Spectral properties of soft X-ray transient MAXI J0637−430 using AstroSat

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ABSTRACT

Soft X-ray transients are systems that are detected when they go into an outburst, wherein their X-ray luminosity increases several orders of magnitude. These outbursts are markers of the poorly understood change in the spectral state of these systems from low/hard state to high/soft state. We report the spectral properties of one such soft X-ray transient: MAXI J0637−430, with data from the SXT and LAXPC instruments on-board AstroSat mission. The source was observed for a total of ∼ 60 ks over two observations on 8th and 21st November, 2019 soon after its discovery. Flux resolved spectral analysis of the source indicates the presence of a multi-colour blackbody component arising from the accretion disk and a thermal Comptonization component. The stable low temperature (∼ 0.55 keV) of the blackbody component, points to a cool accretion disk with an inner disk radius of the order of a few hundred km. In addition, we report the presence of a relativistically broadened Gaussian line at 6.4 keV. The disk dominated flux and photon power law index of ≲ 2 and a constant inner disk radius indicate the source to be in the soft state. From the study we conclude that MAXI J0637−430 is a strong black hole X-ray binary candidate.

Keywords: Accretion — X-ray binaries — Transients — Black Hole physics

1. INTRODUCTION

Soft X-ray transients are a subclass of low mass X-ray binaries (LMXBs) that appear as extremely faint sources (L = 10^{30} – 10^{33} erg s^{-1}) during most of their lifetime. They are characterized by a non-steady transfer of mass onto the compact object and they occasionally undergo sporadic outbursts, which occur at intervals of 1 - 60 years (Chen et al. 1997; Tetarenko et al. 2016). This causes their X-ray luminosity to increase by a factor of upto 10^{7} (Paradijs & McClintock 1995) which then decays back to quiescence with an e - folding timescale of ∼ 30 days (Chen et al. 1997). During the short outbursts, they emit enough X-rays, which makes them the brightest X-ray sources (L = 10^{37} – 10^{38} erg s^{-1}) in the sky. The occurrence of these outbursts is attributed to instabilities in the accretion disk that are both viscous and thermal in nature (Meyer & Meyer-Hofmeister 1981; Cannizzo et al. 1995; King & Ritter 1998; Lasota 2001). Soft X-ray transients, especially the ones harbouring a black hole, usually go undetected; and are discovered only when they undergo an outburst.

MAXI J0637−430 is one such source, which was first detected by the MAXI/GSC nova alert system during seven scan transits from 2nd – 3rd November, 2019 in the 2 – 4 keV and 4 – 10 keV bands. The scans revealed the source to be located at RA (J2000) = 06 h 38 m 54 s, Dec (J2000) = −42 h 45 m 57 s in the soft band (2 – 4 keV) and at RA (J2000) = 06 h 37 m 43 s, Dec (J2000) = −43 h 03 m 15 s in

