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ISTITUTO NAZIONALE DI ASTROFISICA
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ISTITUTO DI ASTROFISICA SPAZIALE E FISICA COSMICA - BOLOGNA

Ricerca di galassie in interazione/fusione in un campione di oggetti selezionati in raggi X di alta energia

Search for galaxies in interaction/merging in a sample of hard X-Ray selected objects

Part 2

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Introduction

An Active Galactic Nucleus (AGN) is a compact region in the center of a galaxy that has a much higher than normal luminosity and that emits more energy, as electromagnetic radiation, than the rest of the galaxy; about 100 times higher. A galaxy which hosts an AGN is an active galaxy. The radiation from AGN is believed to be the result of accretion of mass by a supermassive black hole (SMBH) at the center of its host galaxy.
In the local Universe about 10% of all galaxies are active.
In order for a SMBH to shine as an AGN, it needs a supply of gas to fuel its activity. Two main mechanisms have been suggested to trigger AGN activity: an internal mechanism through a dynamical instability inside the galaxy and **an external mechanism through galaxy-galaxy interaction or merging**. However, it is not yet clear which one is the dominant mechanism, even after many observational studies have been carried out.

The internal mechanism is such that a gas inflow to the central part occurs as a result of instability in the internal structure of a galaxy. For example, a galaxy bar can move gas from the outer regions of a galaxy into its center, and then the gas inflow can trigger the AGN phase.
On the other hand, the external mechanism is represented by galaxy-galaxy encounter and collision. In such a mechanism, gas infall during a major galaxy merging triggers the AGN. There are a number of observational results that support this idea. Studies of galaxy pairs or galaxies in interaction find that the AGN fraction increases in such systems. Binary SMBH in some AGN demonstrate that two or more SMBH can merge into one SMBH. After all, many AGN host galaxies are found to be elliptical galaxies, which do not possess bars or disk instabilities and hence must have been triggered by galaxy-galaxy collisions.
One promising way to investigate the AGN and merger connection is to study objects with merging features. When two galaxies with comparable mass merge, the merging produces an early-type galaxy leaving a trace of the past merging activity in the form of tidal tails, shells, and dust lanes. In support of this theoretical expectation, very deep imaging of early-type galaxies find merging features in many cases (15%–80%, depending on the depth of the image).

Recently a large number (20-25%) of these systems has been found analyzing samples of active galaxies selected in the hard X-ray band (20-100 keV) (see Koss et al. 2010 and Cotini et al. 2013). This fraction is much higher than the one (a few percent only) seen in control samples of normal galaxies and indicates that the AGN activity can indeed be triggered by galaxy-galaxy encounters.

Aim of the present project is to search for interacting/merging galaxies in a similar but much larger sample of AGN compared to the ones used by Koss et al. and Cotini et al.

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In fact, we have made our search using the latest survey made by the instrument BAT on board Swift, a NASA satellite. The identification of a group of AGN in interaction and/or merging selected in the hard X-ray band will allow the astronomers to study in depth their properties and to understand the merging mechanism in more detail.

Data Analysis and Results

We are 4 high school students, which attended the summer stage on the "Search for galaxies in interaction/merging in a sample of hard X-ray selected objects" and divided among ourselves the work load of this project during the 3 weeks spent at IASF/INAF of Bologna. To search for interacting/merging galaxies, we have used the Swift BAT 70-Month Hard X-ray survey catalogue (http://swift.gsfc.nasa.gov/results/bs70mon): this survey contains a total of 1210 high energy objects the majority of which are of extragalactic nature; in particular 822 sources are associated with active galaxies. We divided this sample of AGN in 4 parts: my set included all objects located from RA(J2000)= 0 Degrees, to RA(J2000)= 73 Degrees. For each of these objects, I have analyzed the optical/infrared images available in the archives to look for signs of interaction/merger and have searched the literature to back up my findings. In this project I have used two main databases (NED or NASA/IPAC Extragalactic Database and SIMBAD or Set of Identification, Measurements, and Bibliography for Astronomical Data), as well as the Aladine software to visualize images. I have also searched these databases by coordinates to confirm that the counterpart analyzed was the same as that reported in the Swift catalogue. Sources that were found to display signs of interaction, perturbation or the presence of a nearby companion/s were then further investigated in the archives to find confirmation that they were indeed the type of systems I was looking for.
In NED I also checked notes and references to individual sources to see if someone else had already observed and studied them in order to compare our results.
Finally I checked that eventual companion to interesting sources were at the same distance or redshift. I found 37 galaxies in merger or in interaction from my initial sample of 206 galaxies. These objects are listed in Table where I report the Swift name, companion's name, source's redshift, class of the main source and its morphology.

