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CHANDRA SURVEY OF OPTICALLY SELECTED AGN PAIRS

Meicun Hou (Nanjing University, houmc@smail.nju.edu.cn), Zhiyuan Li (NJU), Xin Liu (UIUC)

1. INTRODUCTION

Active galactic nucleus (AGN) pairs are an ideal laboratory to study the effects of galaxy merger in the standard paradigm of galaxy formation and evolution. The causal link between galaxy interactions and AGNs for low-luminosity AGNs is still elusive (Hopkins et al. 2014). Observations of AGN pairs help understand galaxy mergers in general and tidally-triggered AGN in particular. Based on large, homogeneous optical survey such as SDSS and the ability of X-ray, especially the hard X-ray (2-10 keV) band, to provide the most unambiguous evidence for AGNs, we present an archival X-ray survey of optically selected AGN pairs with a statistically significant sample to confirm their dual AGN nature and study the elusive link between mergers and dual AGNs.

2. SAMPLE

We adopt a sample of spectroscopically identified SDSS **AGN pairs** via emission-line ratios/widths from Liu et al. (2011) with **$0.02 < z < 0.33$**, projected separations **$r_p < 100$ kpc** and line-of-sight velocity offsets **$\Delta v < 600$ km/s**. Among the 1286 AGN pairs candidates, 67 have available *Chandra*/ACIS observation, which is the **largest** sample of AGN pairs known. We also select control samples of 67 **star-forming galaxy pairs** with available *Chandra* observation which are spectroscopically dominated by star-forming activities in the optical from a sample of ~3000 SDSS galaxy pairs and 115 **single AGNs** in isolated galaxies matched in redshift and stellar mass with AGN pairs.

We performed point source detection for these observations in 0.5-8(F), 0.5-2(S), 2-8(H) keV bands and measure the intrinsic X-ray luminosity for each nuclei.

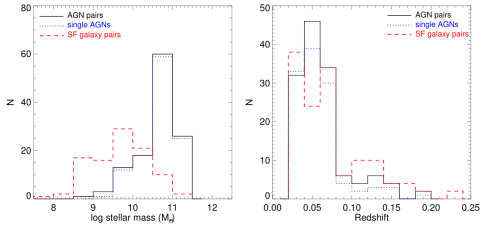


Fig1. Stellar mass and redshift distribution of the AGN pairs and control samples.

3. X-RAY INCIDENCE RATE

- With a matching radius of 2″, among the 67 pairs, 18 AGN pairs have both nuclei detected in X-ray, 39 AGN pairs have one nucleus detected in X-ray and 10 AGN pairs have no X-ray detection. A total of 75 nuclei have X-ray counterparts, giving a **X-ray incidence rate** of 56.0±6.5% (75/134).
- In a control sample of galaxy pairs, only 18 pairs have at lease one of the nuclei detected in X-ray with a X-ray incidence rate of 17.2±3.4% (23/134), which is significantly lower than AGN pairs, indicating only a small fraction of X-ray emission comes from star-forming related processes.
- In a control sample of single AGNs, 66 out of 115 nuclei are detected in X-ray with a X-ray incidence rate of 57.4±7.1% (66/115). The comparable incidence rate with AGN pairs suggests that mergers may not have too much additional contribution to AGN activities.

Sample	Sample size	# of detection	F band	S band	H band	Incidence rate
(1)	(2)	(3)	(4)	(5)	(6)	(7)
AGN pairs	134	75	72	69	47	56.0% ± 6.5%
Single AGNs	115	66	60	58	36	57.4% ± 7.1%
SFG pairs	134	23	22	20	6	17.2% ± 3.4%
SFG pairs (stellar mass $> 10^9$ $M_\odot$)	78	16	16	14	5	20.5% ± 5.1%
AGN pairs ($r_p \gtrsim 10$ kpc)	94	44	41	40	25	46.8% ± 7.1%
AGN pairs ($r_p \lesssim 10$ kpc)	40	31	31	29	22	77.5% ± 13.9%
AGN pairs ($L_{X,2-10} > 10^{41}$ erg s^{-1})	134	37	37	34	36	27.6% ± 4.5%
Single AGNs ($L_{X,2-10} > 10^{41}$ erg s^{-1})	115	28	28	24	27	24.3% ± 4.6%
subsamples (detection limit $> 10^{41.2}$ erg s^{-1})						
AGN pairs	114	65	63	60	40	57.0% ± 7.1%
Single AGNs	94	59	54	53	32	62.8% ± 8.2%
SFG pairs	90	20	20	17	6	22.2% ± 5.0%

NOTE—(1) Samples; (2) sample size; (3) number of detected sources in X-ray for different samples; (4)-(6) number of detected sources in F, S and H X-ray band, respectively; (7) X-ray incidence rate.

