NGC 4258 Galaksisindeki ULX X-6 Kaynağının X-ışın Özellikleri

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İçerik

- ULX'ler
- Çalışmanın amacı ve özeti
- NGC 4258
- Arşiv Uydu Verileri
- Analiz Sonuçları
- Özet ve Sonuç

Ultraluminous X-ray Sources (ULX)
(Aşırı Parlak X-ışın Kaynakları)

$$L_X \geq 10^{39} \text{ erg s}^{-1}$$

Orta Kütleli Karadelikler ($10^2 - 10^4\ M_\odot$)
Eddington altı yığılma (Sub-Eddington)

(Miller ve Colbert 2004, IJMPD, 13 ,1)

Yıldız Kütleli Karadelik
Süper-Eddington (süper-kritik) yığılma

(Shakura ve Sunyaev 1973, A&A, 27, 337)
(Poutanen et al. 2007, MNRAS, 377, 1187)

M82 X-2
Nötron Yıldızı içeren ULX

(Bachetti et al. 2014, Nature, 514, 202)

Çalışmada Amaçlanan

(TÜBITAK 1001 - 113F039)

Yakın galaksilerde seçilen ULX'lerin

- X-ışın tayfsal ve zamansal özelliklerinin (QPO gibi)

ve

- Optik bölgedeki karşılıklarının araştırılması

Çalışmada Amaçlanan

NGC 4258 ULX X-6

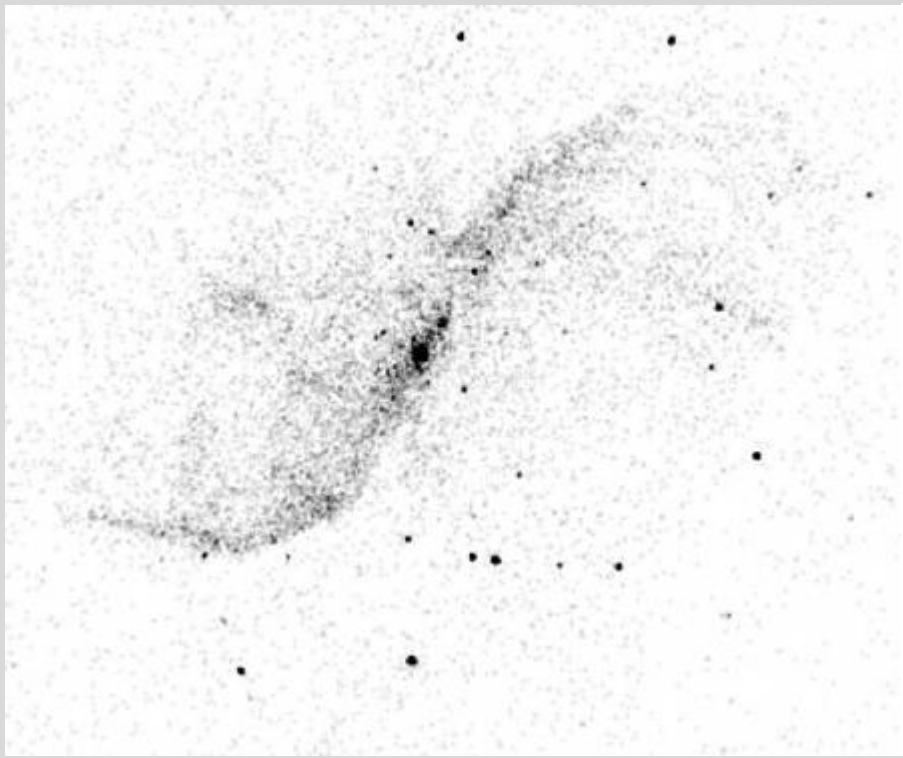
Arşiv *XMM-Newton*, *Chandra* ve *Swift* X-ışın uydularının verileri kullanılarak;

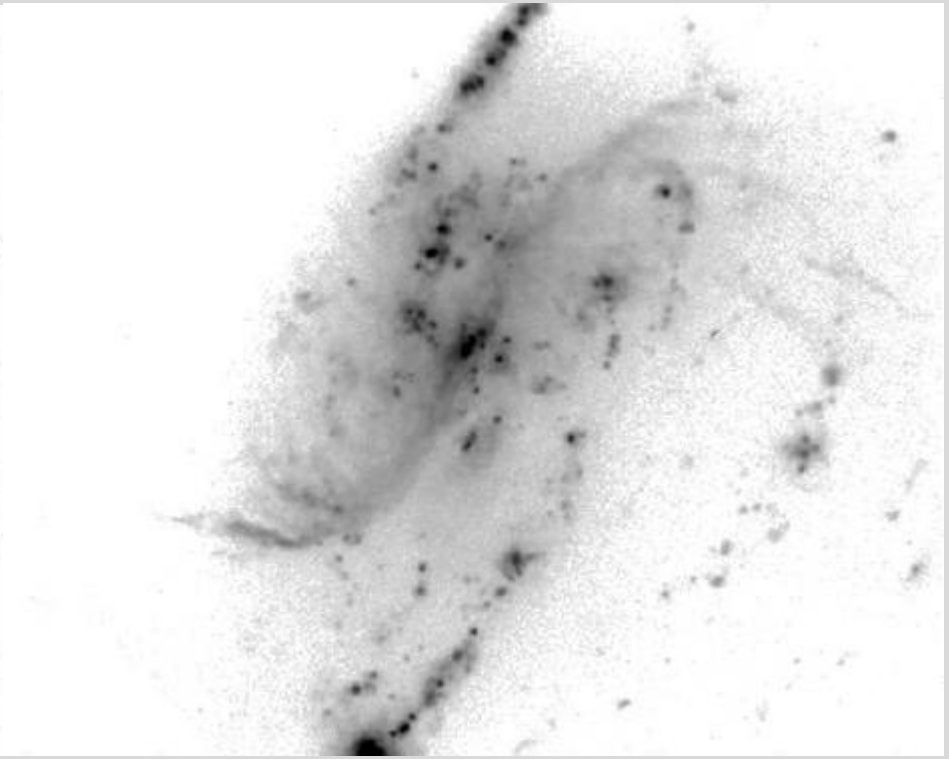
- ULX'in sertlik oranına (hardness ratio, HR) ve tayfsal parametrelerine bakılarak, bilinen Galaktik karadelik çiftlerinde görülen tayfsal geçişlere ve durumlara sahip olup olmadığını incelemek
- Periyodiklik (QPO gibi) analizleri
- Kompakt cismin kütlesi?
- Hubble (*HST*) ile ULX'in Optik bölgedeki karşılığının araştırılması

