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ISTITUTO DI ASTROFISICA SPAZIALE E FISICA COSMICA - BOLOGNA

Ricerca di galassie radio giganti in un campione di oggetti selezionati in raggi X di alta energia (Parte 1)

Search of giant radio galaxies in a sample of hard X-ray selected objects (Part 1)

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OUR AIM

Giant radio galaxies or GRGs are a particular type of radio galaxies with big dimensions and we think that they are very old or very powerful objects. Their number is low (~6%) in radio surveys, but recently a large number (24%) of them has been found analyzing a sample of radio galaxies selected between 20 keV and 100 keV by INTEGRAL, an ESA satellite. Aim of the present project is to search GRGs in a similar sample, using the database of Swift, a NASA satellite. The identification of a group of GRGs in hard X-ray band will allow the astronomers to study in depth their properties and to understand why they are so extended.

INTRODUCTION

Analyzing the sources detected by the IBIS instrument on INTEGRAL, Malizia and Bassani discovered a high fraction of giants objects among the sample of radio galaxies detected in the 20-100 keV also known as the hard X-ray band. Wondering why they decided to extend their sample studying hard X-ray selected radio galaxies found by the instrument BAT. For this purpose we worked on the Swift BAT 70-Month Hard X-ray survey catalogue (http://swift.gsfc.nasa.gov/results/bs70mon) which is an all sky survey obtained with the NASA satellite Swift.

Swift was launched into orbit on the 20th November 2004 to search primarily for gamma ray bursts. It consists of three instruments working on different wavelengths:

- BAT (Burst Alert Telescope)
  Thanks to a coded aperture mask it can image large portions of the sky over the energy range 15 - 150 keV, also covering the hard X-ray range energy.
- XRT (X-ray Telescope)
  With an error circle of approximately 2 arcseconds radius it's more accurate than BAT in locating high energy sources; its energy range is 0.2 – 10 keV.
- UVOT (Ultraviolet/Optical Telescope)
  A Ritchey-Chrétien telescope with a diameter of 30cm which provides optical and ultra-violet photometry (range 170–650 nm) of the sources seen by the high energy telescopes.

A by-product of the BAT instrument is an all sky survey; the most recent one is that produced using 70-Month of data. This survey contains a total of 1210 of high energy objects the majority of which are of extragalactic nature. We extracted from this catalogue 822 objects associated with active galaxies and analyzed the radio images of each one to look for a specific type of source called radio galaxy. In reality only 676 sources were analyzed owing to the fact that for easy access to the data we had to use the NVSS (NRAO VLA Sky Survey) which contains 1.4GHz images of radio-emitting objects located above -40° in declination (Condon et al. 1998); this database is easily accessible via the NED (NASA Extragalactic Database) archive.

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RADIO GALAXIES

In the local universe about 10% of all galaxies have a compact bright nucleus and are defined as Active Galactic Nuclei (AGN). Their brightness in many wavebands, in particular radio, microwave, X-Rays and gamma rays is due to the presence of a supermassive black hole at the source nucleus which is capable of converting gravitational energy into electromagnetic radiation. A small fraction (≤10%) of all AGNs is particularly bright at radio frequencies: these objects are classified as radio galaxies. In these objects the radio emission is due to the synchrotron radiation process. A radio galaxy displays a typical structure, which is due to the interaction between two symmetric jets and the external medium: this interaction provides the structure seen in the figure below where the source core, two jets and two lobes/hotspots of bright radio emission are clearly visible.

