weak emission lines
in multipolar planetary nebulae

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multipolar planetary nebulae in Galactic bulge sample

High imaging quality of HST provided many detailed images of planetary nebulae (PN) and complicated a simply morphological classification of elongated nebulae as elliptical or bipolar. There are identified many multipolar structures posing a question how much remain misclassified, we mention here only the recent contribution of Hsia et al. [H2014] where 10 PNe were decomposed into numerous bipolar lobes.

We collected a sample of 36 Galactic bulge compact planetary nebulae HST/WFPC2 images and VLT/UVES echelle spectra, the objects were randomly selected and not biased towards any morphology. The objects often show complicated morphologies refusing a simple classification. Nevertheless it was possible to identify 6 bipolar objects and 8 multipolar. The bipolar PNe have appearance of two point-symmetric closed lobes. The multipolar appear similarly however they show definitely more than a single pair of lobes, often two such point-symmetric pairs, sometimes three. They are shown at right-hand side.

Skipping their spatial and kinematical decomposition we turned attention to their central stars (cspn).

narrow and weak emission lines in multipolar planetary nebulae

We noticed an interesting correlation:
from the 8 multipolar PNe 7 reveal a presence of narrow emission lines usually attributed to central star.

Four of those PNe were already classified in the literature as 'wels' and one as [WC11] (see the table at upper-right). Our high quality spectra allowed for search of stellar emissions. We identified the well known emission complex near 4650Å for PNe classified wels and [WC11] and for two other multipolar PNe not classified previously. The two `new' emission stars display the emission complex very clearly and very reach in narrow components. It is likely that both objects fall into either wels or Of group.

In the sample of 36 PNe there are only two more objects assigned in the literature as wels or [WC11]. When we look at their images (shown at right further down) we see that they actually might represent multipolar PNe. One can think of a juxtaposed 2-3 pairs of lobes directed towards the observer. So they might confirm the relation between multiple lobes and narrow stellar emission lines.

In our sample there are many more PNe which display weak and narrow stellar emissions:

4650Å emission complex can be identified in up to 15 objects
CIV 5805Å can be identified in up to 8 objects, 7 of which also show 4650Å
CIII 5696Å can be identified in up to 7 objects, 3 of which also show 4650Å
the uncertainties in identifications are related to low S/N and echelle order merging errors

However a reverse correlation (weak emission pointing to multiple lobes) cannot be proven.

The probable pole-on multipolars show that orientation effect can play a role (a disk present?). Both [WC11] PNe show CIII 5696Å emission however H 1-43 shows the 4650Å emission while H 1-55 doesn't.

discussion

We are conscious that we are dealing with a small number of objects and any statistics would be biased. But our objects are not alone. The literature search for `multipolar' PNe finds more of them having central star of types wels or [WC] i.e. definitely displaying stellar emission lines:

He 2-47 and M 1-37 (the starfish twins) were assigned by [W2011] as cspn `emission' and [WC11]
He 2-113 - a multipolar PN has a [WC10] cspn according to [S2000]
NGC 5189 is a multipolar PN with [WC2] cspn according to [S2012]
NGC 6309 is multipolar with cspn of type wels by [W2011] or O(He) by [W2015]
NGC 6644 is multipolar [H2010] and wels [G2004]
NGC 7026 is multipolar PN with [WC3] cspn according to [C2013]

It seems that the extra nebular activity which manifests itself as the multiple nebular lobes is somehow related to the extra (circum?)stellar activity displayed by the narrow emission lines, in particular by the 4650Å blend.

We need a better understanding of the formation of these narrow and weak emission lines. The idea of irradiation by a binary component [W2009] looks promising, maybe an irradiated disk should be considered.

what is `wels' ?

introduced by Tylenda et al. [T1993]:
the only stellar emissions detectable are
the complex near **4650Å** and/or **CIV 5805Å**

usually assumed as **hydrogen deficient**
however recently [W2015] have shown that
this is not a necessary condition

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wels is not a spectral type,
its use should be restricted to mean
"insufficient spectral resolution."

what is 4650Å emission complex ?

it is a blend of NII NIII OII CIII CIV lines
in different proportions and strengths

