The nature of M 2-29

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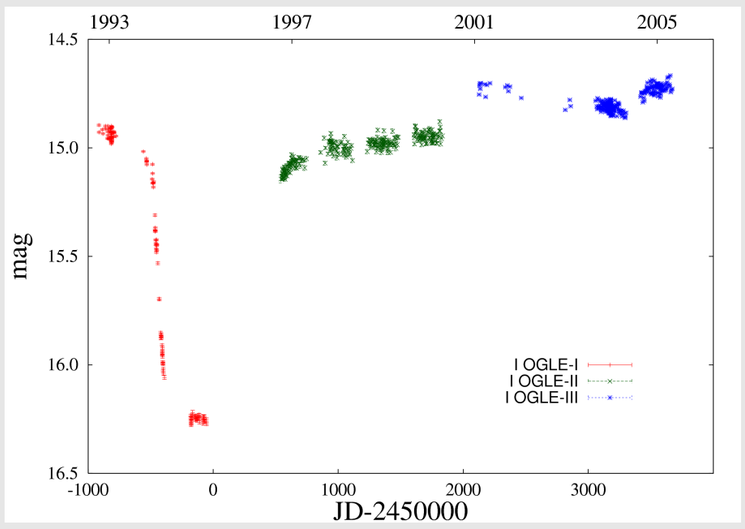
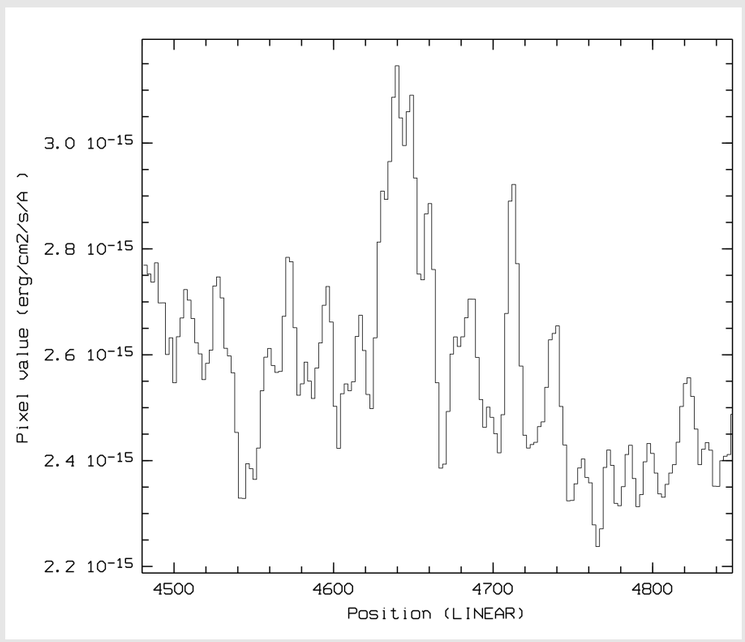
CSPN light curve and spectrum



M 2-29 was observed by the OGLE in I and V bands Udalski et al. (2002) and MACHO (blue and red band) surveys. For presented here OGLE I photometry, collected during 3 epochs, a linear shift was performed in order to reduce the systematic offset between the epochs.

In the OGLE-I long period and non-periodic variables catalogue by Zebrun (1998) the variable V035 (i.e. M 2-29), in the MM1-B field is classified as an R CrB type star candidate.



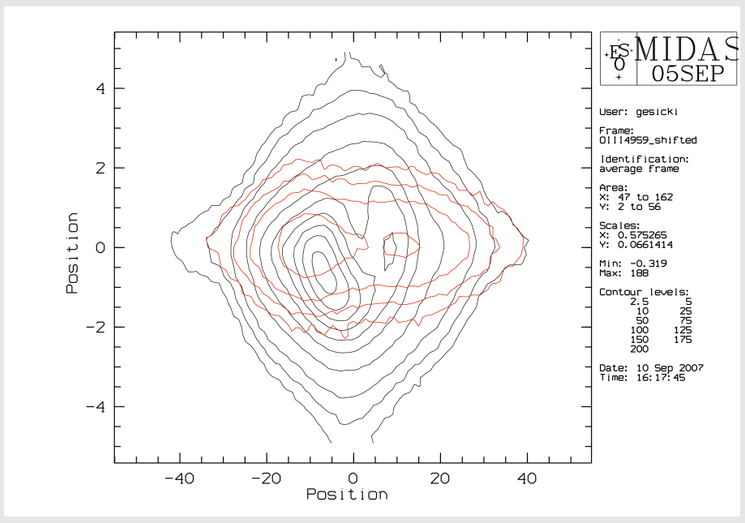
A low dispersion optical spectrum has been obtained in 2005 with 1.9 m SAAO telescope. Above is shown its fragment important for classification.