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the hard band (4 – 10 keV) with 90% confidence level (Negoro et al. 2019). Since its first detection, MAXI J0637−430 underwent a considerable increase in its flux from 59 ± 6 mCrab to ~ 200 mCrab in the 2 – 4 keV band and from 32 ± 6 mCrab to ~ 50 mCrab in the 4 – 10 keV band (Negoro et al. 2019). A Target of Opportunity (ToO) observation performed on 3rd November, 2019 by the Swift mission detected MAXI J0637−430 at RA (J2000) = 06 h 36 m 23.23 s, Dec (J2000) = −42 h 52 m 04.1 s, which was consistent with MAXI’s hard band localization. Its X-ray spectrum modelled using absorbed disk blackbody + power law with inner disk temperature (kTin) of 0.9 ± 0.1 keV and power-law index (Γ) of 2.3 ± 0.8 indicated that the source underwent an outburst and transitioned from hard to soft spectral state. An optical counterpart with a brightness of u = 14.87 ± 0.02 (Vega) was detected by the UVOT instrument on-board Swift at RA (J2000) = 06 h 36 m 23.23 s Dec (J2000) = −42 h 52 m 04.1 s. Since there are no known stars at this position, it was deemed that this optical source underwent a significant brightening, as is common for the optical counterpart of black hole low mass X-ray binaries (BH-LMXBs) during outbursts (Kennea et al. 2019). Follow up observation by the NuStar mission found the source to be at a flux of ~ 95 mCrab. Preliminary analysis of spectrum of the source in the energy range 3 – 79 keV with a thermal disk blackbody component, power law and a reflection component yielded a kTin of 0.628 ± 0.004 keV and a Γ of 2.40 ± 0.04 (90% confidence errors) (Tomsick et al. 2019). MAXI J0637−430 was also observed in radio band with the ATCA with flux densities of 66 ± 15 µJy at 5.5 GHz and 60 ± 10 µJy at 9 GHz (Russell et al. 2019). However, as the nature of the radio jet emission could not be deciphered, the source could not be properly classified using the radio/X-ray correlation in X-ray binaries. The source was also observed in infrared band with the simultaneous imaging camera SIRIUS attached to 1.4 m telescope InfraRed Survey Facility (IRSF), where the estimated magnitudes in the J, H and K bands were 17.40 ± 0.01, 17.69 ± 0.02 and 17.96 ± 0.05, respectively (Murata et al. 2019). Spectral analysis of the X-ray data from Swift observations with an absorbed disk blackbody model showed the source to have a kTin of 0.675 ± 0.003 keV (Kniege et al. 2019), which is consistent with the value obtained from NuStar observations. Since its discovery, MAXI J0637−430 was observed by the NICER mission continuously with a cadence of 1-2 days, which observed it undergo a spectral state transition. After ~ 23 days since its discovery, it was reported that source transitioned into the hard state (Remillard et al. 2020). Subsequent observations by Swift showed that MAXI J0637−430 could possibly be approaching its quiescence level (Tomsick & Lazar 2020). A multi-wavelength study of the source was carried out by Tetarenko et al. (2021) using data from Swift-XRT and UVOT, Gemini/GMOS, ATCA and AAVSO. This study made use of an irradiated accretion disk model - (diskir) (Gierliński et al. 2009) to derive the time-series evolution of its spectral parameters over the entire outburst cycle. Analysis of NICER data by (Jana et al. 2021) revealed the source to comprise of an ultra-soft thermal component (kTin ≤ 0.6 keV) and a power law tail. The study also showed that its spectra do not need a thermal component corresponding to the emission from neutron star surface, thus suggesting that the compact object in the MAXI J0637−430 is most likely a black hole. Mass of the black hole inferred from this study is 5 – 12 M⊙ for a source distance of d < 10 kpc and the distance to the source is found to have a lower limit of 6.5 kpc. Baby et al. (2021) found that the 0.5 – 25 keV spectra of the source could be modelled with a multi-colour disc emission (diskbb) convolved with a thermal Comptonisation component (thcomp). Spectral fitting with the kersbb model in conjunction with the soft-hard transition luminosity, favour a black hole with mass between 3 – 19 M⊙ and retrograde spin at a distance < 15 kpc. Broadband spectral study on NuSTAR data of the source showed that a two-component model, comprising of a combination of multi-color disk blackbody and thermal Comptonization component is adequate to fit the spectra only upto 10 keV. When higher energies are considered, scenarios involving a plunging region and reprocessing of returning disk radiation are equally possible (Lazar et al. 2021).

Encouraged by the observation campaigns carried out by various satellite and ground based telescopes, ToO observations of MAXI J06347−430 were performed using the Soft X-ray Telescope (SXT) and Large Area X-ray Proportional Counter (LAXPC) instruments on-board AstroSat in the 0.3 – 80 keV energy range on 8th and 21st November, 2019. Here, we report the results of spectral and temporal studies carried out on MAXI J0637−430 data from the SXT and LAXPC instruments. The details of AstroSat observations and the data reduction procedures are described in Section 2. In Section 3, lightcurve and hardness intensity diagram (HID) are presented. In Section 4, we present the results of spectral analysis. The findings and summary of the results are discussed in Section 5.

