East European Journal of Physics. 4. 18–28 (2023)
DOI: 10.26565/2312-4334-2023-4-02 ISSN 2312-4334

SPECTRAL AND TIMING STUDY OF THE NEWLY DETECTED ULTRALUMINOUS X-RAY SOURCES IN NGC 3585 USING DIFFERENT *CHANDRA* OBSERVATIONS

S. Rita Devi[a*], **A. Senorita Devi**[b], **Atri Deshamukhya**[a]
[a] *Assam University, Silchar, Assam, India*
[b] *Manipur University, Canchipur, Manipur, India*
[*] *Corresponding Author e-mail: sinamrita26@gmail.com*
Received October 1, 2023; revised November 1, 2023; accepted November 8, 2023

The present work aims to study the previously unstudied Ultraluminous X-ray sources (ULXs) in the galaxy NGC 3585 at its various epochs of *Chandra* observation. We report here the detection of two new ULXs viz. CXOUJ111306.0-264825 (X-1) and CXOUJ111325.3-264732 (X-2) with their bolometric luminosity $> 10^{39} erg\ s^{-1}$ in its various *Chandra* observations. X-1 was found to be a spectrally hard ULX in both the epochs where it was detected. However in the ULX, X-2, a slight hardening of the spectra was observed within a period of 17 years. Assuming isotropic emission and explained by disk blackbody model, the spectrally softer epoch of X-2 with an inner disk temperature, $kT_{in} \sim 0.79$ keV and bolometric luminosity $\sim 2.51 \times 10^{39} erg\ s^{-1}$ implies for X-2 to be powered by a compact object, necessarily a black hole of mass, $M_{BH} \sim 44.85^{+82.11}_{-25.92} M_{\odot}$ accreting at ~ 0.42 times the Eddington limit. The Lightcurve of X-1 and X-2 binned at 500s, 1ks, 2ks and 4ks has shown no signature of short-term variability in both the ULXs in kilo-seconds time scales. Overall, both the detected ULXs seem to be almost static sources both in long-term (years) as well as short-term (kilo-seconds) time scales with the presently available *Chandra* Observations.

Keywords: *Accretion; Accretion disks; Galaxies: individual(NGC 3585); X-rays: binaries*

PACS: 97.10.Gz, 98.52.-b: 98.56.Ew, 95.85.Nv, 97.80.Jp

1. INTRODUCTION

Ultraluminous X-ray sources (ULXs) are defined as point-like, non nuclear X-ray sources with an X-ray luminosity exceeding the Eddington limit for a 20 $M_{\odot}$ black hole (BH) [1]. ULXs have X-ray luminosity $\geq 10^{39}$ erg s^{-1}, which may even rise upto 10^{42} erg s^{-1} in the 0.5-10.0 keV energy range. In early days, these X-ray sources detected in the external galaxies with isotropic luminosities $\geq 10^{39}$ erg s^{-1} were unclear and they were thought to be - underluminous accreting supermassive black holes (SMBH) or overluminous X-ray binaries (XRBs) located near the galactic nucleus, or rather a totally new class of astrophysical object [2]. The first such individual luminous X-ray sources were detected in nearby external spiral galaxies by the Einstein satellite in the 0.3 - 4.0 keV energy range [3]. Since their first discovery with the Einstein Observatory [4], ULX remained mysterious object for more than two decades. The mass accretion rate in ULXs and also the mass of the compact object harbored by ULXs have been controversial, and still it is in debate. However recent observations with Chandra, XMM-Newton, NuSTAR etc. have given clear visions of these sources by detecting many of its kind. Now many ULXs, above 1800 in numbers, have been detected and its population is also well studied [5, 6, 7, 8, 9, 10].

Various models came up to explain the high luminosities of ULXs, such as - (i) Super-Eddington accretion onto stellar mass blackholes with mass, $M_{BH} \approx 10 M_{\odot}$ [11, 12], (ii) sub-Eddington accretion on to Intermediate mass blackholes with masses, $M_{BH} \sim 10^2 - 10^5$ $M_{\odot}$ [13, 14] and (iii) relativistic and geometric beaming from an anisotropic super-critical accretor [15, 16].

In its early days, ULXs were considered to be extragalactic X-ray binaries (XRBs) with stellar-mass black hole (BH) accretors [17] like the XRBs observed in our own galaxy. From their spectral and variability studies, they were suggested to be accreting compact objects in binary systems. Later again, ASCA X-ray spectral studies of many ULXs gave the evidence that they display the characteristics of accreting blackholes. ULX spectra are now studied more precisely by using high quality data from various missions such as that of XMM-Newton, NuSTAR, also data from the very high resolution detectors of Chandra etc.. Advanced studies of ULX spectra and variability of individual sources indicate that some ULXs can represent different spectral states in analogy with those observed in X-ray binaries [7]. Again in some ULXs, transitions of luminosity were also observed such as that of XMMU J004243.6+412519 in M31 which changed from X-ray binary state ($L_x \sim 2 \times 10^{38} erg\ s^{-1}$) to ultraluminous state ($L_x \sim 10^{39} erg\ s^{-1}$) and then returned to binary state [18].

Cite as: S.R. Devi, A.S. Devi, A. Deshamukhya, East Eur. J. Phys. 4, 18 (2023), https://doi.org/10.26565/2312-4334-2023-4-02

These transitions suggest that ULXs can also be an ultraluminous state of accreting compact objects like XRBs. Also in many ULXs, spectral state transitions between two spectral states have been reported such as that in NGC 1313 X-1 [19] and in NGC 247 where spectral state transition occur from soft ULX to super-soft ULX in the brightest ULX source [20]. All these clearly points towards some ULXs being quite closely related to black hole binaries. If ULX sources are indeed accreting compact objects, then their very high luminosity should favor them to harbor massive (stellar mass) black holes. Afterwards, many future works have given the evidence for these ULXs to be powered by accretion on to stellar mass black holes, such as that of Avdan et al.(2016) [21] who studied X-ray and optical properties of the ULX, X-6, in the nearby galaxy NGC 4258 (M106). They reported that the compact object in this ULX is most likely a stellar-mass black hole. Singha and Devi (2017)[22] studied the spectra of the ULXs in NGC 5643 and NGC 7457 and reported that some ULXs were found to be accreting at a sub-Eddington rate and some ULXs were accreting at super-Eddington rate on to stellar mass BHs. They also studied seven ULXs in NGC 2276 and they suggested that the compact objects associated with these seven sources are in the stellar mass BH range [23].