Şenay AVDAN'ın konuşması – 9 Eylül Cuma – 16:10

NGC 4258 (M106)

Wilson et al. 2001, ApJ, 560, 689



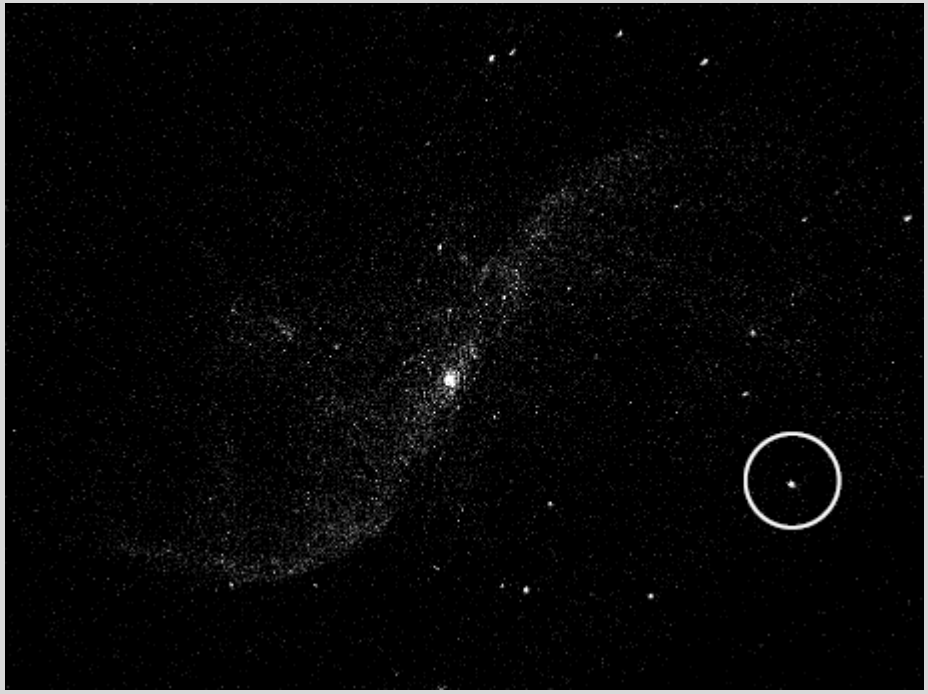


Chandra X-ışın

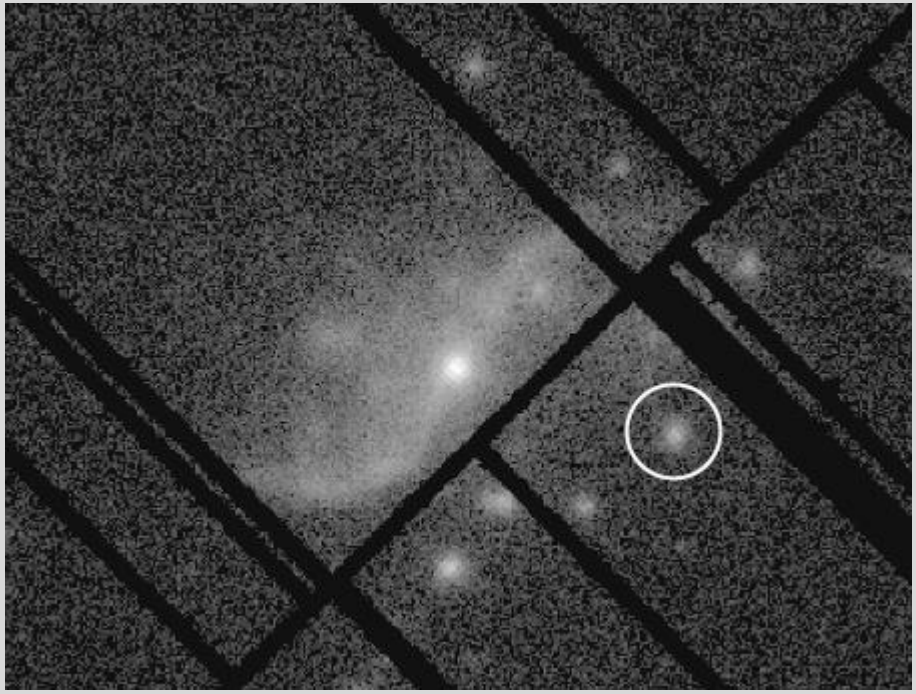
Optik Hα

d = 7.7 Mpc (Swartz et al. 2011, ApJ, 741, 49)