Because He II 4685 Å line is very weak (if detected at all), the star is probably not of Of type.

The "blend 4650", composed of N III 4634 Å, N III 4641Å , C III 4650 Å and C IV 4658 Å, is detected and its four components are resolved.

The emission lines of C IV 5801+5812 Å and C III 5696 Å are not detected, however the presence and strengths of the "blend 4650" allows to classify M 2-29 central star as *wels* (Tylenda et al. 1993, Marcolino & de Araujo 2003).

Nebular spectrum



The VLT echelle spectrum has been obtained in 2005, through the center of the nebula, with the slit aligned with the jet. The contours for 2-D spectra in [O III] lines 4363 Å (red) and 4959 Å (black) are shown above. The X-axis is expansion velocity in [km/s], the Y-axis shows offset (in arcsec) from the centre, the jet is directed down from centre.

We can see that:

the lines of different excitation have different spatial distribution, the inner region has higher electron temperature

the expansion velocities are very low

the jet velocity, as probed by [O III] 4959 Å line, is directed towards us and is decreasing outwards

the inner unresolved nebula, probed by [O III] 4363 Å line, seems to be a bipolar outflow

and image

In 2003 we obtained SNAPshot WFPC2 images of M 2-29, the image in Hα line is shown above, image in [OIII] 5007 Å line is almost identical. We can distinguish four components:

- faint outer halo of 4 arcsec in diameter
- main ring of 3 arcsec in diameter
- unresolved central nebula
- monopolar jet-like structure extending up to the outer halo limits

Discussion

Planetary nebula M 2-29 (PNG 004.0-03.0) and its central star are rather little known. It is located towards Galactic centre although its probable distance is about 4 kpc (Pena et al. 1991). Pena et al. (1992) classified the central star as H-deficient O to Of type. Chemical abundances of the nebula suggest that it belongs to Population II (Pena et al. 1991, Howard et al. 1997).

Gesicki & Zijlstra (2000) obtained the black-body temperature for the star of 75 000 K. They derived very small expansion velocity of 14 km/s for the main ring and (assuming Galactic Bulge distance) the age of 5200 yr. Adopting smaller distance would result in a younger nebula.

The presented here light curve is a unique event among CSPN. The slow recovery suggests an obscuration event of R CrB type, but an unusual one with much longer time scale and much smaller amplitude. An extraction of the nebular emission spectrum would increase the amplitude resulting in better agreement with R CrB. However if we play a little with the uncertain offset between different observing epochs then we would obtain a symmetric light curve, very likely with a flat bottom, indicating an eclipse or transit.

Assuming that the 1995 dimming event is an eclipse we could conclude that this is a long-period binary with orbital plane perpendicular (almost) to the sky. Assuming that this was a dust obscuration of R CrB type also leads to a binary system because a hot component is needed to ionize the nebula.

The seen in new HST images jet-like structure is also unusual among planetary nebulae. The jet is moving very slowly as derived from spectra, what can be explained if it is lying in the plane of the sky, maybe along the axis of the binary orbit. The HST archive image from 1993 is unfortunately of poor quality and therefore is not conclusive regarding any possible expansion.

The nebular spectrum, although of poorer spatial resolution than HST image, shows interesting features. The jet, strong in [O III] 4959 Å emission, has a decreasing outwards velocity. A trace of counterjet seems to be present. Another bipolar structure is emerging from unresolved central region of higher electron temperature.

The [O I] 6300 Å line, not presented here, shows a single narrow component, spatially unresolved. This means that the neutral gas is placed near ionized central nebula. This is similar to the situation in some symbiotic stars, e.g. V 1016 Cyg (Willson et al. 1984) where the neutral gas is present in the wind of the cool star.

References

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