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-IV

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

Part 4

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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.

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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. 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 catalog (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)=73.354 Degrees, to RA(J2000)=165.861 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 Aladin 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 catalog. 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 41 galaxies in merger or in interaction from my initial sample of 203 galaxies. These objects are listed in Table where I report the Swift name, counterpart's redshift, compain's name and his redshift, counterpart's class and morphology.

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TABLE

Swift Name	Z	Compain	Z	Class	Morphology
SWIFT J0508.1+1727	0.017505	2MASX 05082121+1722083	0.016986	Seyfert 2 Galaxy	
SWIFT J0513.8+6627	0.014914	Not found			
SWIFT J0515.3+1854	0.023486	Not found			
SWIFT J0516.3+1928	0.021155	Not found			
SWIFT J0516.4-1034	0.028453	Not found		Seyfert 1 Galaxy	
SWIFT J0501.9-3239	0.012445	ESO 362-17	0.012342	Seyfert 2 Galaxy	SB0/a pec
SWIFT J0528.1-3933	0.036875	ESO 306-001 NED02	0.037152		
SWIFT J0543.9-2749	0.009915	Not Found		Seyfert 2 Galaxy	S0
SWIFT J0548.4-4748	0.050468	2MASX J05482455-4744347 --- 6dFGS gJ054825.6-474655	0.050788 --- 0.05079		Sa pec
SWIFT J0550.7-3212A	0.068998	USNO-A2.0 0525-02416317		BL Lac	
SWIFT J0554.8+4625	0.020484	Not found		Seyfert 2 Galaxy	SB
SWIFT J0602.2+2829	0.033000	2MASX J06021038+2828112		Seyfert 1 Galaxy	
SWIFT J0623.9-6058	0.040521	ESO 121-I628 NOTES1	0.041696	Seyfert 2 Galaxy	SB0/a
SWIFT J0630.7+6342	0.012769	LEDA 213341		Seyfert 1 Galaxy	Sb
SWIFT J0640.4-2554	0.024850	Several small companion		Seyfert 1 Galaxy	Sc
SWIFT J0714.2+3518	0.015694	Not found		Seyfert 2 Galaxy	S
SWIFT J0726.6-3552	0.029404	Not found		Seyfert 2 Galaxy	
SWIFT J0733.2+4558	0.141583	SDSS J073309.50+455507.2		Seyfert 1 Galaxy	
SWIFT J0742.5+4948	0.022189	Many companions		Seyfert 1 Galaxy	SBb
SWIFT J0744.0+2914	0.015844	UGC 3995B	0.015931	Seyfert 2 Galaxy	S pec
SWIFT J0804.6+1045	0.034434	SDSS J080446.73+104641.7	0.035262	Seyfert 2 Galaxy	Sdm
SWIFT J0818.1+0120	0.089000	Not found		Seyfert 1 Galaxy	
SWIFT J0823.4-0457	0.021815	F 271	0.022983	Seyfert 2 Galaxy	