2. OBSERVATIONS AND DATA REDUCTION

ToO observations of MAXI J06347−430 (Thomas et al. 2019) in the 0.3 – 80 keV energy range were carried out using SXT and LAXPC on-board AstroSat for a total of ~ 60 ks on 8th (hereafter, Observation 1), 15th and 21st November, 2019 (hereafter, Observation 2). We did not include the 15th November data in our study as it contains 9-pointing safety observations for the UVIT instrument on-board AstroSat, each with different pointing and offset. Due to this, the spectra from the individual pointing could not be combined as the effective area of the instrument changes with the offset. Moreover, since the LAXPC pointings were also different, flux measurement using SXT+LAXPC data could not be made. AstroSat observations used for our study, marked on the 2 – 20 keV MAXI lightcurve in Figure 1 shows that Observation 1 was carried out shortly after the outburst peak, whereas Observation 2 was performed midway during the outburst decay. The Photon Counting mode (PC) was employed for observation with SXT, whereas for LAXPC, the observation was carried out in the Event Analysis Mode.
(EA). A log of observations used for this study is given in Table 1.

SXT is a focusing telescope equipped with a Charged Coupled Device (CCD) camera that performs X-ray imaging in the 0.3 – 8.0 keV energy range with a spectral resolution of \( \sim 150 \text{ eV} \) at 6 keV (Singh et al. 2016). SXT data of MAXI J06347–430 was processed using the standard SXT pipeline - AS1SXTLevel2-1.4b. This yielded Level 2 event files for individual orbits of the observation, which were then merged into one master event file using the SXT Event Merger Tool\(^2\). The merged event file was then used to extract source images with the help of XSELECT V2.4k. The source was selected between the region of 8\(^{th}\) and 5\(^{th}\) (inner radius) for Observations 1 and 2, respectively, and 15\(^{th}\) (outer radius) to reduce the effect of pile-up of the CCD. The response matrix files provided by the SXT Payload Operations Centre (POC) were used for the analysis. Off-axis Auxiliary Response File (ARF) was created with the sxt_ARFModule\(^3\). SXT data in the range 0.5 – 5.0 keV for Region 1 and 3; and 0.5 – 4.8 keV for Region 2 were used (Figure 4) as the data quality above and below these energy ranges were poor.

LAXPC is a cluster of three co-aligned proportional counters (LAXPC-10, LAXPC-20, LAXPC-30) that operates in the 3 – 80 keV energy range with an absolute temporal resolution of 10 \( \mu \text{s} \) (Yadav et al. 2016; Agrawal 2017; Antia et al. 2017). Data from LAXPC was processed with the LAXPC-\text{SOFT} (Format A)\(^5\) to obtain event files, Good Time Interval (GTI) files, lightcurves, source and background energy spectra, Response Matrix Files (RMF) and power density spectra. LAXPC-20 data alone was used for our study as it was reported by the POC that LAXPC-10 underwent an abnormal change in its gain on 28\(^{th}\) March, 2018 and LAXPC-30 was not operational during this time. Moreover, as the energy spectrum above 20 keV was background dominated, spectral studies using LAXPC were restricted to 4 – 20 keV energy range.