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N.	Name	Companion	z	Class	Morphology
1	SWIFT J0003.3+2737	?	?	galaxy	?
2	SWIFT J0009.4-0037	J000912.50-003718.0 J0009116-003655 (stesso redshift)	0.073	Seyfert 2	?
3	SWIFT J0010.5+1057 MRK 1501/ III Zw 2A	III Zw 002 B	0.089	Seyfert 1	spherical
4	SWIFT J0042.9-2332	NGC 0235B RSCG 04	0.022	Seyfert 1	S0 Pec
5	SWIFT J0048.8+3155 MRK 348	J00485285+3157309 J00484423+3158168 Group of galaxies	0.015	Seyfert 2	SA0/a?(s)
6	SWIFT J0100.9-4750 ESO 195-IG 021	J0100367-475202 ESO 195-IG 021 B	0.048	Seyfert 1.8	?
7	SWIFT J0105.6-3433	2MFGC 00788	0.057	Seyfert 1	?
8	SWIFT J0113.8+1313 MRK 975	LEDA 200187	0.049	Seyfert 1	S?
9	SWIFT J0113.8-1450 MRK 1152	Mrk 1152s	0.052	Seyfert 1	?
10	SWIFT J0114.4-5522 NGC 0454	NGC 0454 NED01	0.0121	Seyfert 2	?
11	SWIFT J0123.8-3504 NGC 526 A	NGC 0526B	0.019	Seyfert 1.5	E
12	SWIFT J0123.9-5846 FAIRALL 9	2MASX J01234906-5848308	0.047	Seyfert 1	Sc
13	SWIFT J0124.5+3350 NGC 513	KUG 0121+335 (stesso z)	0.019	Seyfert 2	S?
14	SWIFT J0128.4+1631 CGCG 459-058	CGCG 459-059 (stesso z)	0.038	Galaxy	S?
15	SWIFT J0149.2+2153B	UGC 01286 GROUP	0.009	Galaxy	SB(s)b? edge-on
16	SWIFT J0152.8-0329 MCG -01-05-047 IGR J01528-0326	KUG 0150-036A KUG 0150-036B	0.017	Seyfert 2	SA(s)c? edge-on
17	SWIFT J0209.5-1010 NGC 835	Interacting with NGC 0838 in compact group Arp 318	0.013	Seyfert 2	?
18	SWIFT J0214.6-0049 Mrk 590	SDSS J021429.36-004604.7 Pair but seems not interacting	0.026	Seyfert 1	SA(s)a?
19	SWIFT J0223.4+4551	V Zw 232 NOTES01 V Zw 232 NOTES02 V Zw 232 NOTES03	?	Galaxy triple	?
20	SWIFT J0226.4-2821	2MASX J02262568-2820588	0.059	Seyfert 1	S
21	SWIFT J0228.1+3118	LEDA 212995	0.016	Seyfert 1	SAbc