NGC 4258 (M106)



Chandra



XMM-Newton

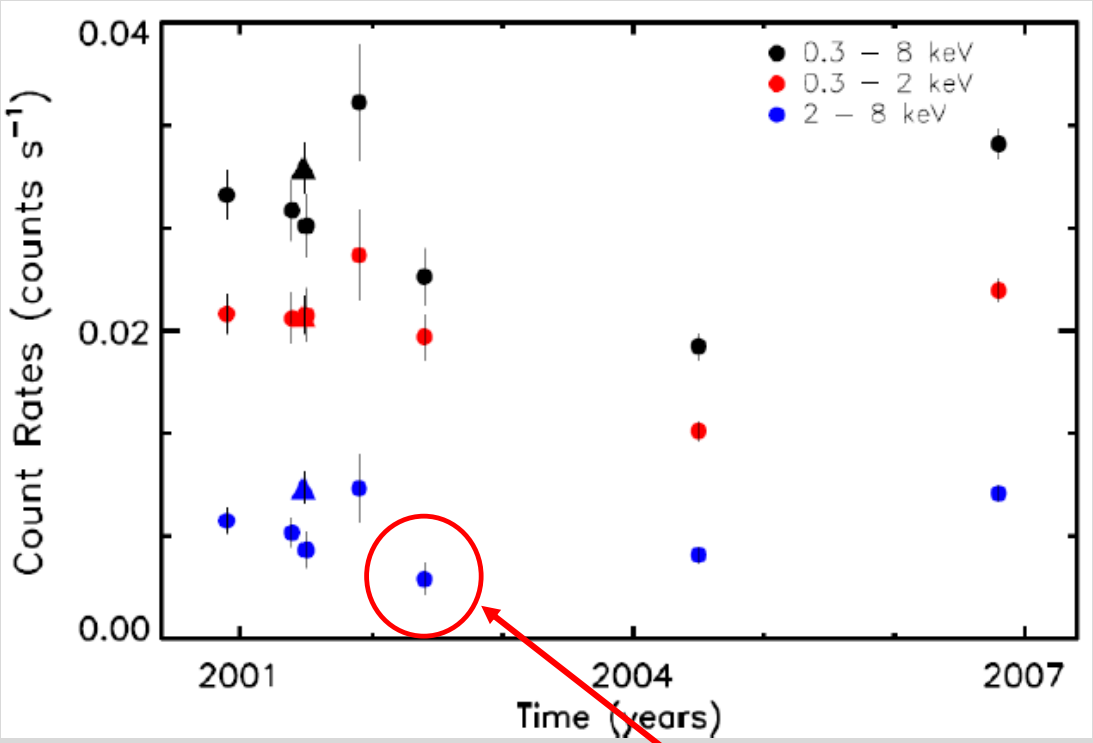
ULX X-6, literatürde ULX olarak sınıflandırılmış bir kaynak (Swartz et al. 2011, ApJ, 741, 49).

ULX X-6'nın arşiv X-ışın gözlemleri

	Belirteç	Gözlem No.	Gözlem Tarihi	Poz Süresi (ks)
XMM-Newton	XM1	0110920101	2000.12.08	16
	XM2	0059140101	2001.05.06	9
	XM3	0059140201	2001.06.17	10
	XM4	0059140401	2001.12.17	12
	XM5	0059140901	2002.05.22	14
	XM6	0203270202	2004.06.01	47
	XM7	0400560301	2006.11.17	59
Chandra	C1	1618	2001.05.28	21
Swift XRT	S1	00037259001	2008.03.01	10
	S2	00037317001	2008.05.06	3
	S3	00037317002	2009.03.09	4
	S4	00037317003	2009.05.09	2
	S5	00037259002	2014.05.21	2
	S6	00037259005	2014.05.24	1
	S7	00037259006	2014.05.25	2
	S8	00080599001	2014.05.25	2
	S9	00037259007	2014.05.30	2
	S10	00037259009	2014.06.08	2
	S11	00037259011	2014.06.18	0.03
	S12	00037259012	2014.06.22	2