3. LIGHTCURVE AND HARDNESS INTENSITY DIAGRAM (HID)

Net lightcurves of the source were obtained in the 0.7 – 7.0 keV range from the SXT instrument; and 4.0 – 5.0 keV and 5.0 – 30.0 keV ranges from the LAXPC instrument. These lightcurves were binned to \( \sim 50 \text{ s} \). It is seen that during the beginning of the outburst decay i.e. in Observation 1, the source intensity remains fairly constant at \( \sim 30 \text{ counts/s} \) and \( \sim 28 \text{ counts/s} \) in the 4.0 – 5.0 keV (Panel 2 in Figure 2) and 5.0 – 30 keV (Panel 3 in Figure 2) ranges respectively. This then changes as the count rates in both energy ranges increase by a small factor towards the end of the observation. This jump in the count rate is reflected in the hardness-time diagram too (Panel 4 in Figure 2). In comparison, the LAXPC net flux along with the hardness ratio is seen to decrease monotonically through the latter part of the outburst decay i.e. in Observation 2 (Panels 2, 3 and 4 in Figure 3). Using LAXPC-20 data of both the observations, a combined, 50 s binned HID was generated with hardness defined as the ratio of counts in the 5.0 – 30.0 keV range to 4.0 – 5.0 keV range and intensity defined as the sum of counts in the 4.0 – 30 keV range. From the pattern traced by the HID, it is not possible to determine if the source showed characteristics of the q-diagram exhibited by BH-LMXBs (Remillard & McClintock 2006) or the Z or Atoll pattern exhibited by NS-LMXBs (Hasinger & van der Klis 1989). However, it is seen that the HID showed variability in hardness from \( \sim 0.9 \) to \( \sim 1.9 \) (Figure 4). Further, in order to investigate the hardness-intensity relation in energy range < 4 keV, data from the SXT instrument, corresponding to the three regions in the LAXPC-HID was used to generate an HID (Figure 5). The hardness of this SXT-HID was defined as the ratio of counts in the 1.0 – 7.0 keV range to 0.3 – 1.0 keV range and the intensity was defined as the sum of counts in the 0.3 – 7.0 keV range, for time corresponding to all the three regions from the LAXPC-HID. Regions 1 and 3 in this SXT-HID show variations in average flux and hardness, whereas Region 2 has too less data points to make a definitive conclusion.

![Figure 1](image.png)

**Figure 1.** 1 day binned MAXI lightcurve of MAXI J0637–430 in 2 – 20 keV band

4. SPECTRAL ANALYSIS

The simultaneous broadband X-ray spectral coverage of AstroSat with the SXT and LAXPC instruments was used to perform flux resolved spectroscopy. This was done by dividing the LAXPC-HID into 3 regions: Region 1, 2 and 3. The divisions were made such that each region denotes an isolated

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1. [https://www.tifr.res.in/~astrosat_sxt/sxtpipeline.html](https://www.tifr.res.in/~astrosat_sxt/sxtpipeline.html)
2. [https://www.tifr.res.in/~astrosat_sxt/dataanalysis.html](https://www.tifr.res.in/~astrosat_sxt/dataanalysis.html)
3. [sxt_pc_mat_g0to12.rmf](http://astrosat-ssc.iucaa.in/?q=laxpcData)
4. [SkyBkg_comb_EL3p5_C1_Rd16p0_y01.pha](http://astrosat-ssc.iucaa.in/?q=laxpcData)
5. [http://astrosat-ssc.iucaa.in/?q=laxpcData](http://astrosat-ssc.iucaa.in/?q=laxpcData)
Table 1. Observation log

| Obs. ID    | Date      | MJD   | Exposure (ks) | SXT | LAXPC |
|------------|-----------|-------|---------------|-----|-------|
| 9000003290 | 08-11-2019| 58795 | 8.7           | 6.5 |       |
| 9000003328 | 21-11-2019| 58808 | 19.1          | 24.8|       |

Figure 2. SXT lightcurve of the source in 0.7 – 7.0 keV energy range (Panel 1), LAXPC-20 net lightcurve in the energy ranges 4.0 – 5.0 keV (Panel 2) and 5.0 – 30 keV (Panel 3) and their hardness ratio (Panel 4) from Observation 1.

Figure 3. SXT lightcurve of the source in 0.7 – 7.0 keV energy range (Panel 1), LAXPC-20 net lightcurve in the energy ranges 4.0 – 5.0 keV (Panel 2) and 5.0 – 30 keV (Panel 3) and their hardness ratio (Panel 4) from Observation 2.