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	NGC 0931				
22	SWIFT J0234.6-0848 NGC 0985	NGC 0985 NED01 NGC 0985 NED02	0.043	Seyfert 1	Pec Ring
23	SWIFT J0238.2-5213 ESO 198-024	3XMM J023817.4-521136 (flux pn 1.8 x e-12 cgs)	0.045	Seyfert 1	?
24	SWIFT J0241.6+0711 Mrk 595	2MASX J02413426+0710510	0.026 0.037800 (companion)	Seyfert 1.5	?
25	SWIFT J0242.0+0516 2MASX J02420381+0510061	2MASX J02420535+0510191	0.069	Seyfert 2	?
26	SWIFT J0250.7+4142 NGC 1106	2MASX J02503882+4141561	0.014	Seyfert 2	SA0^+
27	SWIFT J0251.6-1639 NGC 1125	NGC 1125 NED01	0.010931 0.011595	Seyfert 2	(R')SB0/a?(r)
28	SWIFT J0255.2-0011 NGC 1142 o NGC 1144	SDSS J025511.52-001107.0 SDSS J025511.39-001059.8 SDSS J025511.26-001057.8 ARP 118 [BFW2006] J043.79505-00.17973 SDSS J025512.05-001032.9 NGC 1143 Mr18:[BFW2006] 05722 Interacting in a group	0.028	Seyfert 2	Ring
29	SWIFT J0256.4-3212 ESO417- G 006	APMUKS(BJ) B025418.68-322330.5	0.016	Seyfert 2	(R)SA0/a?
30	SWIFT J0308.2-2258 NGC 1229	NGC 1230 NGC 1228	0.036	Seyfert 2	SBb Pec
31	SWIFT J0325.0-4154 ESO 301- G 013	LCRS B032316.2-420431 LCRS B032318.5-420448 LCRS B032312.7-420353 LCRS B032320.9-420459 LCRS B032325.6-420447	0.058	Seyfert 1.5	?
32	SWIFT J0324.9+4044 LEDA 097012	2MASX J03251221+4042021	0.047	?	?
33	SWIFT J0342.0-2115 ESO 548-G 081	APMUKS(BJ) B033950.41-212355.6	0.014	Seyfert 1	SB(rs)a
34	SWIFT J0350.1-5019 2MASX J03502377-5018354	ESO 201-IG 004	0.036	Seyfert 2	?
35	SWIFT J0438.2-1048 MCG-02-12-050	2MASX J04381113-1047474 2MASX J04381880-1047004	0.036	Seyfert 1	*SBc*

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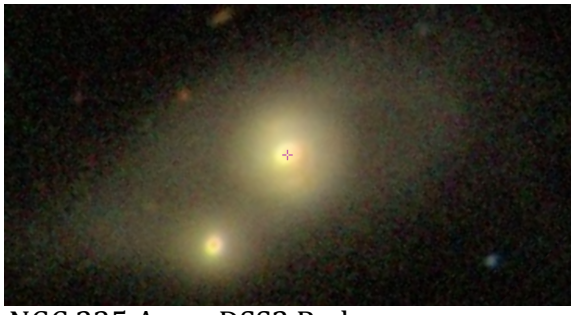
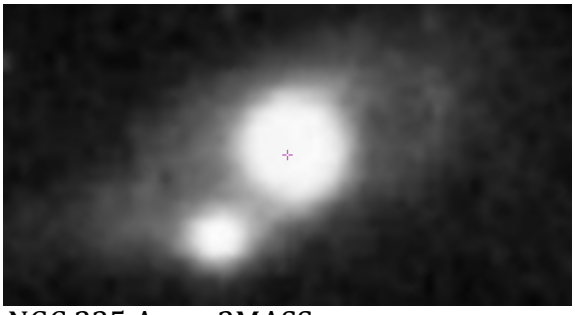
36	SWIFT J0440.2-5941 ESO118-IG 033 NED02	ESO 118-IG 033 NED02	0.057	Seyfert 2	S
37	SWIFT J0441.2-2704 IRAS 04392-2713	APMUKS(BJ) B043922.03-271406.8	0.083	Seyfert 1.5	?

