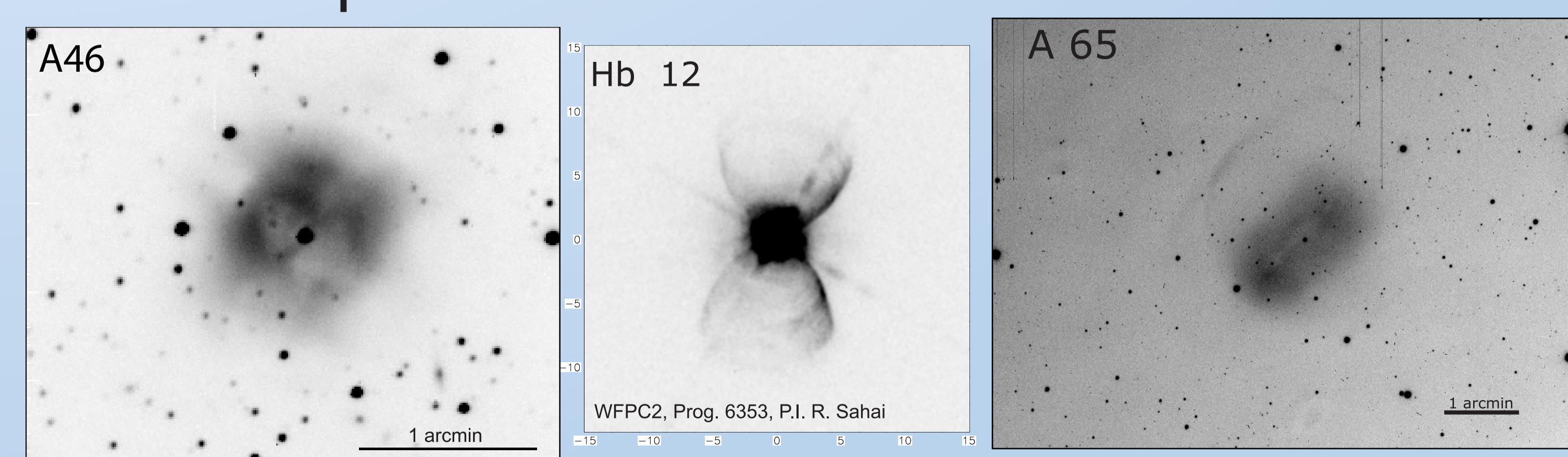
The binary system at the centre of this PN has a period of 2.91 days and shows a photometric variability of 0.1 mag in B-band<sup>3</sup>.



The [O $_{\text{III}}$ ] image of Sp1 shows a ring-like nebula, believed to be a bipolar viewed almost end-on. Examples of longslit spectra from some of the marked slit positions are shown together with synthetic spectra from a model tilted at  $15^{\circ}$  to the sky. Initial attempts to model this system with a suitably scaled version of the A63 model were unsuccessful and so an alternative, cusp-waisted model was used. If the binary system is aligned with the nebular orientation, then the secondary must be filling its Roche lobe in order to produce the observed reflection effect seen in the light curve<sup>6</sup>.

## Work in Progress

We have (or are about to obtain) data on most of the PNe with known close binary central stars, including these examples, and expect to learn much more about how these stars shape their nebulae.



A 46 - eclipsing binary, period 11.3 hrs<sup>7</sup>

Hb 12 - eclipsing binary, period 3.4 hrs<sup>8</sup>

A 65 - eclipsing binary, period 1 day<sup>9</sup>

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