Cluster of points in the LAXPC-HID (Figure 4). Simultaneous GTIs for both the SXT and LAXPC instruments were generated, using which simultaneous spectra for both instruments were generated for all three regions of the LAXPC-HID. The spectra were then fit with the spectral modelling tool XSPEC version: 12.10.10 (Arnaud 1996) in the energy ranges 0.5 – 5.0 keV from the SXT instrument for Regions 1 and 3; and 0.5 – 4.8 keV for Region 2; whereas form the LAXPC instrument, the energy range 4.0 – 20 keV was chosen for all three regions. These energy ranges were chosen as the spectra below 0.5 and above 4.8 keV (from the SXT instrument) showed very high residuals and that above 20.0 keV (from the LAXPC) was dominated by the background. A multi-colour blackbody model - diskbb (Mitsuda et al. 1984), was used along with a convolution Comptonization model - simpl (Steiner et al. 2009), in order to explain the emission from the accretion disk and thermally Comptonized corona, respectively. The energy range for the spectral fits were extended using energies 0.01 100 500 log to supply an energy-binning array. To account for absorption in the interstellar medium, we used the Tuebingen-Boulder Inter-Stellar Medium absorption model - tbabs, with the solar abundance table given by Wilms et al. (2000). Further, a multiplicative constant factor was included to address uncertainties caused due to cross calibration of the SXT and LAXPC instruments. As prescribed by the POC, a systematic error of 3% was added to all spectral fit (Bhattacharya 2017). In addition to this, gain fit was performed for the SXT data to account for the non-linear change in the detector gain. Slope of the gain was frozen to 1 leaving the offset to vary. There were positive residuals around 6.4 keV indicating possible presence of a disk reflection feature. A Gaussian component with its line energy frozen at 6.4 keV was later added to account for this. The addition of the Gaussian component yielded a small change in $\Delta \chi^2$ from 1.03 and 0.92 to 1.0 and 0.76 in Regions 1 and 2 respectively; whereas for Region 3 it remained constant. The model combination - constant $\times$ tbabs(simpl $\times$ diskbb + gaussian)
yielded good fits for all the three regions, with $\Delta \chi^2$ of $\sim$ 0.9 (Figure 6). The best fit spectral parameters of this fit are given in Table 2 and the corresponding spectra are give in Figure 6. The Norm of diskbb remains fairly constant in all the three regions. Hence, in order to understand the observed variation in the HID, spectral fit was repeated with the Norm of diskbb fixed at 2075. This value was obtained by fitting a constant through the Norms of all the three regions. Further, the unabsorbed total and disk flux were calculated in the 0.5 $-$ 20 keV range using the cflux model. The best fit parameters of this spectral fit are given in Table 3.

In addition to this, we also carried out temporal analysis with data from the LAXPC instrument in the 4 $-$ 30 keV range. However, it did not yield substantial results.