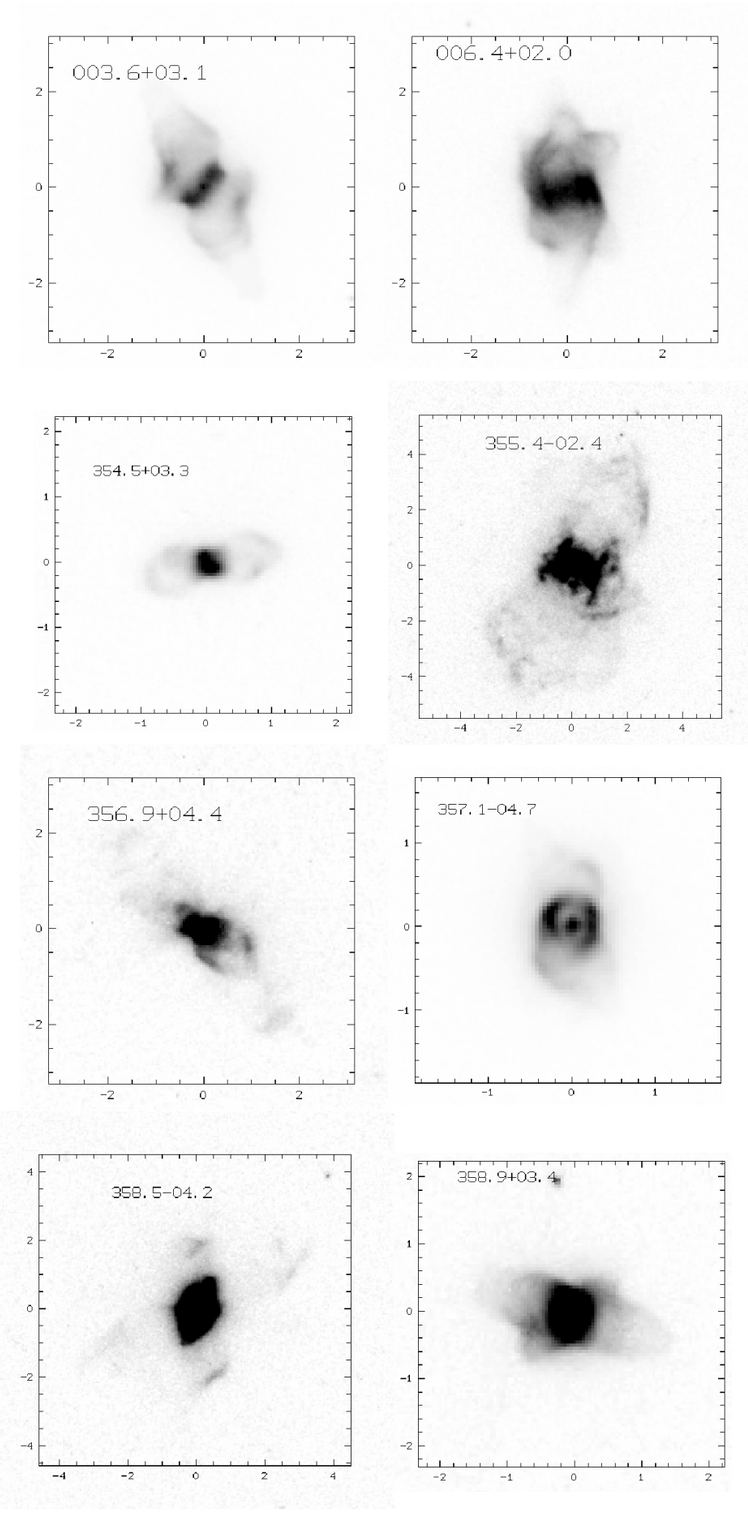
it is a feature of stars of types:
Of, O(H), WR, [WC], wels, ...

excitation mechanism is not well established,
considered are: dielectronic recombination,
and fluorescence either line or continuum

in standard atmospheric models this blend is in absorption; however it can be explained through irradiation by a binary component [W2009]

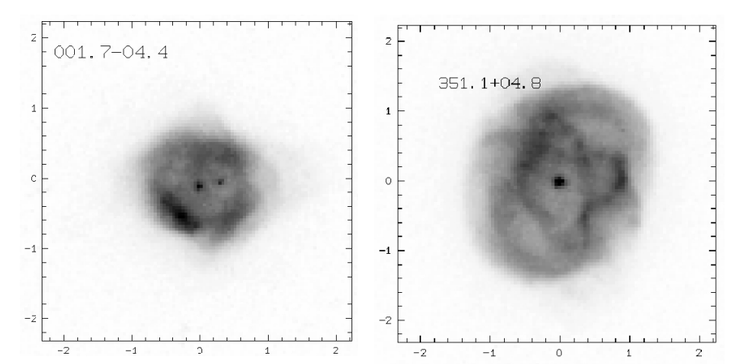
multipolar nebulae of classic appearance

PN G No.	name	weak	stellar (?) emission
003.6+03.1	M 2-14		wels [G2004]
006.4+02.0	M 1-31		wels [G2004]
354.5+03.3	Th 3-4		
355.4-02.4	M 3-14		emiss. near 4650Å
356.9+04.4	M 3-38		wels [D2011]
357.1-04.7	H 1-43		[WC11] [G2004]
358.5-04.2	H 1-46		emiss. near 4650Å
358.9+03.4	H 1-19		wels [D2011]



probable multipolar nebulae seen pole-on

PN G No.	name	weak	stellar (?) emission
001.7-04.4	H 1-55		[WC11] [W2011]
351.1+04.8	M 1-19		wels [G2004]



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This publication was supported by the Polish National Science Centre (NCN) through the grant 2011 / 03 / B / ST9 / 02552