Although the high luminosity of some ULXs were well explained by stellar mass black holes, some ULXs which are very luminous, having luminosities above 10^{41} erg s^{-1}, could not be explained by super-Eddington accretion onto stellar mass black holes. Indeed, they require black hole mass greater than the stellar mass to explain their high luminosities. Black holes having mass range, $M_{BH} \sim 10^2 - 10^4$ $M_\odot$ are called intermediate-mass black holes (IMBHs) and it express the missing component of the black hole mass spectrum in the gap between those of stellar mass black holes found in Galactic X-ray binaries and those associated with active galactic nuclei (AGN), $M_{BH} \sim 10^6 - 10^9 M_\odot$ [24]. Farrell et al (2009) [25] discovered the most luminous hyper luminous X-ray source (HLX), HLX-1, in the spiral galaxy ESO 243-49 having peak luminosity of the order of 10^{42} erg s^{-1}. Their analysis suggest that HLX-1 harbour black hole with mass, M, 3000 $M_\odot$ < M < 10^5 $M_\odot$ which is the range of IMBHs. The review of Miller & Colbert (2004)[26] and Miller (2005)[27] discussed various arguements regarding the evidence for IMBHs in ULXs. Many other bright ULXs such as M82 X-1 [28, 29], M51 ULX-7 [30] and NGC 2276–3c [31] also give evidence for ULXs harboring IMBHs. Many other such HLXs with bolometric luminosity greater than 10^{41} erg s^{-1} such as the HLXs reported in Singha and Devi (2019)[14] highly points towards these extremely luminous X-ray sources to be powered by accretion on to IMBH. Sanatombi et al. (2023)[32] reported the super-soft ULX, CXOUJ132943.3+471135, in the galaxy M51 to harbor a black hole with mass $\sim 10^4 M_\odot$ where they have also reported that even with extreme beaming case, the mass of the black hole harbored by this source is $\sim 10^3 M_\odot$.

Another breakthrough discovery for ULX model is the ULX pulsar. Pulsations are recently detected in many ULXs, so they are also sometimes modelled as an accreting system in which the compact object is a neutron star with mass $\sim$ 1 - 2 $M_\odot$, accreting at extreme super-Eddington rates. NuSTAR observations of the starburst galaxy M82 reported the first ULX pulsations [33], later on many other ULXs were confirmed to present pulsations [34, 35, 36, 37]. Doroshenko et al.(2020)[38] reported the first Galactic pulsating ULX - Swift J0243.6+6124. King et al. (2023)[16] has reported for a kind of recently reported system in which some high mass X-ray binaries (HMXBs) ocassionally becomes ULXs like the system A0538-66. Here, they pointed out that a normal Be X-ray Binary which is a HMXB, makes regular transitions between normal Be X-ray binary states to PULXs and back again. These Be X-ray binaries in their PULXs states have very high super-Eddington accretions even though they behave as normal Be X-ray systems when it is in its usual Be X-ray binary state. Thus, in recent years, deep X-ray studies of ULXs have shown that the ULX population is dominated by supercritical accretors which may be either a stellar mass BH or a neutron star. However, the ULX population appears to remain heterogeneous with some candidate Intermediate mass black hole (IMBH) also.

In this paper, we present the spectral study of the non-nuclear X-ray point sources in NGC 3585 from all its available *Chandra* observations. The NGC 3585 group is known to include NGC 3585 itself, which is an E6 galaxy and the brightest galaxy in the group [39]. NGC 3585 has not been studied extensively in X-rays. In this work, we also investigate for any signature of kiloseconds variability of the sources detected. Also, we have investigated for any long term variability of the point sources at the available different epochs of *Chandra* observation of NGC 3585. The distance to the galaxy, NGC 3585, is adopted to be 20 Mpc [40].

The observation and data analysis are described in Section 2. Results and discussion are presented in Section 3 and summarized in Section 4.

2. OBSERVATION AND DATA ANALYSIS

In the present work, we have carried out spectral and timing analysis of the point sources in NGC 3585 as detected by *Chandra* ACIS-S detector. NGC 3585 has been observed by Chandra ACIS-S detector five times-first in the year 2001 (Obs ID 2078), second in the year 2008(Obs ID 9506) and then three times in the year 2018 (Obs ID 19332, Obs ID 21034, Obs ID 21035). The detail *Chandra* observational log of NGC 3585 is given in Table 1. The data reduction and analysis were done using CIAO 4.14 and HEASOFT 6.30.1. For each of the observation data sets, using acis_set_ardlib, observation-specific bad pixel lists were set in the ardlib parameterfile. Figure 1 shows a three-color X-ray image of the galaxy NGC 3585 which is created by using CIAO

Table 1. Chandra ACIS-S Observation log for NGC 3585

Galaxy	Distance (Mpc)	ObsId*	Exposure (ks)	Observation Year	N($\geq$ 100)**
NGC 3585	20.0	2078	36	2001-06-03	2
		9506	60	2008-03-11	1
		19332	62	2018-03-13	1
		21034	30	2018-03-14	-
		21035	30	2018-03-15	-

*ObsID - *Chandra* Observation ID ; **N-number of sources with net counts $\geq$ 100

tools dmcopy and dmimg2jpg. The soft X-rays with energy $\approx (0.3-1.0keV)$, medium X-rays $\approx (1.0-2.0keV)$ and hard X-rays $\approx (2.0-8.0keV)$ are represented in red, green and blue respectively. X-ray point sources were extracted from the level 2 event lists by using the CIAO source detection tool *Wavdetect*. Using a combination of CIAO tools and calibration data, the source (and background) spectrum were extracted. Spectra were grouped and rebinned so that each bin had a minimum of 15 counts. The spectral analysis was done using spectral fitting package XSPEC version 12.12.1, available in the Heasoft package. Sources with counts $\geq$ 100 are chosen for the spectral analysis so that spectral parameters could be constrained properly while using two-parameter model. With this criteria, we detected two new Ultraluminous X-ray sources - CXOUJ111306.0-264825 (X-1) and CXOUJ111325.3-264732 (X-2). The spectra of the two sources are fitted in the energy range 0.3 -8.0 keV using two empirical spectral models - the absorbed power law and an absorbed disk-blackbody. XSPEC model-*phabs* was used to take into account the absorption in the spectrum. While fitting the spectra, the hydrogen column density (n_H) was generally set free to vary, however for those cases when the estimated n_H was much lower than the average Galactic value, it was frozen to the Galactic value $\sim 4.96 \times 10^{20} cm^{-2}$. Since the number of counts in each sectrum was typically low, C statistics were used for the analysis. A measure of the goodness of fit is determined by C-stat/(degrees of freedom(dof)), which should be approximately one. The intrinsic bolometric luminosity is a good parameter for the study and identification of the ULXs, so from the model parameters and the distance to the galaxy, the bolometric luminosity of the point sources are estimated for the disk-blackbody model. However for power-law model, the luminosity in the 0.3-8.0 keV range are estimated.

Using the disk blackbody model, the mass of the compact object harboured by the ULXs can be indirectly estimated. So, for ULXs at few mega parsec, to roughly estimate the black hole mass, we assume the inner-disk radius, $R_{in} \sim 10\ GM/c^2$. The inner disk radius, R_{in} is then computed from normalization of the disk black body component using the distance to the source D=20 Mpc, and taking the viewing angle, cos i=0.5, and color factor, f=1.7 [14]. Thus the mass of the compact object harbored by the corresponding ULX is estimated.