5. RESULTS AND DISCUSSION

In this work, we analysed the SXT and LAXPC data from AstroSat observations (8th and 21st November, 2019) of MAXI J0637–430 in the 0.5 $-$ 20 keV energy range. The analysis revealed three distinct clusters in the LAXPC-HID of the source (Figure 4). However, these clusters do not form a clear pattern to give insights regarding the exact nature of the source. Monitoring the source through its entire outburst cycle with NICER and MAXI has revealed its HID to exhibit signatures of the various states of a BH-LMXB in outburst (Jana et al. 2021; Baby et al. 2021). Flux resolved spectral analysis showed that the spectra can be characterized by a multi-colour blackbody component arising from the accretion disk along with a thermal Comptonization component. Our choice of model - diskbb, to characterise the soft component is in agreement with erstwhile studies carried out on the source. However, different models have been used to characterise its hard component - powerlaw (Tetarenko et al. 2021), nthcomp (Jana et al. 2021; Lazar et al. 2021) and thcomp (Baby et al. 2021). The accretion disk temperatures, 0.61, 0.65 and 0.52 keV in Regions 1, 2 and 3 respectively, point to a cool disk. This is in agreement with the studies carried out by Tetarenko et al. (2021), Jana et al. (2021) and Baby et al. (2021), where the disk temperature is seen to decay from $\sim$ 0.6 to $\sim$ 0.1 keV during the course of the outburst. The slightly lower value of disk temperature in Region 3 correlates with the region being harder in the HID (Figure 4). The diskbb Norms of 2103, 1455 and 2083 in Regions 1, 2 and 3, indicate constant accretion disk radius throughout both the observations which is consistent with that exhibited by many BH-LMXBs in the soft state (Done et al. 2007). Similar results have been found by Baby et al. (2021) who used the convolution model thcomp along with diskbb to characterise the AstroSat spectra of the source. Assuming a source distance of 10 $kpc$, inclination angle of 70° and a colour hardening factor of 1.7 (Shimura & Takahara 1995), we calculated the inner disk radius to be $\sim$ 98, $\sim$ 81 and $\sim$ 97 $km$ in Regions 1, 2 and 3 respectively. For a black hole of 20 $M_\odot$, keeping the disk normalization constant at 2075, we estimated the inner disk radius to be $\sim$ 6 $R_g$. This is the distance at which the Innermost Stable Circular Orbit (ISCO) is located for a non-rotating black hole. The increase in scatter fraction (obtained using simp1 model) from 0.016 $^{+0.004}_{-0.003}$ in Region 1 to 0.031 $^{+0.01}_{-0.006}$ in Region 2 reflects the increased LAXPC count rate in the HID. In addition, the presence of a Gaussian line at 6.4 keV points to a reflection feature from the accretion disk. The width of this line ($\sim$ 1 keV in Regions 1 and 2) shows that it is broadened due to relativistic effects around the vicinity of the central compact object. It is to be noted that the width and the Norm of the Gaussian component is significantly smaller in Region 3. The unabsorbed total flux and disk flux of the source in the 0.5 $-$ 20 keV range imply Eddington fraction of 0.025, 0.023 and 0.0141 for Regions 1, 2 and 3 respectively (Table 3). The ratio of
unabsorbed disk flux to the total flux ($\sim 0.9$) in all three Regions (Table 3), suggests that the total flux is dominated by emission from the accretion disk. This consistent disk dominated flux combined with the photon power law index of $\gtrsim 2$, across all the three regions of the HID, shows the source to be in soft state.

6. CONCLUSIONS

We carried out flux resolved spectral studies on two observations ($\sim 60$ ks) of the soft X-ray transient source MAXI J0637 $- 430$ in the $0.5 - 20$ keV energy range using the SXT and LAXPC instruments on-board AstroSat. Spectral analysis of shows the source to have a cool accretion disk having temperature $\sim 0.55$ keV with a reflection feature at 6.4 keV. The value of photon index of $\gtrsim 2$ and the ratio of unabsorbed disk flux to the total disk of $\sim 0.9$ points that MAXI J0637 $- 430$ was in the soft spectral state when observed by AstroSat. Also, it is seen that the value of the disk normalization is consistent with being constant (Table 2) and points to an accretion disk with an inner disk radius of $11.1 \ R_\odot$. This is observed in several BH-LMXBs in the soft state. We conclude from our study that MAXI J0637 $- 430$ is a strong black hole X-ray binary candidate. Further observations and in-depth studies of the source during its future outbursts are essential to confirm its nature and unravel other physical parameters.