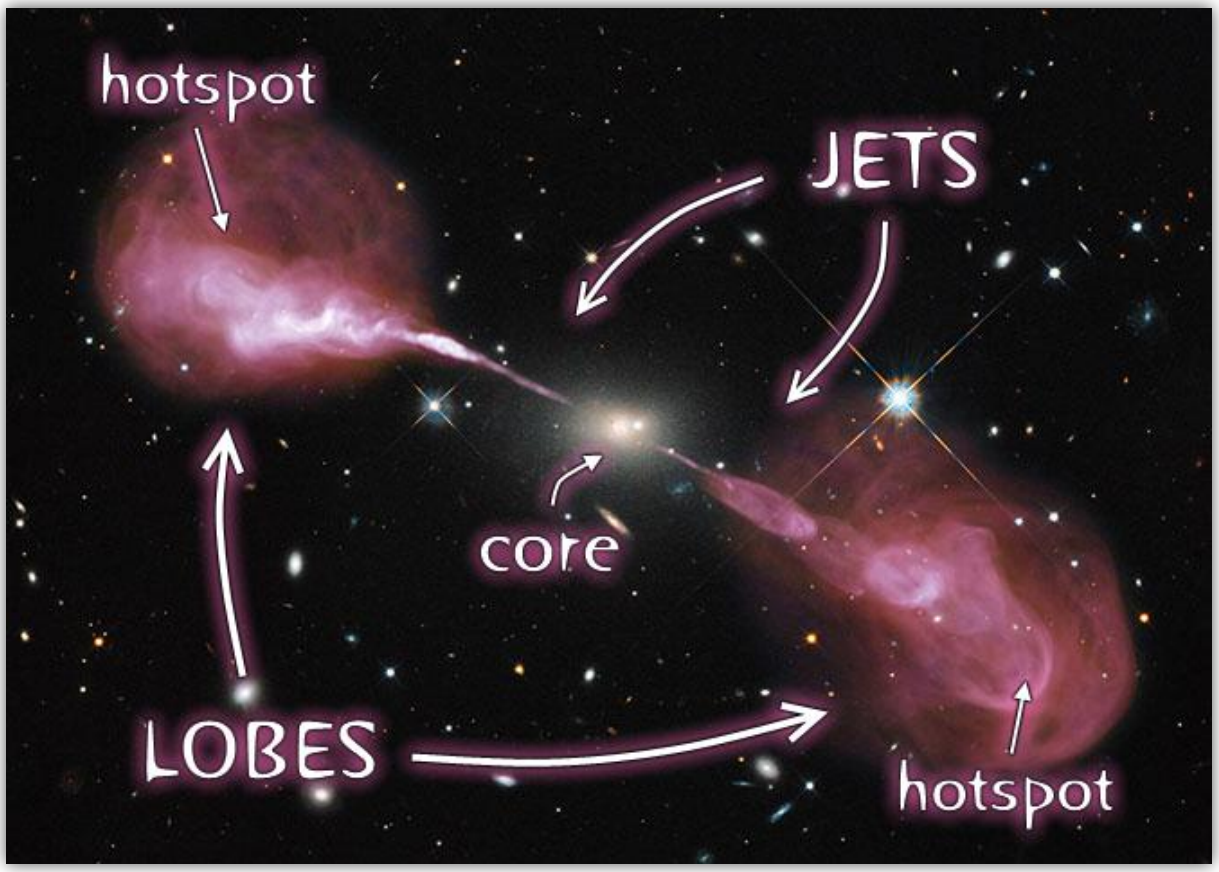

Fig 1. A Multi-Wavelength (optical/radio) View of the Radio Galaxy Hercules A. Credit: NASA

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STEP 1. SEARCH FOR RADIO GALAXIES

The sample of 676 active galaxies to be analyzed was divided in 4 parts: my sample of 169 includes all objects that are located from declination δ_0 = -11.369 to δ_f = 17.412. For each of these objects I analyze the NVSS radio image, in order to find signatures of a radio galaxy or the components outline in the figure above.

Below are listed all the radio galaxies I found in my sample. The underlined one has an uncertain nature: it could only be studied by further radio observations which will help astronomers to better understand the source properties and decide to maintain it or not in the sample of radio galaxies detected by BAT.

BAT name	RA[1]	Dec[1]	Ctpt Name	Ctpt RA[2]	Ctpt Dec[2]	Redshift[3]	L_{BAT}[4]
Swift J2223.9-0207	335.973	-2.131	3C 445	335.956	-2.103	0.0558	44.50
Swift J1952.4+0237	298.058	2.502	3C 403	298.065	2.506	0.0590	44.46
Swift J0407.4+0339	61.824	3.754	3C 105	61.818	3.707	0.0890	44.74
Swift J0433.0+0521	68.292	5.339	3C 120	68.296	5.354	0.0330	44.38
Swift J0947.7+0726	146.934	7.412	3C 227	146.938	7.422	0.0862	44.64
Swift J0245.2+1047	41.291	10.782	4C +10.08	41.306	10.789	0.0700	44.18
Swift J0413.8+1112	63.446	11.207	3C 109	63.418	11.203	0.3056	45.62
Swift J0109.0+1320	17.185	13.360	3C 033	17.220	13.337	0.0597	44.38
Swift J2327.4+1525	351.836	15.413	2MASX J23272195+1524375	351.841	15.410	0.0457	43.71

[1] The BAT source positions as listed in the 70-month catalogue and are J2000 coordinates.
External link: BAT 70-Month Hard X-ray Survey

[2] The counterpart position is taken from online NED database.