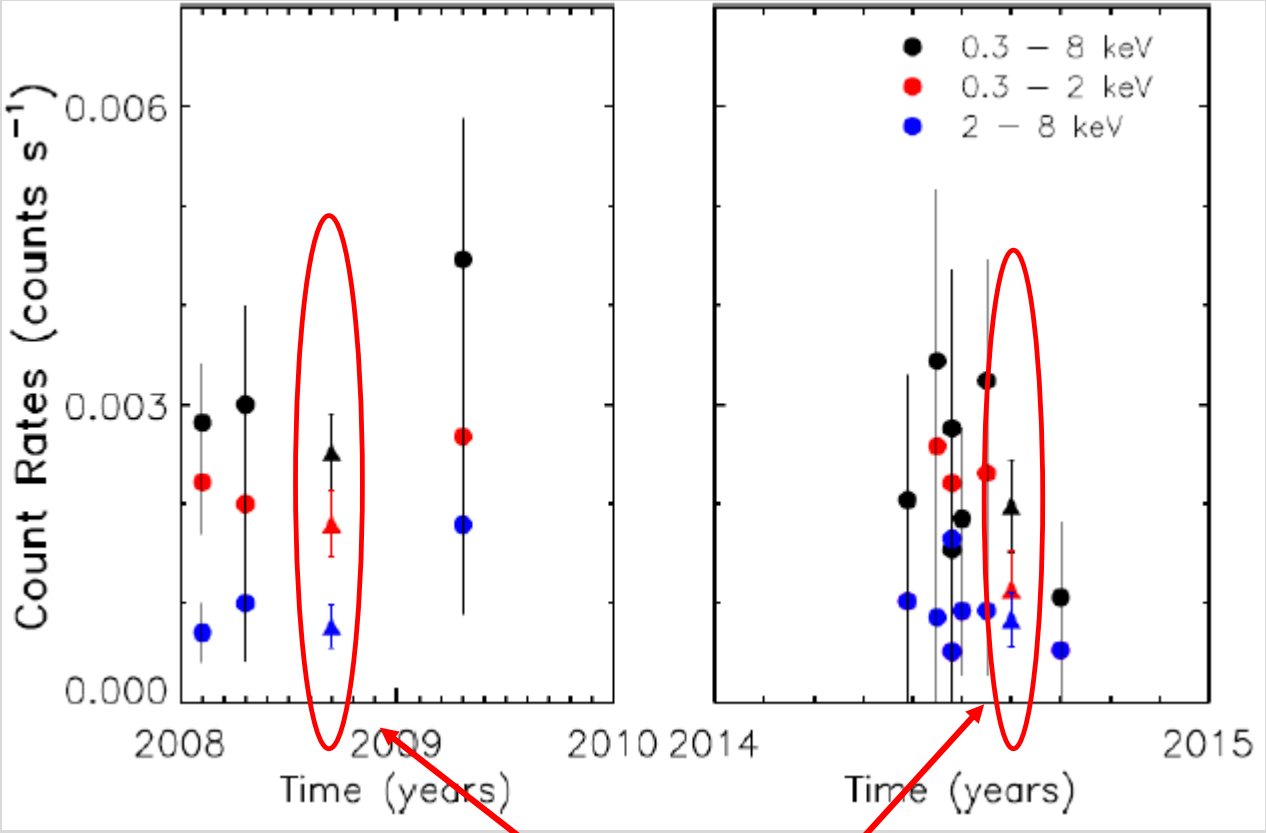
~ Son 17 ks'lik kısmı art alan parlamasına maruz kalmıştır.

Uzun dönemli ışık eğrisi (*XMM-Newton* ve *Chandra*)



XM5 verisi

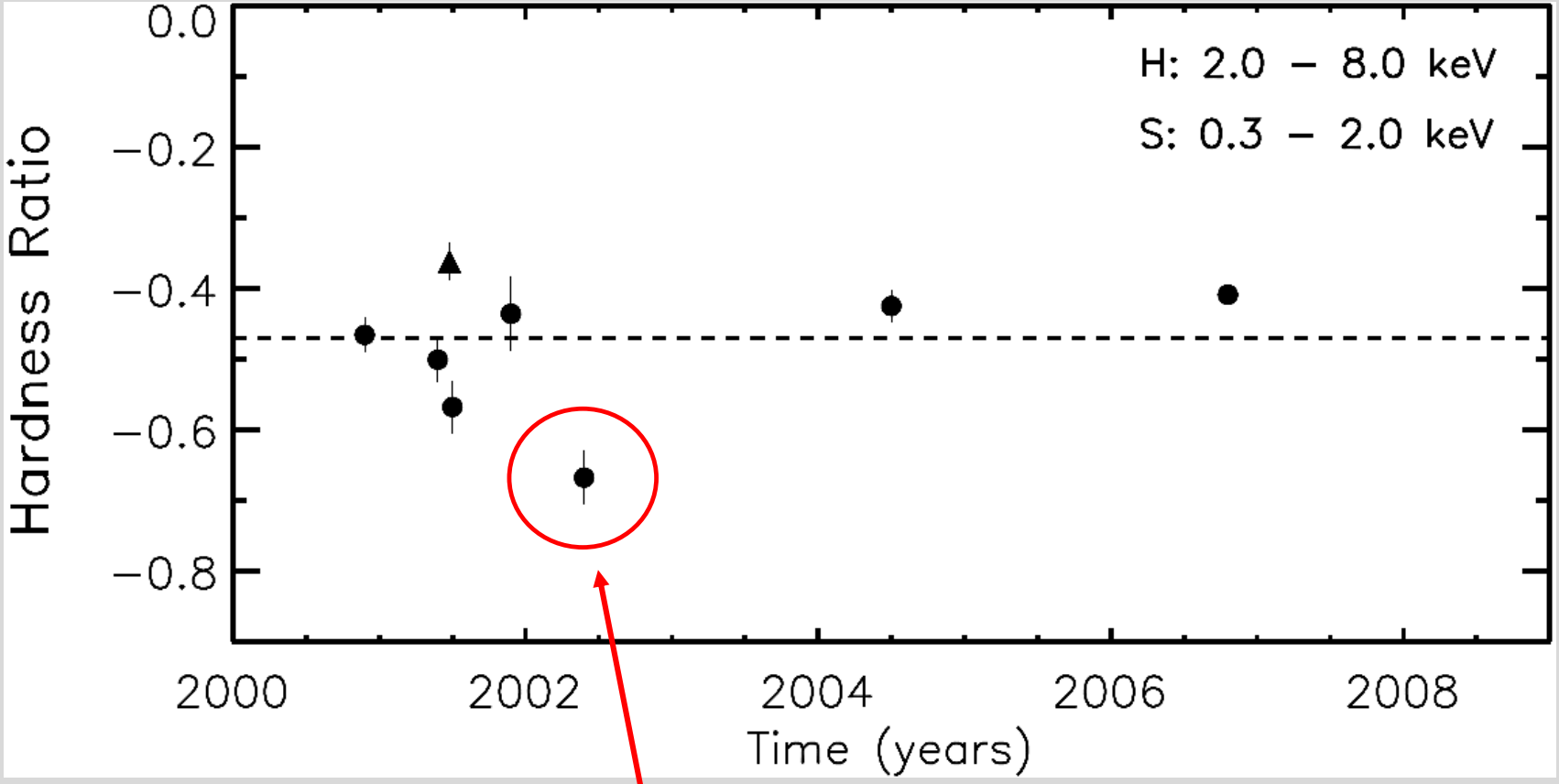
Uzun dönemli ışık eğrisi (*Swift* XRT)



