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Chandra and XMM–Newton Observations of H_2O Maser Galaxy Mrk 348

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Abstract. For H_2O megamaser galaxy Mrk 348, Chandra and XMM–Newton data are analysed. The nuclear fitting results of XMM–Newton data suggest the possible existence of a heavily obscured AGN. But the nuclear spectrum extracted from Chandra cannot be well-fitted by the best fitting model for XMM–Newton. Further optimal fitting and discussions are needed.

Key words. Maser—galaxies: active—galaxies: nuclei—galaxies: individual (Mrk 348)—X-rays: galaxies.

1. Introduction

Because of its ultraluminosity, a H_2O megamaser ($L > 10L_{\odot}$) has been considered to be related to an AGN, which is supported by statistical analysis of maser luminosity, nuclear X-ray luminosity and central black hole mass (Kondratko *et al.* 2006). Observations show that H_2O maser spots are located preferentially in the obscured nuclear region of Sy 2 or LINERs and most of them are heavily obscured ($N_{\rm H} > 10^{23}\,{\rm cm}^{-2}$), and are even Compton-thick ($N_{\rm H} > 10^{24}{\rm cm}^{-2}$, Zhang *et al.* 2010). For X-ray penetrability, observations of nuclear hard X-ray emission provide one effective method to probe those obscured nuclear regions with maser spots.

Mrk 348 is a nearby Sy 2 galaxy ($z = 0.015$, Huchra *et al.* 1999) for which there is evidence of a broad Hα-line component (FWHM $\sim 7400\,{\rm km\,s}^{-1}$) in the polarized light (Miller & Goodrich 1990). Falcke *et al.* (2000) reported the discovery of a very luminous H_2O maser in Mrk 348 during a radio flare of AGN.

2. Data reduction and analysis

Mrk 348 was observed by Chandra and XMM–Newton on 2010 October 13 (ID: 12809) and 2002 July 18 (ID: 0067540201), respectively. These data are processed separately using CIAO v4.4 and SAS v12.0.

2.1 *Spatial analysis*

From Chandra and XMM–Newton X-ray smoothed image, the nucleus X-ray emission is more stronger, especially in the hard band (see Fig. 1).

2.2 *Spectral analysis*

The nuclear spectra are extracted from Chandra (radius is $5''$) and XMM–Newton (radius is $40''$) data. We extracted the background spectra from nearby regions free of other X-ray sources in the same CCD. The RMF and ARF of the nuclei are computed. Then for the statistics, all spectra are grouped to contain not < 50 counts per bin. The spectral fits are performed using XSPEC v 12.7.1 package. All errors quoted below correspond to 90% confidence level for the interesting parameter, i.e., $\Delta\chi^2 = 2.71$.

The models, which were used in previous papers for the spectra from EPIC PN (Awaki *et al.* 2006; Noguchi *et al.* 2009; Brightman & Nandra 2011; Singh *et al.* 2011), are used to fit simultaneously for EPIC MOS (mos 1 + mos 2) and PN of XMM–Newton. Only the model in Singh *et al.* (2011) can fit well in these spectra. The best fit model to 0.2–10.0 KeV spectra includes an absorbed power-law ($N_{\rm H} = 7.13 \pm 0.76 \times 10^{22}\,{\rm cm}^{-2}$, $\Gamma = 1.77 \pm 0.04$) with partial covering ($N_{\rm H} = 10.22 \pm 0.42 \times 10^{22}\,{\rm cm}^{-2}$, covering fraction $f = 0.87 \pm 0.04$) for the hard component, another power-law ($\Gamma = 2.45 \pm 0.07$) for the soft component and a narrow Gaussian fitted to the Fe Kα line (EW$\sim$48 eV) (see Fig. 2).

The common model for Seyfert 2 and the above models cannot be well-fitted with the Chandra spectra. Residuals in terms of sigma show significant excess in 2–4 KeV and over 8 KeV in all model fitting results (see Fig. 2). The Fe Kα line at 6.4 KeV was not detected in the observations, and a line can be found at $\sim$6.9 KeV.