[3] The redshift which gives an indication of the source distance are taken from NED.

[4] Logarithmic value of the BAT luminosity is in units of ergs/s over the 14-195 keV band.

For every source listed in the table I extracted the ESO DSSII-red image (http://archive.eso.org/dss/dss) over which I overlaid the NVSS radio contours. In each image I specify the source Swift name and counterpart name as well as the reference frame for the particular sky region surrounding the source. All images are displayed in the appendix at the end of the text.

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STEP 2. IDENTIFICATION OF GIANT RADIO GALAXIES

Giant radio galaxies are the largest known single entities in the universe. According to the recent radio surveys, GRGs are about 6-7% of the whole radio galaxy population. A radio galaxy is considered giant when its size is equal or exceeds 0.7 Mpc (or 700 kpc). This is a conventional number adopted when the following cosmology is used: $H_0 = 69.6$ km s^{-1} Mpc^{-1}, $\Omega_m = 0.286$, $\Omega_\Lambda = 0.714$.

To search for giant radio galaxies in my sample I first looked for information in the literature and then I measured myself the source size from the images displayed in the appendix. In particular we used the largest angular scale (LAS) to evaluate the source size. In the table below I list the Swift name, counterpart name, conversion factor from arcsecond to kpc, LAS and size found from the literature, redshift and LAS and size measured in this work. The yellow lines highlights those objects that have size close or above 700 kpc and are therefore eligible to be called giant radio galaxies.

SWIFT name	Counterpart Name	C.F. *Kpc/"*	LAS (ref.) *Arcsec*	Size (ref.) *Kpc*	Redshift	Our LAS *Arcsec*	Our Size *Kpc*
Swift J2223.9-0207	3C 445	1.090	570 (2)	859.0 (2)	0.0558	639.6	697.16
Swift J1952.4+0237	3C 403	1.149	97.0 (1)	152.7 (1)	0.0590	130.2	149.59
Swift J0407.4+0339	3C 105	1.673	309 (1)	704.1 (1)	0.0890	407.5	681.83
Swift J0433.0+0521	3C 120	0.662	*	*	0.0330	424.5	281.04
Swift J0947.7+0726	3C 227	1.626	215 (1)	475.3 (1)	0.0862	305.66	497.01
Swift J0245.2+1047	4C +10.08	1.345	104.1 (3)	187.4 (3)	0.0700	147.2	197.94
Swift J0413.8+1112	3C 109	4.551	96.0 (1)	577.2 (1)	0.3056	162.1	737.26
Swift J0109.0+1320	3C 033	1.161	249 (1)	398.1 (1)	0.0597	328.3	381.16
Swift J2327.4+1525	2MASX J232721952B1524375	0.0904	–	–	0.0457	1020	922.08

Notes: (1) Nilsson et al. 1993, (2) Hardcastle et al. 1998, (3) Landt & Bignall 2008, * LAS and the size of the source from the literature are not reported because of conflicting estimates.

Three of the nine radio galaxies I uncovered are found to be giants, but one of them Swift J0413.8+1112 is just at the border to be considered a GRG.

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CONCLUSIONS

All together we analyzed 676 Swift galaxies discovering that 51 of them have the typical features of radio galaxies. This represents 7.5% of the sample. Among them we measured 17 objects with dimensions ≥ 0.7 Mpc, which represent 33% of the entire sample of hard X-ray selected radio galaxies. This is very similar to the sample of INTEGRAL selected radio galaxies, confirming that hard x-Ray surveys are capable of detecting with great efficiency this type of sources. The sample of radio galaxies and more specially GRGs found during our stage, will be used to further studies both type of objects.