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Table 2. Best fit model spectral parameters

| Model | Parameter | Region 1         | Region 2                  | Region 3                  |
|-------|-----------|------------------|---------------------------|---------------------------|
| tbabs | $N_H(10^{20} \text{cm}^{-2})$ | $3.30 \pm 0.006$ | $2.120^{+0.045}_{-0.021}$ | $1.250 \pm 0.005$         |
| simpl | $\Gamma$  | $2.00^{+0.14}_{-0.16}$ | $1.95^{+0.17}_{-0.20}$     | $2.46 \pm 0.03$           |
|       | $FracSctr$| $0.016^{+0.0004}_{-0.003}$ | $0.031^{+0.010}_{-0.009}$   | $0.100^{+0.0008}_{-0.008}$ |
| diskbb| $kT_{in}$ (keV) | $0.610 \pm 0.005$ | $0.650 \pm 0.030$ | $0.520 \pm 0.007$         |
|       | $Norm$    | $2103^{+165}_{-152}$ | $1455^{+714}_{-465}$       | $2083^{+104}_{-98}$       |
| Gaussian | $Line$ (keV) | $6.4(f)$       | $6.4(f)$                  | $6.4(f)$                  |
|        | $Width$ (keV) | $1.06^{+0.35}_{-0.40}$ | $1.49^{+0.42}_{-0.47}$     | $0.20^{+0.56}_{-0.37}$    |
|        | $Norm(10^{-3})$ | $1.39^{+0.60}_{-0.50}$ | $3.24^{+1.60}_{-1.40}$     | $0.34 \pm 0.30$          |
|        | Reduced $\chi^2/dof$ | $1.03/363$     | $0.76/109$                 | $1.33/460$                |

Table 3. Best fit model spectral parameters with fixed diskbb Norm

| Model | Parameter | Region 1         | Region 2                  | Region 3                  |
|-------|-----------|------------------|---------------------------|---------------------------|
| tbabs | $N_H(10^{20} \text{cm}^{-2})$ | $3.31 \pm 0.006$ | $3.87^{+0.04}_{-0.03}$     | $1.12 \pm 0.005$         |
| simpl | $\Gamma$  | $2.00^{+0.14}_{-0.16}$ | $2.00^{+0.15}_{-0.17}$     | $2.49 \pm 0.03$           |
|       | $FracSctr$| $0.016^{+0.0004}_{-0.003}$ | $0.028\pm 0.007$          | $0.100 \pm 0.008$         |
| diskbb| $kT_{in}$ (keV) | $0.610 \pm 0.003$ | $0.620 \pm 0.005$ | $0.520 \pm 0.005$         |
|       | $Norm$    | $2075(f)$       | $2075(f)$                  | $2075(f)$                  |
| Gaussian | $Line$ (keV) | $6.4(f)$       | $6.4(f)$                  | $6.4(f)$                  |
|        | $Width$ (keV) | $1.06^{+0.35}_{-0.40}$ | $1.32^{+0.34}_{-0.42}$     | $0.37^{+0.56}_{-0.46}$    |
|        | $Norm(10^{-3})$ | $1.39^{+0.60}_{-0.50}$ | $3.14^{+1.50}_{-1.30}$     | $0.40^{+0.30}_{-0.20}$    |
|        | Unabsorbed disk flux | $(10^{-9} \text{erg cm}^{-2} \text{s}^{-1})$ | $5.31^{+1.05}_{-0.95}$ | $4.77^{+1.30}_{-0.84}$ | $2.58^{+1.05}_{-0.95}$ |
|        | Unabsorbed total flux | $(10^{-9} \text{erg cm}^{-2} \text{s}^{-1})$ | $5.53^{+1.05}_{-0.95}$ | $5.15^{+1.18}_{-0.85}$ | $3.07^{+1.04}_{-0.96}$ |
|        | Unabsorbed disk flux/total flux | $0.96$ | $0.92$ | $0.84$ |
|        | $L/L_{Ed}$ | $0.025$ | $0.023$ | $0.141$ |
|        | Reduced $\chi^2/dof$ | $1.02/364$     | $0.77/110$                 | $1.34/461$                |
Figure 6. SXT+LAXPC unfolded spectra of Regions 1, 2 and 3 fit with the model combination constant $\times$ tbabs(simpl $\times$ diskbb + gaussian). The residuals ($\chi = \frac{(data - model)}{error}$) are plotted in the bottom panels.

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