A few examples of the sources I found are display in the following images:

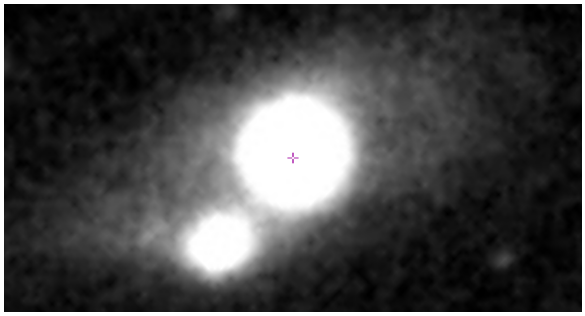
NGC 235 A con SDSS9



NGC 235 A con DSS2 Blue

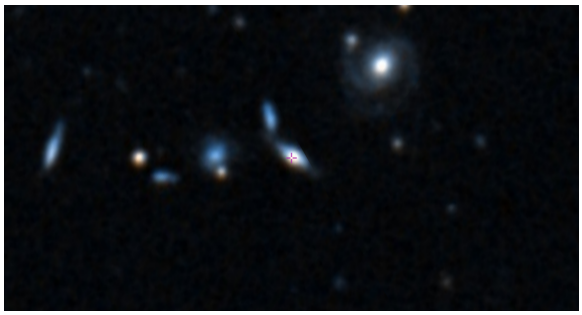


NGC 235 A con DSS2 Red



NGC 235 A con 2MASS

LCRS B032315.2-420449



Mrk 348

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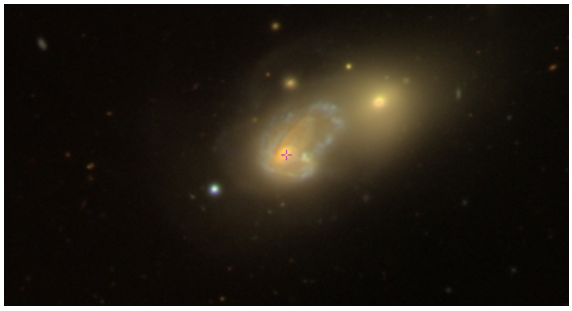
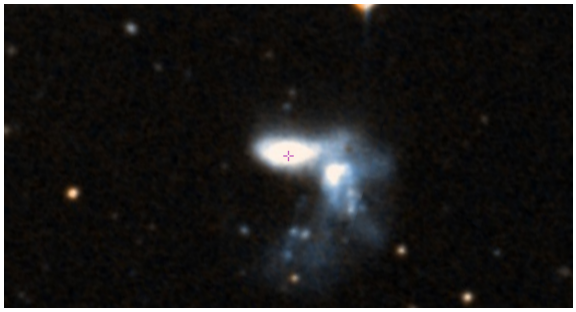
V Zw 232

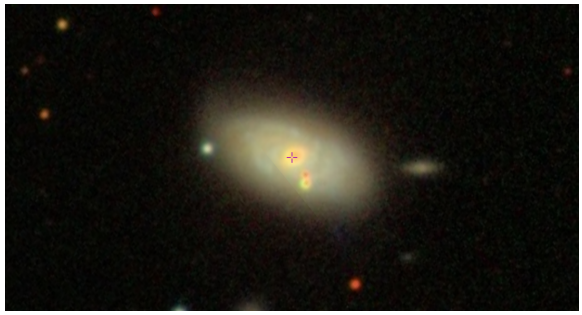
NGC 1142



NGC 454 E



NGC 513



Conclusions

17.9% of the 206 galaxies analyzed by me have been found to be in interaction/merging, this number is similar to the fraction found in previous studies by Koss et al. (2010) and Cotini et al. (2013). All together the 4 students of my stage found 152 galaxies in interaction/merging in the total sample of 822 galaxies analysed: this represents a fraction of 18,5 %. Thus our research confirms in total previous studies made by the above authors and further indicates that indeed the encounter between galaxies may play a role in the activation of an AGN.

References

Koss, M. et al. (2010) Ap. J. 716, L125
Cotini et al. (2013)MNRAS 431, 266

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