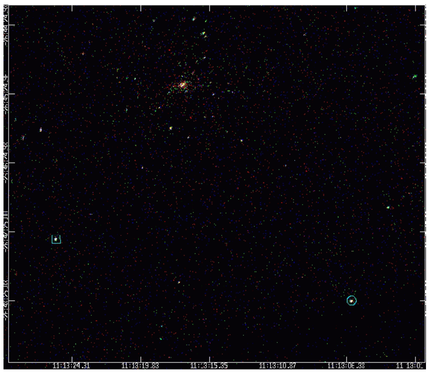

Figure 1. Three-colour X-ray image of NGC 3585 (ObsID 2078): Red represents soft X-ray emission (0.3–1 keV), green represents medium-hard X-rays (1-2 keV) and blue denotes hard X-rays (2-8 keV). X-1 is represented by the circle in cyan and X-2 by the box in cyan.

3. RESULTS AND DISCUSSION

Two new Ultraluminous X-ray sources - CXOUJ111306.0-264825 (X-1) and CXO-UJ111325.3-264732 (X-2) were identified whose details are tabulated in Table 2. Both the sources were estimated to have X-ray luminosities, $L_x, \geq 10^{39}$ erg s^{-1}, probably considered both the sources to be ULX. The spectral properties of the ULX sources as estimated by the two models are tabulated in Table 3.

Table 2. Details of the X-ray sources

Source	Source name	R.A.*	Decl.**	ObsId	Counts
X-1	CXOUJ111306.0-264825	+11:13:06.04	-26:48:25.34	2078	220
				9506	358
X-2	CXOUJ111325.3-264732	+11:13:25.32	-26:47:31.67	2078	142
				19332	124

*R.A - in (hours, minutes and seconds); **Decl. in (degrees, arcminutes and arcseconds)

Table 3. Spectral properties of the two ULXs (X-1 and X-2)

Source	Obs Id.	Powerlaw n_H ($10^{22} cm^{-2}$)	Γ	$\log(L_x)$ (ergs s^{-1})	$Cstat$/dof	Disk-blackbody n_H ($10^{22} cm^{-2}$)	KT_{in} keV	$\log(L_x)$ (ergs s^{-1})	$Cstat$/dof
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
X-1	2078	0.0496*	$1.69^{+0.20}_{-0.18}$	$39.44^{+0.06}_{-0.07}$	13.78/10	0.0496*	$0.98^{+0.25}_{-0.23}$	$39.69^{+0.07}_{-0.08}$	34.19/10
X-1	9506	$0.07^{+0.09}_{-0.06}$	$1.74^{+0.34}_{-0.24}$	$39.50^{+0.05}_{-0.03}$	12.31/19	0.0496*	$0.95^{+0.16}_{-0.16}$	$39.69^{+0.04}_{-0.05}$	26.37/19
X-2	2078	$0.27^{+0.19}_{-0.16}$	$2.65^{+0.73}_{-0.63}$	$39.46^{+0.34}_{-0.19}$	4.64/5	$0.03^{+0.11}_{-0.03}$	$0.79^{+0.26}_{-0.18}$	$39.42^{+0.08}_{-0.05}$	6.40/5
X-2	19332	$0.53^{+0.72}_{-0.48}$	$2.17^{+0.97}_{-0.78}$	$39.33^{+0.53}_{-0.18}$	5.83/4	$0.07^{+0.48}_{-0.06}$	$1.34^{+0.68}_{-0.45}$	$39.37^{+0.09}_{-0.06}$	6.63/4

* Freeze to the Galactic hydrogen Column density $\sim 4.96 \times 10^{20} cm^{-2}$

Columns: (1): Source (2): Observation ID. (3): n_H, equivalent hydrogen column density. (4): Γ,the powerlaw photon index. (5):(L_x),X-ray luminosity in the 0.3 -8.0 keV energy range, (6): Cstat/Degrees of freedom. (7): n_H, equivalent hydrogen column density. (8): KT_{in},the inner disk temperature. (9):(L_x), bolometric X-ray luminosity. (10):Cstat/Degrees of freedom.

The observed normalized net count distribution of these sources as fitted with powerlaw model and disk blackbody model are shown in Figure 2 and Figure 3. The detail study and findings of the the two newly detected ULXs are discussed below.