Verilerin toplanması ile hesaplanan foton sayım oranları

Uzun dönemli HR grafiği

$HR = H\text{-}S \,/\, H\text{+}S$



XM5 verisi

En iyi uyum veren model parametreleri

No.	N_H (10^{22} cm^{-2})	Γ	T_{in} (keV)	χ^2/dof	N_{PL}[a] (10^{-5})	N_{disk}[b] (10^{-3})	L_X[c] (10^{39}) (erg s^{-1})	L_{bol}[d] (10^{39}) (erg s^{-1})
				tbabs*powerlaw				
XM1	$0.10^{+0.03}_{-0.02}$	$1.77^{+0.10}_{-0.10}$	-	40.11/33	$2.59^{+0.18}_{-0.18}$	-	$1.21^{+0.08}_{-0.09}$	-
XM2	$0.21^{+0.04}_{-0.04}$	$2.13^{+0.19}_{-0.19}$	-	16.76/17	$3.66^{+0.32}_{-0.32}$	-	$1.37^{+0.12}_{-0.11}$	-
C1	$0.22^{+0.04}_{-0.04}$	$1.91^{+0.16}_{-0.15}$	-	10.39/15	$3.74^{+0.33}_{-0.33}$	-	$1.57^{+0.14}_{-0.14}$	-
XM3	$0.34^{+0.05}_{-0.04}$	$2.47^{+0.15}_{-0.15}$	-	15.67/22	$5.49^{+0.48}_{-0.48}$	-	$1.80^{+0.17}_{-0.15}$	-
XM4	$0.21^{+0.06}_{-0.04}$	$1.96^{+0.22}_{-0.20}$	-	35.13/28	$5.05^{+0.53}_{-0.53}$	-	$2.06^{+0.21}_{-0.21}$	-
XM5	$0.19^{+0.03}_{-0.03}$	$2.40^{+0.20}_{-0.19}$	-	30.49/28	$3.32^{+0.29}_{-0.29}$	-	$1.11^{+0.10}_{-0.10}$	-
XM6	$0.25^{+0.02}_{-0.02}$	$2.11^{+0.11}_{-0.11}$	-	101.26/79	$5.84^{+0.32}_{-0.32}$	-	$2.20^{+0.12}_{-0.12}$	-
XM7	$0.20^{+0.02}_{-0.02}$	$1.90^{+0.06}_{-0.06}$	-	160.34/150	$3.87^{+0.19}_{-0.19}$	-	$1.65^{+0.07}_{-0.08}$	-
				tbabs*diskbb				
XM1	<0.82	-	$1.25^{+0.12}_{-0.10}$	51.67/33	-	$2.21^{+0.16}_{-0.16}$	$0.80^{+0.05}_{-0.06}$	$0.84^{+0.05}_{-0.07}$
XM2	$0.02^{+0.04}_{-0.02}$	-	$1.01^{+0.12}_{-0.10}$	19.07/17	-	$4.96^{+0.43}_{-0.43}$	$0.74^{+0.06}_{-0.07}$	$0.78^{+0.08}_{-0.06}$
C1	$0.06^{+0.04}_{-0.03}$	-	$1.17^{+0.13}_{-0.11}$	8.18/15	-	$3.48^{+0.30}_{-0.30}$	$0.96^{+0.08}_{-0.09}$	$1.01^{+0.08}_{-0.09}$
XM3	$0.09^{+0.05}_{-0.04}$	-	$0.93^{+0.12}_{-0.10}$	20.26/22	-	$7.50^{+0.66}_{-0.66}$	$0.82^{+0.07}_{-0.07}$	$0.87^{+0.06}_{-0.09}$
XM4	$0.01^{+0.05}_{-0.01}$	-	$1.23^{+0.17}_{-0.14}$	35.97/28	-	$3.74^{+0.39}_{-0.39}$	$1.23^{+0.14}_{-0.12}$	$1.31^{+0.14}_{-0.13}$
XM5	<0.82	-	$0.83^{+0.10}_{-0.09}$	35.18/28	-	$7.33^{+0.66}_{-0.66}$	$0.53^{+0.05}_{-0.05}$	$0.58^{+0.01}_{-0.09}$
XM6	$0.07^{+0.02}_{-0.02}$	-	$1.06^{+0.07}_{-0.07}$	101.28/79	-	$6.87^{+0.37}_{-0.37}$	$1.24^{+0.06}_{-0.06}$	$1.32^{+0.08}_{-0.07}$
XM7	$0.04^{+0.01}_{-0.01}$	-	$1.37^{+0.07}_{-0.06}$	174.51/150	-	$2.12^{+0.10}_{-0.10}$	$1.09^{+0.06}_{-0.05}$	$1.15^{+0.06}_{-0.06}$

ULX, genel olarak sert bir tayfa sahip ($\Gamma \sim 1.8 - 2.1$)