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SWIFT J0856.0+7812	0.004670	AN 0849+78		Seyfert 2 Galaxy	SAB0/a
SWIFT J0902.0+6007	0.011088	UGC 4727	0.010791	Seyfert 1 Galaxy	S
SWIFT J0904.3+5538	0.037142	2MASX J09043675+5535515		Seyfert 1 Galaxy	
SWIFT J0917.2-6221	0.057300	Not found		Seyfert 1 Galaxy	
SWIFT J0920.8-0805	0.019644	MCG -01-24-011 --- MCG -01-24-013	0.019644 --- 0.019220	Seyfert 2 Galaxy	SAB(rs)c
SWIFT J0925.0+5218	0.035291	Not found		Seyfert 1 Galaxy	
SWIFT J0926.2+1244	0.029150	2MASX J09260351+1243341		Seyfert 1 Galaxy	S0
SWIFT J0927.3+2301	0.026315	Cluster of galaxies		Seyfert 1 Galaxy	S0
SWIFT J0934.7-2156	0.016285	ESO 565-18	0.0164	Seyfert 2 Galaxy	E
SWIFT J0935.9+6120	0.039363	Many possible companions		Seyfert 1 Galaxy	S
SWIFT J0945.6-1420	0.007710	NGC 2993	0.0081	Seyfert 2 Galaxy	Sa pec
SWIFT J1020.5-0237B	0.060200	Double nucleus			
SWIFT J1023.5+1952	0.003859	NGC 3226	0.0044386	Seyfert 1 Galaxy	SABa pec
SWIFT J1033.8+5257	0.064360	2MASX J10331570+5252182	0.065341		
SWIFT J1044.8+3812	0.025881	SDSS J104444.22+381032.9	0.025251	Seyfert 2 Galaxy	S
SWIFT J1046.8-2556	0.020591	LEDA 213731	0.020272	Seyfert 2 Galaxy	Sa
SWIFT J1051.2-1704B	0.018266	SGC 104909-1651.3			(R)SB(rs)ab pec
SWIFT J1052.8+1043	0.087835	SDSS J105231.95+103634.8		Seyfert 1 Galaxy	

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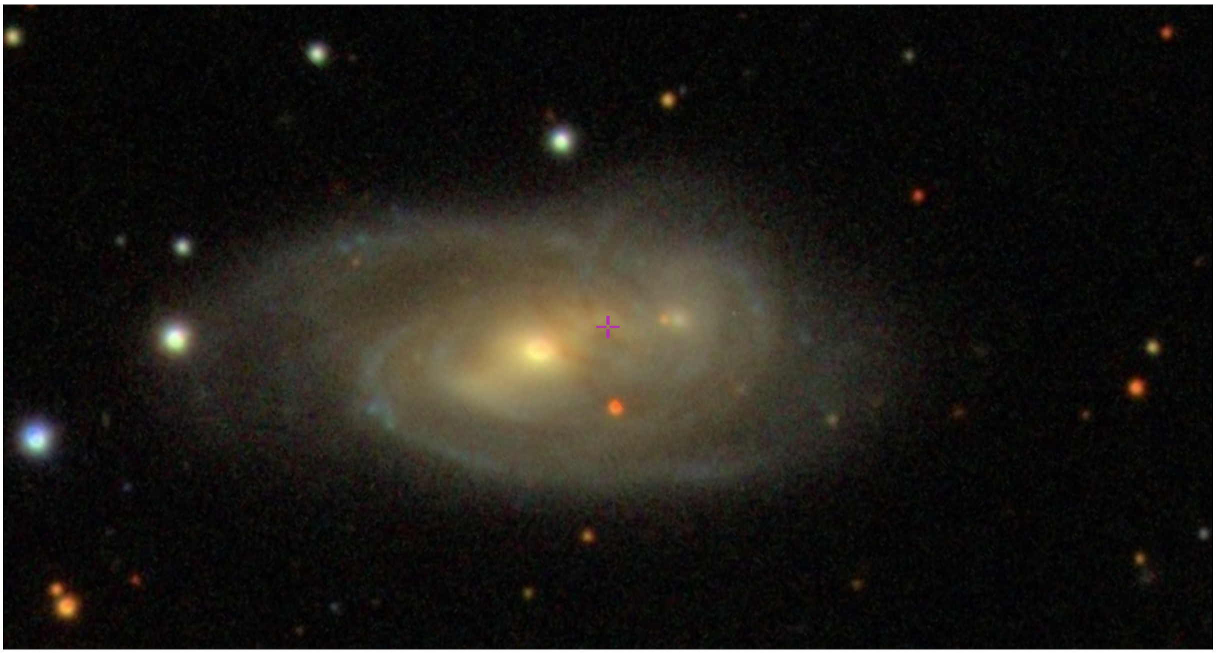
A few examples of the sources I found are display in the following images:



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Conclusions

20% of the 204 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 analyzed: 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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