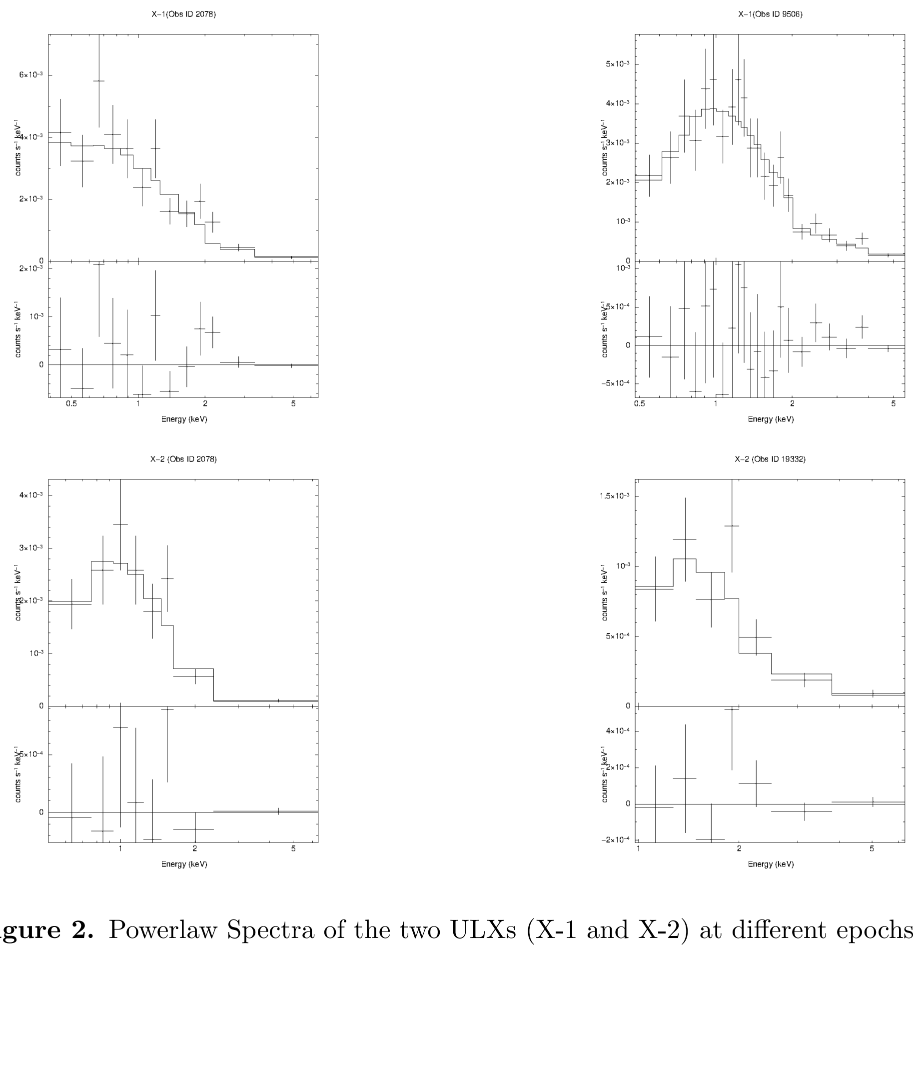

Figure 2. Powerlaw Spectra of the two ULXs (X-1 and X-2) at different epochs

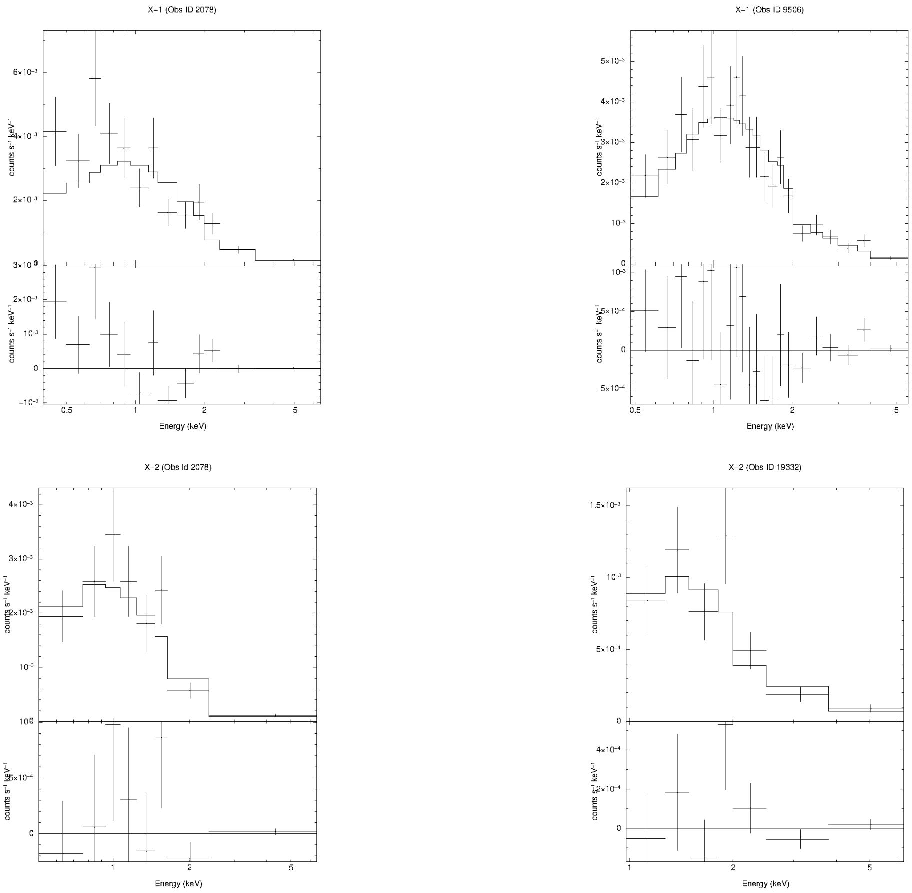

Figure 3. Disk blackbody Spectra of the two ULXs (X-1 and X-2) at different epochs

3.1. CXOUJ111306.0-264825 (X-1)

CXOUJ111306.0-264825 (X-1) has been detected in two of the *Chandra* observations of NGC 3585. In the year 2001 observation (ObsId 2078), the spectrum of X-1 is found to prefer the powerlaw model than the disk blackbody model. In this epoch of observation, X-1 is found to be spectrally hard with a powerlaw photon index (Γ) $\sim$ 1.69. However, both the models estimate the X-ray luminosity of this source to be in the ULX range with few times 10^{39} erg s^{-1}. After a period of 7 years in the year 2008 observation (ObsId 9506) also, the spectrum of X-1 remains hard with powerlaw photon index (Γ) $\sim$ 1.74, while the inner disk temperature (kT_{in}), as explained by the disk blackbody model remains around $\sim$ 1 keV in both the observations. In the later observation, both the models could well explain the spectra of X-1, but with a slight preference to the disk blackbody model. In both the two epochs, the luminosity of X-1 is almost consistent.

The radiative mechanism of this hard ULX, X-1, may be due to inverse comptonization of soft photons near the accretion disk. But, if we try to explain the spectra of X-1 with the disk blackbody model as being seen to slightly prefer this model in the case of ObsID 9506, then with the assumption of isotropic emission, the mass of the compact object harbored by this ULX is estimated to be in the stellar mass BH which is likely accreting at sub-Eddington rate.

3.2. CXOUJ111325.3-264732 (X-2)

CXOUJ111325.3-264732 (X-2) has been detected in four *Chandra* observations - ObsId 2078 of the year 2001, ObsIds 19332, 21034 and 21035 of the year 2018. However the net source counts in the observations - ObsIds 21034 and 21035 were only 57 and 38 respectively. So due to this very low counts, the spectrum could not be fitted properly as the number of variable parameters exceeds the number of bins. Hence for the present study, we consider the spectra of X-2 only in the two epochs of observation with ObsIds - 2078 and 19332. The spectra of X-2 can equally be well explained by both the models in both these epochs of observations. In the year 2001 observation, its spectra was relatively soft with an inner disk temperature, kT_{in} $\sim$ 0.79 keV as

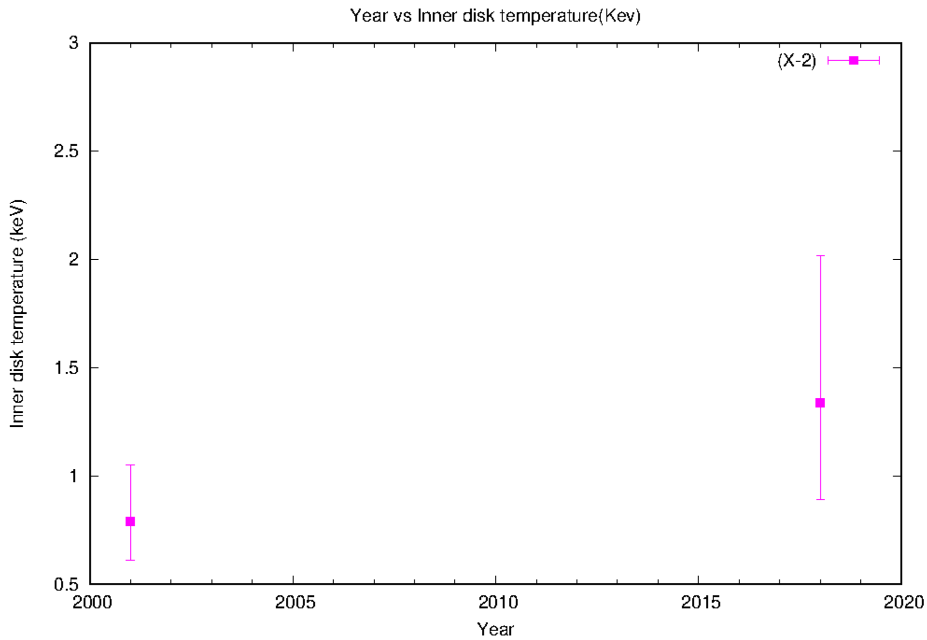

Figure 4. Spectral state transitions in X-2

explained by the disk blackbody model, which after a period of nearly 17 years in the ObsId 19332, the spectra becomes slightly harder with kT$_{in}$ $\sim$ 1.34 keV (Figure 4).