No.	L_X[c] (10^{39}) (erg s^{-1})	L_{bol}[d] (10^{39}) (erg s^{-1})
XM1	$1.21^{+0.08}_{-0.09}$	-
XM2	$1.37^{+0.12}_{-0.11}$	-
C1	$1.57^{+0.14}_{-0.14}$	-
XM3	$1.80^{+0.17}_{-0.15}$	-
XM4	$2.06^{+0.21}_{-0.21}$	-
XM5	$1.11^{+0.10}_{-0.10}$	-
XM6	$2.20^{+0.12}_{-0.12}$	-
XM7	$1.65^{+0.07}_{-0.08}$	-
XM1	$0.80^{+0.05}_{-0.06}$	$0.84^{+0.05}_{-0.07}$
XM2	$0.74^{+0.06}_{-0.07}$	$0.78^{+0.08}_{-0.06}$
C1	$0.96^{+0.08}_{-0.09}$	$1.01^{+0.08}_{-0.09}$
XM3	$0.82^{+0.07}_{-0.07}$	$0.87^{+0.06}_{-0.09}$
XM4	$1.23^{+0.14}_{-0.12}$	$1.31^{+0.14}_{-0.13}$
XM5	$0.53^{+0.05}_{-0.05}$	$0.58^{+0.01}_{-0.09}$
XM6	$1.24^{+0.06}_{-0.06}$	$1.32^{+0.08}_{-0.07}$
XM7	$1.09^{+0.06}_{-0.05}$	$1.15^{+0.06}_{-0.06}$

PL

$L_X \sim (1.1 – 2.2)\times10^{39}$ erg s^{-1}

DISKBB

$L_X \sim (0.5 – 1.2)\times10^{39}$ erg s^{-1}

No.	N_H (10^{22} cm^{-2})	Γ	T_{in} (keV)	χ^2/dof	N_{PL}[a] (10^{-5})	N_{disk}[b] (10^{-3})	L_X[c] (10^{39}) (erg s^{-1})	L_{bol}[d] (10^{39}) (erg s^{-1})
				tbabs*powerlaw				
XM1	$0.10^{+0.03}_{-0.02}$	$1.77^{+0.10}_{-0.10}$	-	40.11/33	$2.59^{+0.18}_{-0.18}$	-	$1.21^{+0.08}_{-0.09}$	-
XM2	$0.21^{+0.04}_{-0.04}$	$2.13^{+0.19}_{-0.19}$	-	16.76/17	$3.66^{+0.32}_{-0.32}$	-	$1.37^{+0.12}_{-0.11}$	-
C1	$0.22^{+0.04}_{-0.04}$	$1.91^{+0.16}_{-0.15}$	-	10.39/15	$3.74^{+0.33}_{-0.33}$	-	$1.57^{+0.14}_{-0.14}$	-
XM3	$0.34^{+0.05}_{-0.04}$	$2.47^{+0.15}_{-0.15}$	-	15.67/22	$5.49^{+0.48}_{-0.48}$	-	$1.89^{+0.17}_{-0.15}$	-
XM4	$0.21^{+0.06}_{-0.04}$	$1.96^{+0.22}_{-0.20}$	-	35.13/28	$5.05^{+0.53}_{-0.53}$	-	$2.06^{+0.21}_{-0.21}$	-
XM5	$0.19^{+0.03}_{-0.03}$	$2.40^{+0.20}_{-0.19}$	-	30.49/28	$3.32^{+0.29}_{-0.29}$	-	$1.11^{+0.10}_{-0.10}$	-
XM6	$0.25^{+0.02}_{-0.02}$	$2.11^{+0.11}_{-0.11}$	-	101.26/79	$5.84^{+0.32}_{-0.32}$	-	$2.20^{+0.12}_{-0.12}$	-
XM7	$0.20^{+0.02}_{-0.02}$	$1.90^{+0.06}_{-0.06}$	-	160.34/150	$3.87^{+0.19}_{-0.19}$	-	$1.65^{+0.07}_{-0.08}$	-
				tbabs*diskbb				
XM1	<0.82	-	$1.25^{+0.12}_{-0.10}$	51.67/33	-	$2.21^{+0.16}_{-0.16}$	$0.80^{+0.05}_{-0.06}$	$0.84^{+0.05}_{-0.07}$
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XM3	$0.09^{+0.05}_{-0.04}$	-	$0.93^{+0.12}_{-0.10}$	20.26/22	-	$7.50^{+0.66}_{-0.66}$	$0.82^{+0.07}_{-0.07}$	$0.87^{+0.06}_{-0.09}$
XM4	$0.01^{+0.05}_{-0.01}$	-	$1.23^{+0.17}_{-0.14}$	35.97/28	-	$3.74^{+0.39}_{-0.39}$	$1.23^{+0.14}_{-0.12}$	$1.31^{+0.14}_{-0.13}$
XM5	<0.82	-	$0.83^{+0.10}_{-0.09}$	35.18/28	-	$7.33^{+0.66}_{-0.66}$	$0.53^{+0.05}_{-0.05}$	$0.58^{+0.01}_{-0.09}$
XM6	$0.07^{+0.02}_{-0.02}$	-	$1.06^{+0.07}_{-0.07}$	101.28/79	-	$6.87^{+0.37}_{-0.37}$	$1.24^{+0.06}_{-0.06}$	$1.32^{+0.08}_{-0.07}$
XM7	$0.04^{+0.01}_{-0.01}$	-	$1.37^{+0.07}_{-0.06}$	174.51/150	-	$2.12^{+0.10}_{-0.10}$	$1.09^{+0.06}_{-0.05}$	$1.15^{+0.06}_{-0.06}$