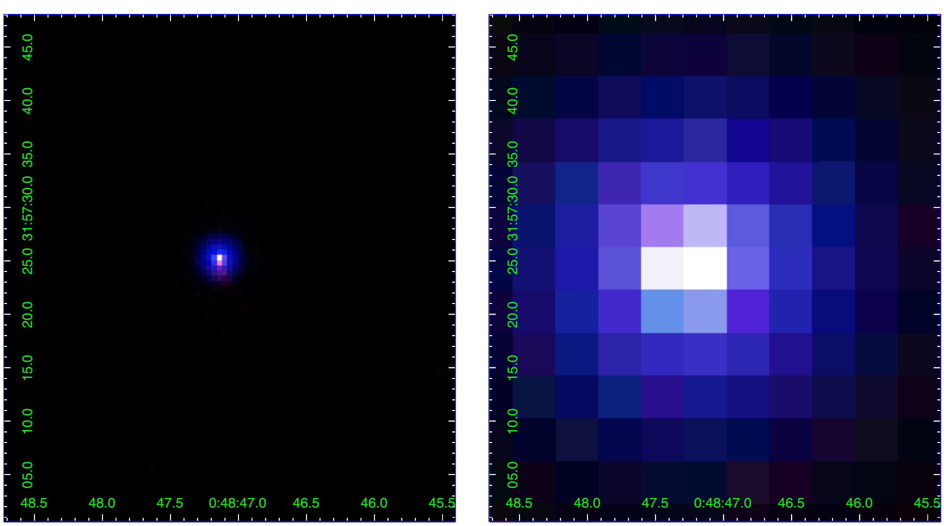

Figure 1. Adaptively smoothed three-colour image. *Left*: Chandra. *Right*: XMM–Newton PN. Red: 0.3–0.8 KeV, green: 0.8–2.0 KeV, blue: 2.0–8.0 KeV.

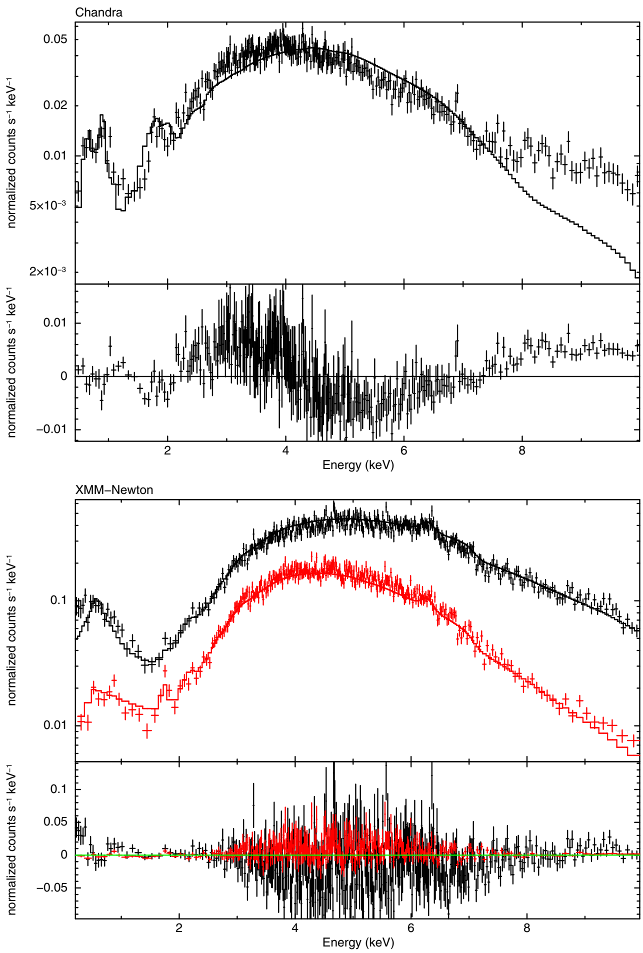

Figure 2. Spectra of the nuclear regions and the fitting models wabs(mekal + zwabs * pow) for Chandra (*top*) and wabs(pow + zwabs * pcf * pow + gau) for XMM–Newton (*bottom*). Black: PN spectrum, red: MOS spectrum.

3. Discussion

For the nuclear X-ray of XMM–Newton, the hard X-ray spectra are best fitted by a partial absorbed power-law model with absorbing column density $N_{\rm H} \geq 10^{23}{\rm cm}^{-2}$. Both the notable iron fluorescent line and detected nuclear H_2O maser spots support the possible existence of a heavily obscured AGN. But the spectrum extracted from Chandra observations cannot be well-fitted by this model. The hard X-ray spectra becomes flat over 8 keV and this may be caused by reflecting from the high density gas which transited the line-of-sight. Further complex fitting and discussions are needed.

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