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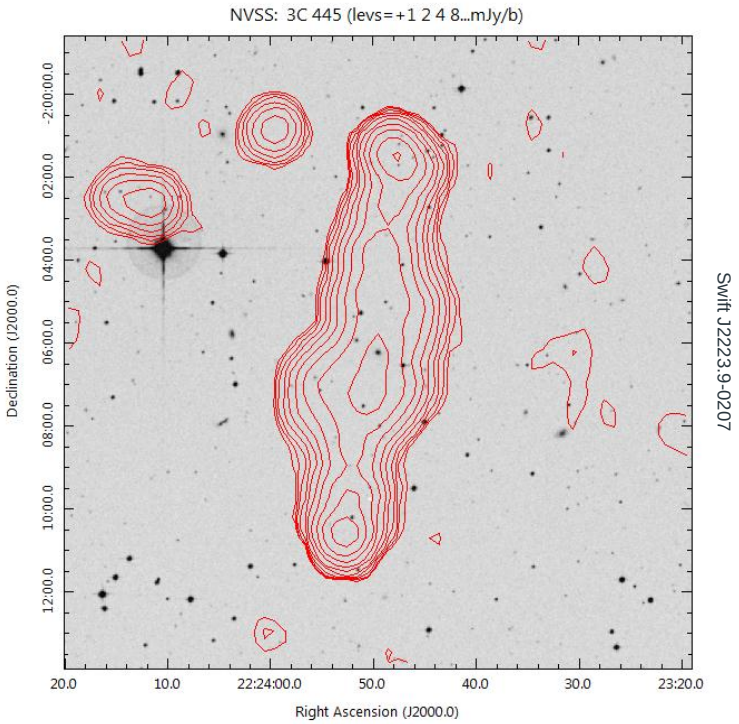
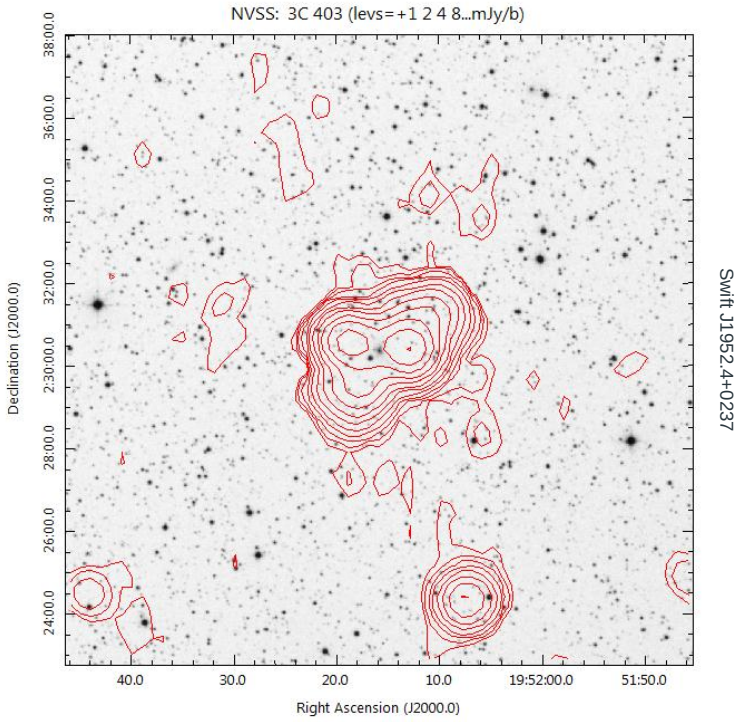
APPENDIX:





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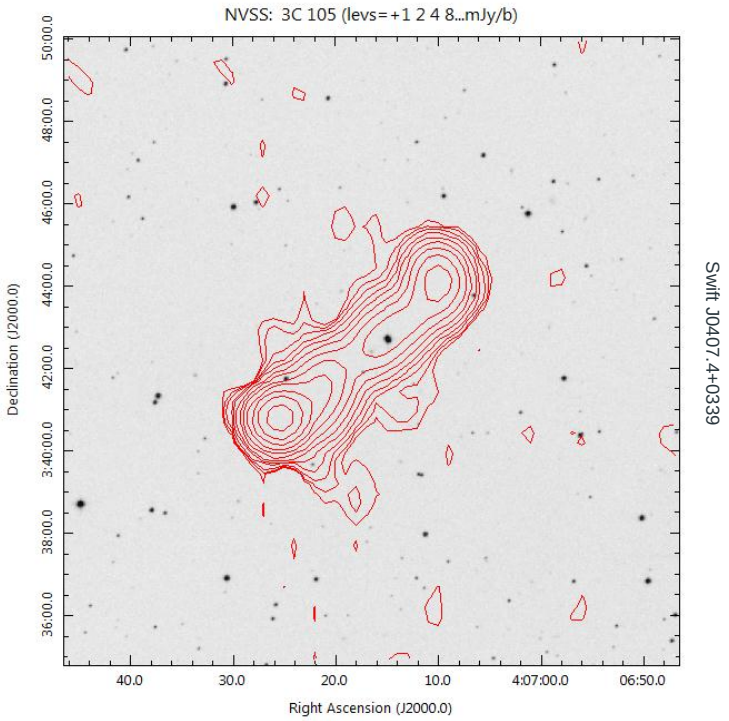

