X-ray Aureola of Central Stars

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Abstract. We report the discovery of a correlation between X-ray luminosity of PNe and bolometric luminosity of central stars from CHANDRA data and discuss briefly its interpretation.

1. X-ray properties of the PNe ensemble

The ROSAT All-Sky Survey indicated that about 25% of all PN were X-ray sources. Non-detections were explained away as selection effects. Discovery by CHANDRA observatory of X-rays from NGC 7027, not detected previously, demonstrated that all PN may generate X-rays (Guerrero et al. 2000, Kastner et al. 2000). A “hot bubble” formed when the recent supersonic (1000 km sec$^{-1}$) wind rams into the ejected slowly moving (10 km sec$^{-1}$) red giant envelope is presumably responsible for the diffuse X-ray source (Volk & Kwok 1985) with characteristic temperatures of a few MK. The point X-ray sources with similar temperatures may be produced by the fast radiatively driven stellar wind of central stars (CS). On the other hand the photospheric emission of a central white dwarf would result in much lower ($10^{5}$K) temperatures of X-ray emission. To date CHANDRA has pointed observations of only four PNe and NGC 7009 was observed with XMM-NEWTON recently (Guerrero et al., these proceedings). All of those PNe possess rather hard X-ray spectra.

Table 1. CHANDRA observavtions of PN

<table>
<thead>
<tr>
<th>PN (NGC)</th>
<th>$N_{H}$ (10$^{21}$ cm$^{-2}$)</th>
<th>$N_{H}$ (10$^{21}$ cm$^{-2}$)</th>
<th>CS2 (cps)</th>
<th>CS2 (cps)</th>
<th>Log($L_{X}$/$L_{bol}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6543</td>
<td>0.042</td>
<td>0.002</td>
<td>-5.55</td>
<td>-5.55</td>
<td></td>
</tr>
<tr>
<td>7027</td>
<td>6.0</td>
<td>0.014</td>
<td>—</td>
<td>-5.64</td>
<td></td>
</tr>
<tr>
<td>7293</td>
<td>0.044</td>
<td>0.044</td>
<td>-5.79</td>
<td>-5.79</td>
<td></td>
</tr>
<tr>
<td>BD+303639</td>
<td>0.99</td>
<td>0.244</td>
<td>—</td>
<td>-5.22</td>
<td></td>
</tr>
</tbody>
</table>

1 counts per second  2 counts detected from central star

It is intuitively clear that for any mechanism of X-ray production involving interaction of the fast radiatively driven wind from the CS the correlation of X-rays and wind momentum may be expected. Nevertheless it was not reported before. We decided to seek such a correlation which would have a rationale based on the wind momentum–luminosity relation for central stars of PNe (Pauldrach, these proceedings).

Table 1 summarizes the results of CHANDRA’s PN pointings (Kastner et al. 2000; Kastner et al. 2001; Guerrero et al. 2001; Chu et al. 2001). The errors are small and comparable for all measurements (~0.002 cps) and $L_{X}$ are calculated

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using the same distance as $L_{\text{bol}}$ making their ratio distance independent. Though only four in number these objects clearly demonstrate a tight correlation of total X-ray luminosity with central star luminosity $L_X \sim 10^{-5.5} L_{\text{bol}}$, despite their different X-ray morphology (Fig. 1). This is especially intriguing because of the different nature of the central stars in this sample including [WC] stars (NGC 6543 and BD+303639) and a WD (NGC 7293) where no strong stellar wind is detected. Clearly, more observations are needed.

2. Possible detection of X-ray emission of a PN in the SMC

We report detection of the X-ray emission of an area coinciding with the location of PN LHA 115-N 70 which is detected during 100 ksec CHANDRA’s ACIS-S exposure of a stellar cluster in Small Magellanic Cloud. There are a total of 18 counts from two illuminated pixels. The average size of a PN in SMC derived according to the review of Jacoby et al. (1990) is 0.73 arcsec. The ACIS-S’s pixel size is 0.49 arcsec. The estimated luminosity is $L_X \approx 0.28 \pm 0.28 L_\odot$ applying $N_H = 2 \times 10^{21} \text{cm}^{-2}$ when $D = 65 \text{kpc}$.

References