However, within error limits, this hardening of the spectrum within a period of 17 years is not very significant. In both the epochs of observation, the powerlaw photon index(Γ) $\approx$ 2, within error limits. The luminosity of X-2 almost remain consistent in both the epochs. With the assumption of isotropic emission and explain by disk blackbody model, the spectral parameters of X-2 in its relatively softer state with kT$_{in}$ $\sim$ 0.79 keV and bolometric luminosity $\sim 2.51 \times 10^{39} erg\ s^{-1}$(ObsId 2078), estimates a black hole of mass, M$_{BH}$ $\sim 44.85^{+82.11}_{-25.92} M_{\odot}$ accreting at $\sim$ 0.42 times the Eddington limit.

3.3. Temporal property of the ULXs

As investigated in its various epochs of observation, the two detected ULXs were found to have no long-term variability in their luminosity . Bachetti et al.(2014)[33] reported for a variable ULX spatially coincident with a pulsating neutron star whose X-ray luminosity can reach upto $1.8 \times 10^{40} erg\ s^{-1}$ in the 0.3 -10 keV range. This implies for certain variable ULXs to be neutron star candidates which are super-accretors. As such, to check the presence of any short-term/kiloseconds variability for the two ULXs detected in the present study, temporal analysis was carried out. The lightcurve of X-1 and X-2 binned over 0.5, 1, 2 and 4 ks for each of the *Chandra* observations in which these two ULXs are detected, are shown in Figure 5 and Figure 6 respectively.

For CXOUJ111306.0-264825 (X-1), in all these time bins, the probability for the count rate being a constant during the observation with ObsID 2078 is all greater than 0.045 and that in the observation with ObsID 9506 is all > 0.31. Likewise for CXOUJ111325.3-264732 (X-2) also, in all these time bins, the probability for the count rate being a constant during the observation with ObsID 2078 is all > 0.73 and that in the observation with ObsID 19332 is all > 0.24. For, the sources to be variable, their variability probability should be $\geq$ 99% or rather the probability for their count rate being constant should be less than 0.01 (1 %), which is not so in case of X-1 and X-2 in the present study. This clearly shows the absence of any short-term variability in kilo-seconds time-scales in both the two newly detected ULXs- CXOUJ111306.0-264825 and CXOUJ111325.3-264732 with the currently available Chandra data. So, it is indicative that these two ULXs in NGC 3585 is more likely to be static sources both in long-term (years) as well as short-term (kiloseconds) scales.

However, due to limited timing capabilities of many sensitive X-ray instruments aboard X-ray satellites, the transient nature of pulsations of many variable sources have eluded detections. So, a more detail future work with high quality data from other missions may enable us to ascertain the real physical nature of these two ULXs and many more such ULXs in more details.

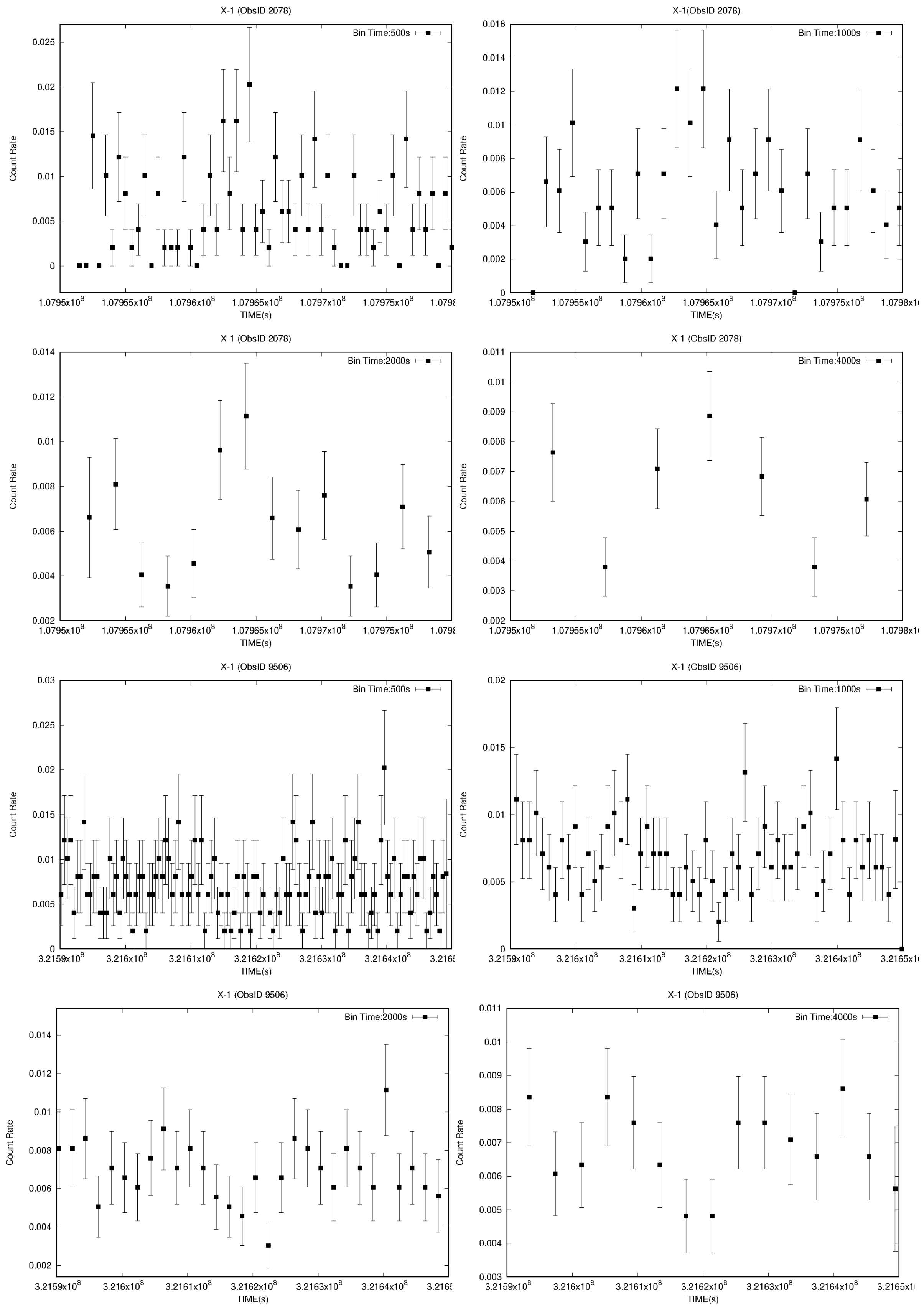

Figure 5. Lightcurve of CXOUJ111306.0-264825 (X-1) in its two epochs - ObsID 2078 and ObsId 9506, in different time bins (500 s, 1000 s, 2000 s and 4000 s)