No.	N_H (10^{22} cm^{-2})	Γ	T_{in} (keV)	χ^2/dof	N_{PL}[a] (10^{-5})	N_{disk}[b] (10^{-3})	L_X[c] (10^{39}) (erg s^{-1})	L_{bol}[d] (10^{39}) (erg s^{-1})
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XM1	$0.10^{+0.03}_{-0.02}$	$1.77^{+0.10}_{-0.10}$	-	40.11/33	$2.59^{+0.18}_{-0.18}$	-	$1.21^{+0.08}_{-0.09}$	-
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C1	$0.22^{+0.04}_{-0.04}$	$1.91^{+0.16}_{-0.15}$	-	10.39/15	$3.74^{+0.33}_{-0.33}$	-	$1.57^{+0.14}_{-0.14}$	-
XM3	$0.34^{+0.05}_{-0.04}$	$2.47^{+0.15}_{-0.15}$	-	15.67/22	$5.49^{+0.48}_{-0.48}$	-	$1.89^{+0.17}_{-0.15}$	-
XM4	$0.21^{+0.06}_{-0.04}$	$1.96^{+0.22}_{-0.20}$	-	35.13/28	$5.05^{+0.53}_{-0.53}$	-	$2.06^{+0.21}_{-0.21}$	-
XM5	$0.19^{+0.03}_{-0.03}$	$2.40^{+0.20}_{-0.19}$	-	30.49/28	$3.32^{+0.29}_{-0.29}$	-	$1.11^{+0.10}_{-0.10}$	-
XM6	$0.25^{+0.02}_{-0.02}$	$2.11^{+0.11}_{-0.11}$	-	101.26/79	$5.84^{+0.32}_{-0.32}$	-	$2.20^{+0.12}_{-0.12}$	-
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XM2	$0.02^{+0.04}_{-0.02}$	-	$1.01^{+0.12}_{-0.10}$	19.07/17	-	$4.96^{+0.43}_{-0.43}$	$0.74^{+0.06}_{-0.07}$	$0.78^{+0.08}_{-0.06}$
C1	$0.06^{+0.04}_{-0.03}$	-	$1.17^{+0.13}_{-0.11}$	8.18/15	-	$3.48^{+0.30}_{-0.30}$	$0.96^{+0.08}_{-0.09}$	$1.01^{+0.08}_{-0.09}$
XM3	$0.09^{+0.05}_{-0.04}$	-	$0.93^{+0.12}_{-0.10}$	20.26/22	-	$7.50^{+0.66}_{-0.66}$	$0.82^{+0.07}_{-0.07}$	$0.87^{+0.06}_{-0.09}$
XM4	$0.01^{+0.03}_{-0.01}$	-	$1.23^{+0.17}_{-0.14}$	35.97/28	-	$3.74^{+0.39}_{-0.39}$	$1.23^{+0.14}_{-0.12}$	$1.31^{+0.14}_{-0.13}$
XM5	<0.82	-	$0.83^{+0.10}_{-0.09}$	35.18/28	-	$7.33^{+0.66}_{-0.66}$	$0.53^{+0.05}_{-0.05}$	$0.58^{+0.01}_{-0.09}$
XM6	$0.07^{+0.02}_{-0.02}$	-	$1.06^{+0.07}_{-0.07}$	101.28/79	-	$6.87^{+0.37}_{-0.37}$	$1.24^{+0.06}_{-0.06}$	$1.32^{+0.08}_{-0.07}$
XM7	$0.04^{+0.01}_{-0.01}$	-	$1.37^{+0.07}_{-0.06}$	174.51/150	-	$2.12^{+0.10}_{-0.10}$	$1.09^{+0.06}_{-0.05}$	$1.15^{+0.06}_{-0.06}$

No.	N_H (10^{22} cm^{-2})	Γ	T_{in} (keV)	χ^2/dof	N_{PL}[a] (10^{-5})	N_{disk}[b] (10^{-3})	L_X[c] (10^{39}) (erg s^{-1})	L_{bol}[d] (10^{39}) (erg s^{-1})
				tbabs*powerlaw				
XM1	$0.10^{+0.03}_{-0.02}$	$1.77^{+0.10}_{-0.10}$	-	40.11/33	$2.59^{+0.18}_{-0.18}$	-	$1.21^{+0.08}_{-0.09}$	-
XM2	$0.21^{+0.04}_{-0.04}$	$2.13^{+0.19}_{-0.19}$	-	16.76/17	$3.66^{+0.32}_{-0.32}$	-	$1.37^{+0.12}_{-0.11}$	-
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XM7	$0.20^{+0.02}_{-0.02}$	$1.90^{+0.06}_{-0.06}$	-	160.34/150	$3.87^{+0.19}_{-0.19}$	-	$1.65^{+0.07}_{-0.08}$	-
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XM1	<0.82	-	$1.25^{+0.12}_{-0.10}$	51.67/33	-	$2.21^{+0.16}_{-0.16}$	$0.80^{+0.05}_{-0.06}$	$0.84^{+0.05}_{-0.07}$
XM2	$0.02^{+0.04}_{-0.02}$	-	$1.01^{+0.12}_{-0.10}$	19.07/17	-	$4.96^{+0.43}_{-0.43}$	$0.74^{+0.06}_{-0.07}$	$0.78^{+0.08}_{-0.06}$
C1	$0.06^{+0.04}_{-0.03}$	-	$1.17^{+0.13}_{-0.11}$	8.18/15	-	$3.48^{+0.30}_{-0.30}$	$0.96^{+0.08}_{-0.09}$	$1.01^{+0.08}_{-0.09}$
XM3	$0.09^{+0.05}_{-0.04}$	-	$0.93^{+0.12}_{-0.10}$	20.26/22	-	$7.50^{+0.66}_{-0.66}$	$0.82^{+0.07}_{-0.07}$	$0.87^{+0.06}_{-0.09}$
XM4	$0.01^{+0.05}_{-0.01}$	-	$1.23^{+0.17}_{-0.14}$	35.97/28	-	$3.74^{+0.39}_{-0.39}$	$1.23^{+0.14}_{-0.12}$	$1.31^{+0.14}_{-0.13}$
XM5	<0.82	-	$0.83^{+0.10}_{-0.09}$	35.18/28	-	$7.33^{+0.66}_{-0.66}$	$0.53^{+0.05}_{-0.05}$	$0.58^{+0.01}_{-0.09}$
XM6	$0.07^{+0.02}_{-0.02}$	-	$1.06^{+0.07}_{-0.07}$	101.28/79	-	$6.87^{+0.37}_{-0.37}$	$1.24^{+0.06}_{-0.06}$	$1.32^{+0.08}_{-0.07}$
XM7	$0.04^{+0.01}_{-0.01}$	-	$1.37^{+0.07}_{-0.06}$	174.51/150	-	$2.12^{+0.10}_{-0.10}$	$1.09^{+0.06}_{-0.05}$	$1.15^{+0.06}_{-0.06}$