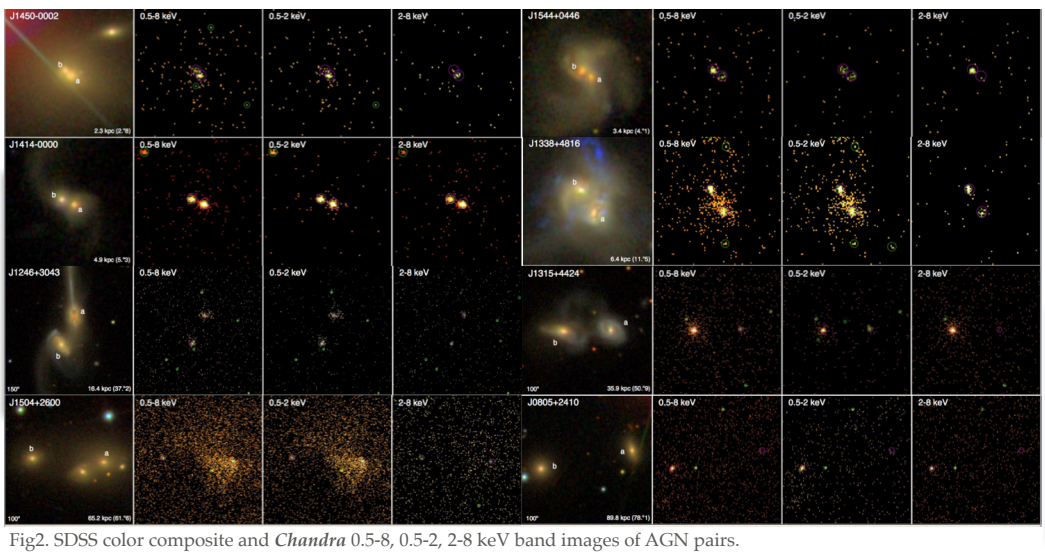


Fig2. SDSS color composite and ***Chandra*** 0.5-8, 0.5-2, 2-8 keV band images of AGN pairs.

4. PROPERTIES

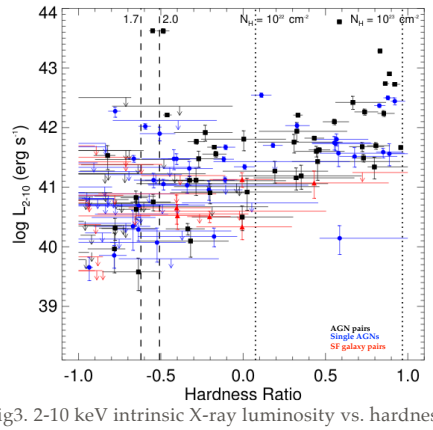


Fig3. 2-10 keV intrinsic X-ray luminosity vs. hardness ratio defined as HR = $(H - S)/(H + S)$.

X-ray emission are dominated by AGN for sources > 10^{41} erg s^{-1}, while star formation may dominate the emission for less luminous and soft sources.

5. LUMINOSITY TREND

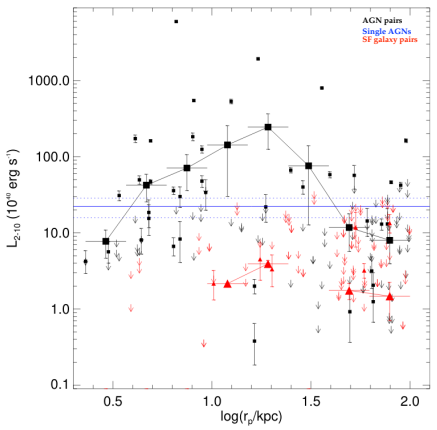
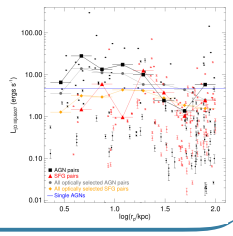


Fig4. 2-10 keV luminosity vs. projected separation r_p. The larger symbols are mean value of each r_p bin.

The X-ray luminosity increases with decreasing projected separation for AGN pairs with $r_p > 10$ kpc, suggesting an enhancement of central BH activity. While it decreases when $r_p < 10$ kpc, which is not consistent with [O III] luminosity trend. That trend may be caused by obscuring, merger-induced gas inflows or gas depletion in the central region of AGNs.



Reference

(1) Hopkins, P. F., Kocevski, D. D., & Bundy, K. 2014, MNRAS, 445, 823
(2) Liu, X., Shen, Y., Strauss, M. A., & Hao, L. 2011, ApJ, 737, 101

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