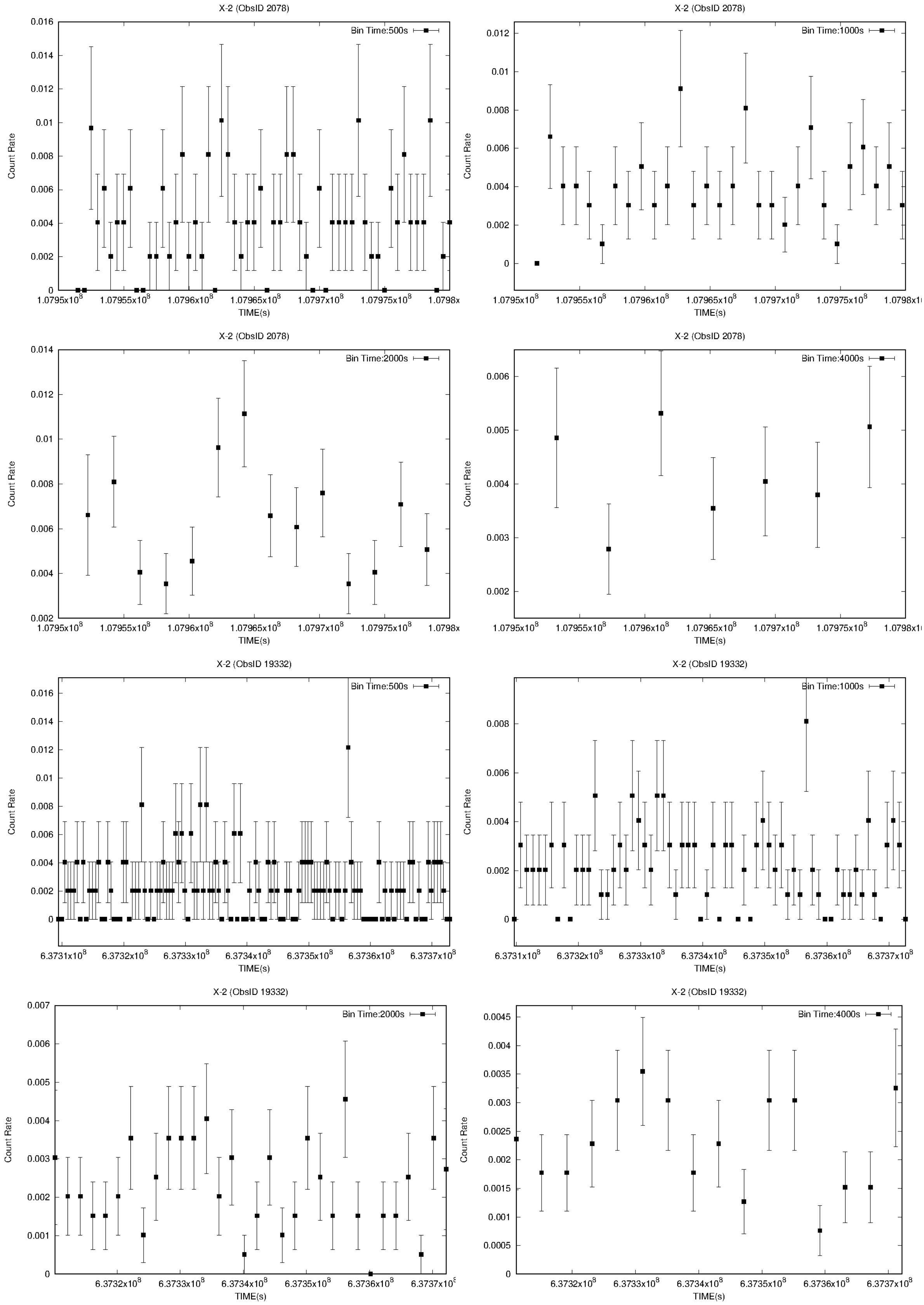

Figure 6. Lightcurve of CXOUJ111325.3-264732 (X-2) in its two epochs - ObsID 2078 and ObsId 19332, in different time bins (500 s, 1000 s, 2000 s and 4000 s)

4. CONCLUSION

We present the results of spectral and timing analysis of the X-ray point sources in the galaxy NGC 3585 as observed by *Chandra* in different epochs. NGC 3585 is least studied in X-rays and the point sources in NGC 3585 are hardly reported. Two point sources- CXOUJ111306.0-264825 (X-1) and CXOUJ111325.3-264732 (X-2) with net source count > 100 were detected and thus considered for the present study. The spectra of the two sources were fitted with two empirical models - the absorbed power law and an absorbed disk black-body. The ULX source, X-1, was observed in two *Chandra* observational epochs with a gap of nearly 7 years. In both the epochs, X-1 is found to be spectrally hard with an inner disk temperature, $kT_{in} \sim 1$ keV as explained by the disk blackbody model and a powerlaw photon index, $\Gamma, \sim 1.69$ as explained by the powerlaw model.

However in both the epochs, its bolometric luminosity was nearly constant at around $4.89 \times 10^{39} erg\ s^{-1}$, showing an absence of long term variability with the available *Chandra* data. ULX source, X-2, is being studied here in two *Chandra* epochs at a gap of nearly 17 years. X-2 seem to have some sort of spectral hardening within a period of 17 years, however this hardening of the spectrum is not very significant within error limits. In both the epochs, X-2 also have almost nearly consistent bolometric luminosity around $2.51 \times 10^{39} erg\ s^{-1}$, thereby showing no evidence of long term variability in years scale. The spectral parameters of X-2 in its relatively softer state with $kT_{in} \sim 0.79$ keV (ObsId 2078), estimates a black hole of mass, $M_{BH} \sim 44.85^{+82.11}_{-25.92} M_{\odot}$ accreting at sub-Eddington limit. Timing analysis of both X-1 and X-2 reveals no short-term/kilo-seconds variability in these two ULXs. Hence with the available *Chandra* data, both the two detected ULXs seems to be nearly static sources both in long-term as well as short-term scales. However, a more detail future work with high quality data from other missions may enable us to ascertain the real physical nature of these two ULXs and many more such ULXs.

ACKNOWLEDGMENT

The authors would like to thank Chandra X-ray Center (CXC) archive for its resources of data that are used in the present work.