$M_{BH} \sim 15\ M_{\odot}$

DISKPBB model (p-free model)

$T\,(R) \propto R^{p}$

İnce disk; $p = 0.75$

Kalın disk; $p = 0.50$

No.	N_H (10^{22} cm^{-2})	T_{in} (keV)	p	χ^2/dof	N_{disk}[a] (10^{-4})	L_X[b] (10^{39}) (erg s^{-1})
			tbabs*diskpbb			
XM1	$0.05^{+0.03}_{-0.02}$	1.70	$0.60^{+0.03}_{-0.03}$	44.17/33	$3.49^{+0.25}_{-0.25}$	$0.92^{+0.06}_{-0.07}$
XM2	$0.16^{+0.04}_{-0.03}$	1.70	$0.52^{+0.03}_{-0.03}$	17.04/17	$1.93^{+0.16}_{-0.16}$	$1.11^{+0.10}_{-0.10}$
C1	$0.05^{+0.04}_{-0.03}$	$1.16^{+0.13}_{-0.11}$	$0.76^{+0.10}_{-0.07}$	8.18/14	$37.39^{+0.33}_{-0.33}$	$0.95^{+0.09}_{-0.08}$
XM3	$0.27^{+0.05}_{-0.04}$	$1.52^{+0.78}_{-0.39}$	$0.50^{+0.02}_{-0.02}$	16.30/21	$2.88^{+0.25}_{-0.25}$	$1.32^{+0.12}_{-0.11}$
XM4	$0.10^{+0.05}_{-0.04}$	1.70	$0.59^{+0.05}_{-0.04}$	35.34/28	$5.29^{+0.55}_{-0.55}$	$1.48^{+0.18}_{-0.14}$
XM5	$0.16^{+0.03}_{-0.03}$	1.70	$0.48^{+0.03}_{-0.02}$	30.86/28	$0.93^{+0.08}_{-0.08}$	$0.94^{+0.09}_{-0.08}$
XM6	$0.18^{+0.02}_{-0.02}$	$1.54^{+0.24}_{-0.19}$	$0.55^{+0.02}_{-0.02}$	99.06/78	$5.96^{+0.32}_{-0.32}$	$1.66^{+0.09}_{-0.09}$
XM7	$0.16^{+0.02}_{-0.02}$	$2.58^{+0.46}_{-0.34}$	$0.55^{+0.01}_{-0.01}$	156.23/149	$0.66^{+0.03}_{-0.03}$	$1.45^{+0.07}_{-0.08}$

Süper-Eddington (süperkritik) yığılma diski;

$R << R_{sp} \rightarrow H/R \sim 1 \rightarrow T\,(R) \propto R^{1/2}$

Kompakt Cismin Kütlesi?

XM3 verisi için hesaplanan DISKBB ve DISKPBB normalizasyon parametreleri kullanılarak…

→ $M_{BH} \sim 10\ M_{\odot}$

Eddington limiti kullanılarak….

→ $M_{BH} \sim 15\ M_{\odot}$

Yıldız kütleli bir karadelik…

Özet

- ULX'in *XMM-Newton* ve *Chandra* X-ışın tayflarında belirgin tayfsal geçişler görülemese de, tayfsal değişim görülmektedir.

- Gözlemler boyunca sertlik oranındaki değişim de bu sonucu desteklemektedir.

- Sistemdeki kompakt cisim yıldız kütleli bir karadelik olabilir.

Çalışmamız

X-ray Spectral ve Optical Properties of a ULX in NGC 4258 (M106)

başlığı ile The Astrophysical Journal'da kabul edilmiştir.

(arxiv:1607.02881)

NGC 4258 Galaksisindeki ULX X-6 Kaynağının X-ışın Özellikleri

Hasan AVDAN,
Şenay AVDAN, Aysun AKYÜZ, Şölen BALMAN,
Nazım AKSAKER, İnci AKKAYA ORALHAN

Bu çalışma TÜBİTAK tarafından 113F039 nolu proje ile desteklenmiştir.

UAK 2016 5 – 9 Eylül 2016 Atatürk Üniversitesi

Dinlediğiniz için Teşekkürler...