ORCID

S. Rita Devi, https://orcid.org/0000-0002-0663-1538; **A. Senorita Devi**, https://orcid.org/0000-0001-9971-4262; **Atri Deshamukhya**, https://orcid.org/0000-0003-4350-6645

REFERENCES

[1] S.N. Fabrika, K.E. Atapin, A.S. Vinokurov, and O.N. Sholukhova, "Ultraluminous X-Ray Sources," Astrophy. Bulle. **76**, 6-38 (2021). https://doi.org/10.1134/S1990341321010077

[2] E.J.M. Colbert, R. Petre, E.M. Schlegel, and S.D. Ryder, "Soft X-Ray Emission from the Spiral Galaxy NGC 1313," Astrophys.J. **446**, 177 (1995). https://doi.org/10.1086/175777

[3] G. Fabbiano, D.-W. Kim, and G. Trinchieri, "An X-Ray Catalog and Atlas of Galaxies," Astrophys. J Suppl. Ser. **80**, 531-644 (1992). https://ui.adsabs.harvard.edu/link_gateway/1992ApJS...80..531F/doi:10.1086/191675

[4] G. Fabbiano, "X Rays From Normal Galaxies," Ann. Rev. Astron. Astrophys. **27**, 87-138 (1989). https://doi.org/10.1146/annurev.aa.27.090189.000511

[5] D.A. Swartz, K.K. Ghosh, A.F. Tennant, and K. Wu,"The Ultra-Luminous X-ray Source Population from the Chandra Archive of Galaxies," Astrophys. J. Suppl. Ser. **154**, 519 (2004). https://ui.adsabs.harvard.edu/link_gateway/2004ApJS..154..519S/doi:10.48550/arXiv.astro-ph/0405498

[6] A.S. Devi, R. Misra, V. Agrawal, and K.Y. Singh, "The dependence of the estimated luminosities of ULX on spectral models," Astrophys. J. **664**, 458-466 (2007). https://doi.org/10.48550/arXiv.0704.1107

[7] P. Kaaret, H. Feng, and T. Roberts, "Ultraluminous X-Ray Sources," Ann. Rev. of Astro. and Astrophy. **55**, 303-341 (2017). https://doi.org/10.1146/annurev-astro-091916-055259

[8] H.P. Earnshaw, T.P. Roberts, M.J. Middleton, D.J. Walton, and S. Mateos, "A new, clean catalogue of extragalactic non-nuclear X-ray sources in nearby galaxies," Mon. Not. R. Astron. Soc. **483**, 5554–5573 (2019). https://doi.org/10.1093/mnras/sty3403

[9] K. Kovlakas, A. Zezas, J.J. Andrews, A. Basu-Zych, T. Fragos, A. Hornschemeier, B. Lehmer, and A. Ptak, "A census of ultraluminous X-ray sources in the local Universe," Mon. Not. R. Astron. Soc. **498**(4), 4790–4810 (2020). https://doi.org/10.1093/mnras/staa2481

[10] D.J. Walton, A.D.A. Mackenzie, H. Gully, N.R. Patel, T.P. Roberts, H.P. Earnshaw, and S. Mateos, "A multimission catalogue of ultraluminous X-ray source candidates," Mon. Not. R. Astron. Soc. **509**(2), 1587–1604 (2022). https://doi.org/10.1093/mnras/stab3001

[11] J. Poutanen, G. Lipunova, S. Fabrika, A. G. Butkevich, and P. Abolmasov, "Supercritically accreting stellar mass black holes as ultraluminous X-ray sources," Mon. Not. R. Astron. Soc. **377**, 1187–1194 (2007). https://doi.org/10.1111/j.1365-2966.2007.11668.x

[12] E.S. Mukherjee, D.J. Walton, M. Bachetti, F.A. Harrison, D.Barret, E. Bellm, S.E. Boggs, et al., "A Hard X-Ray Study of Ultraluminous X-ray Source NGC 5204 X-1 with NuSTAR and XMM-Newton," Astrophys. J. **808**, 64 (2015). https://doi.org/10.1088/0004-637X/808/1/64

[13] O. Godet, B. Plazolles, T. Kawaguchi, J. Lasota, D. Barret, S. Farrell, V. Braito, M. Servillat, N. Webb, and N. Gehrels, Astrophys. J. **752**, 34 (2012). https://ui.adsabs.harvard.edu/link_gateway/2012ApJ...752...34G/doi:10.48550/arXiv.1204.3461

[14] A.C. Singha, and A.S. Devi, "Bimodal Distribution of the Hyperluminous X-ray Sources," Acta Astrono. **69**, 339–360 (2019). https://doi.org/10.32023/0001-5237/69.4.3

[15] A.R. King, M.B. Davies, M.J. Ward, G. Fabbiano, and M. Elvis, "Ultraluminous X-Ray Sources in External Galaxies," Astrophys. J. **552**, L109–L112 (2001). https://doi.org/10.48550/arXiv.astro-ph/0104333

[16] A.R. King, J.P. Lasota, and M. Middleton, "Ultraluminous X-ray sources," New Astron. Rev. **96**, 101672 (2023). https://doi.org/10.1016/j.newar.2022.101672

[17] S.A. Rappaport, P. Podsiadlowski, and E. Pfahl, "Stellar-mass black hole binaries as ultraluminous X-ray sources," Mon. Not. R. Astron. Soc. **356**, 401–414 (2005). https://doi.org/10.1111/j.1365-2966.2004.08489.x

[18] M.J. Middleton, J.C.A. Miller-Jones, S. Markoff, R. Fender, M. Henze, N. Hurley-Walker, Anna M. M. Scaife, et al., "Bright radio emission from an ultraluminous stellar-mass microquasar in M 31," Nature. **493**, 187–190 (2013). https://doi.org/10.1038/nature11697

[19] H. Feng, and P. Kaaret, "Spectral State Transitions of the Ultraluminous X-Ray Sources X-1 and X-2 in NGC 1313," Astrophys. J. **650**, L75 (2006). https://ui.adsabs.harvard.edu/link_gateway/2006ApJ...650L..75F/doi:10.1086/508613

[20] C. Pinto, R. Soria, D.J. Walton, A. D'Ai, F. Pintore, P. Kosec, W.N. Alston, et al., "XMM-Newton campaign on the ultraluminous X-ray source NGC 247 ULX-1: outflows," Mon. Not. R. Astron. Soc. **505**, 5058–5074 (2021). https://doi.org/10.1093/mnras/stab1648

[21] H. Avdan, S. Avdan, A. Akyuz, S. Balman, N. Aksaker, and I. Akkaya Oralhan, "X-RAY SPECTRAL AND OPTICAL PROPERTIES OF A ULX IN NGC 4258 (M106)," Astrophy. J. **828**, 105 (2016). https://doi.org/10.3847/0004-637X/828/2/105

[22] A.C. Singha, and A.S. Devi, "Study of X-ray point sources in NGC 5643 and NGC 7457 with Chandra," Astrophys. Space Sci. **362**, 1-9 (2017). https://doi.org/10.1007/s10509-017-3189-6

[23] A.C. Singha, and A.S. Devi, "Spectral and Temporal Analysis of Ultraluminous X-ray Sources in NGC 2276," Acta Astronomica, **71**, 261–279 (2021). https://doi.org/10.32023/0001-5237/71.4.1

[24] D. Richstone, E.A. Ajhar, R. Bender, G. Bower, A. Dressler, S.M. Faber, A.V. Filippenko, et al., "Supermassive Black Holes and the Evolution of Galaxies," Nature, **395**, A14 (1998). https://doi.org/10.48550/arXiv.astro-ph/9810378

[25] S.A.Farrell, N.A. Webb, D. Barret, O. Godet, and J.M. Rodrigues, "An intermediate-mass black hole of over 500 solar masses in the galaxy ESO 243-49," Nature, **460**, 73-75 (2009). https://doi.org/10.1038/nature08083

[26] M.C. Miller, and E.J.M. Colbert, Int. J. Mod. Phys. D. **13**, 1–64 (2004). https://doi.org/10.1142/S0218271804004426

[27] J.M. Miller, "Present Evidence for Intermediate Mass Black Holes in ULXs and Future Prospects," Astrophys. Space Sci. **300**, 227–238 (2005). https://doi.org/10.1007/s10509-005-1181-z

[28] H. Feng, and P. Kaaret, "Identification of the X-Ray Thermal Dominant State in an Ultraluminous X-Ray Source in M82," The Astrophy. J. Let. **712**, L169–L173 (2010). https://doi.org/10.1088/2041-8205/712/2/L169

[29] D.R. Pasham, T.E. Strohmayer, and R.F. Mushotzky, "A 400-solar-mass black hole in the galaxy M82," Nature, **513**, 74–76 (2014). https://doi.org/10.1038/nature13710

[30] H.M. Earnshaw, T.P. Roberts, L.M. Heil, M. Mezcua, D.J. Walton, C. Done, F.A. Harrison, et al., "A variable ULX and possible IMBH candidate in M51a,"Mon. Not. R. Astron. Soc. **456**, 3840-3854 (2016). https://doi.org/10.1093/mnras/stv2945

[31] M. Mezcua, T.P. Roberts, A.P. Lobanov, and A.D. Sutton, "The powerful jet of an off-nuclear intermediate-mass black hole in the spiral galaxy NGC 2276," Mon. Not. R. Astron. Soc. **448**, 1893–1899 (2015). https://doi.org/10.1093/mnras/stv143

[32] T. Sanatombi, A.S. Devi, and K.Y. Singh, "Spectral study of the Ultraluminous X-ray sources in M51 at different epochs of Chandra observation," Chin. J. of Phys. **83**, 579–598 (2023), https://doi.org/10.1016/j.cjph.2023.04.010

[33] M. Bachetti, F. Harrison, D. Walton, B. Grefenstette, D. Chakrabarty, F. Fürst, D. Barret, A. Beloborodov, et al., "An ultraluminous X-ray source powered by an accreting neutron star," Nature, **514**, 202-212 (2014). https://doi.org/10.1038/nature13791

[34] G.L. Israel, A. Papito, P. Esposito, L. Stella, L. Zampieri, A. Belfiore, G.A.R. Castillo, et al., "Discovery of a 0.42-s pulsar in the ultraluminous X-ray source NGC 7793 P13," Mon. Not. R. Astron. Soc. **466**, L48-L52 (2017). https://doi.org/10.1093/mnrasl/slw218

[35] S. Carpano, F. Haberl, C. Maitra, and G. Vasilopoulos, "Discovery of pulsations from NGS 300 ULX1 and its fast period evolution," Mon. Not. R. Astron. Soc. **476**, L45-49 (2018). https://doi.org/10.1093/mnrasl/sly030

[36] R. Sathyaprakash, T.P. Roberts, D.J. Walton, F. Fuerst, M. Bachetti, C. Pinto, W.N. Alston, et al., "The discovery of weak coherent pulsations in the ultraluminous X-ray source NGC 1313 X-2," Mon. Not. R. Astron. Soc. **488**, L35-40 (2019). https://doi.org/10.1093/mnrasl/slz086

[37] G.A.R. Castillo, G.L. Israel, A. Belfiore, F. Bernardini, P. Esposito, F. Pintore, et al., "Discovery of a 2.8 s pulsar in a 2 d orbit High-Mass X-ray Binary powering the Ultraluminous X-ray source ULX-7 in M51," Astrophys.J. **895**, 60 (2020). https://doi.org/10.48550/arXiv.1906.04791

[38] V. Doroshenko, S. Tsygankov, J. Long, A. Santangelo, S. Molkov, A. Lutovinov, L.D. Kong, et al., "First characterization of Swift J1845.7–0037 with NuSTAR," Astron and Astroph. **634**, A89 (2020). https://doi.org/10.1051/0004-6361/201937036

[39] G. de Vaucouleurs, *Third Reference Catalogue of Bright Galaxies*, (Springer, Berlin, 1991).

[40] A. Bogdan, and M. Gilfanov, "Soft band X/K luminosity ratios for gas-poor early-type galaxies," Astron and Astroph. **512**, A16 (2010). https://doi.org/10.1051/0004-6361/200913651

СПЕКТРАЛЬНЕ ТА ЧАСОВЕ ДОСЛІДЖЕННЯ НЕЩОДАВНО ВИЯВЛЕНИХ ДЖЕРЕЛ УЛЬТРАСВІТОВОГО РЕНТГЕНІВЬСОГО ВИПРОМІНЮВАННЯ В NGC 3585 З ВИКОРИСТАННЯМ РІЗНИХ *Chandra* СПОСТЕРЕЖЕНЬ

С. Ріта Деві[a], А. Сеньорита Деві[b], Атрі Дешамухья[a]

[a] *Ассамський університет, Сілчар, Ассам, Індія*

[b] *Маніпурський університет, Канчіпур, Маніпур, Індія*

Ця робота має на меті вивчити раніше невивчені джерела ультрасвітового рентгенівського випромінювання (ULX) у галактиці NGC 3585 у різні епохи її спостереження *Chandra*. Тут ми повідомляємо про виявлення двох нових ULX, а саме. CXOUJ111306.0-264825 (X-1) і CXOUJ111325.3-264732 (X-2) з їхньою болометричною світністю $> 10^{39}$ s^{-1} у різних спостереженнях *Chandra* . Було виявлено, що X-1 є спектрально жорстким ULX в обидві епохи, коли він був виявлений. Проте в ULX, X-2 спостерігалося невелике посилення спектрів протягом 17 років. Припускаючи ізотропне випромінювання та пояснюючи модель чорного тіла диска, спектрально м'якша епоха X-2 із внутрішньою температурою диска kT$_{in}$ $\sim$ 0,79 кеВ і болометричною світністю $\sim 2,51 \times 10^{39}$ s^{-1} означає, що X-2 живиться від компактного об'єкта, обов'язково чорної діри з масою M$_{BH}$ $\sim 44,85^{+82,11}_{-25,92} M_\odot$ збільшується у $\sim$ 0,42 рази від межі Еддінгтона. Крива світла X-1 і X-2, згрупована на 500 с, 1 кс, 2 тис. і 4 тис. Загалом обидва виявлені ULX є майже статичними джерелами як у довгостроковому (роки), так і в короткостроковому (кілосекунди) часовому масштабі з наявними на даний момент спостереженнями *Chandra*.

Ключові слова: *акреція, акреаційні диски; галактики: окремі (NGC 3585); рентгенівські промені: бінарні*