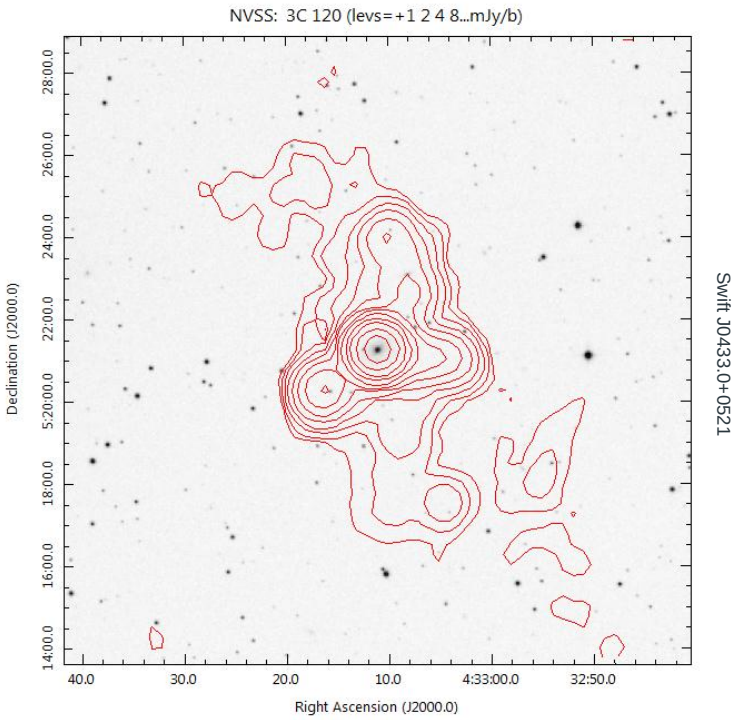

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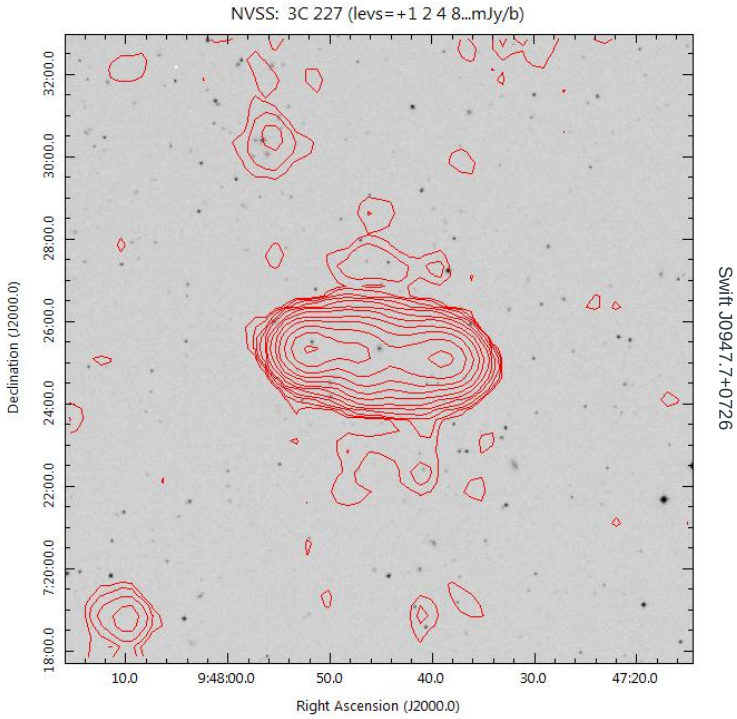

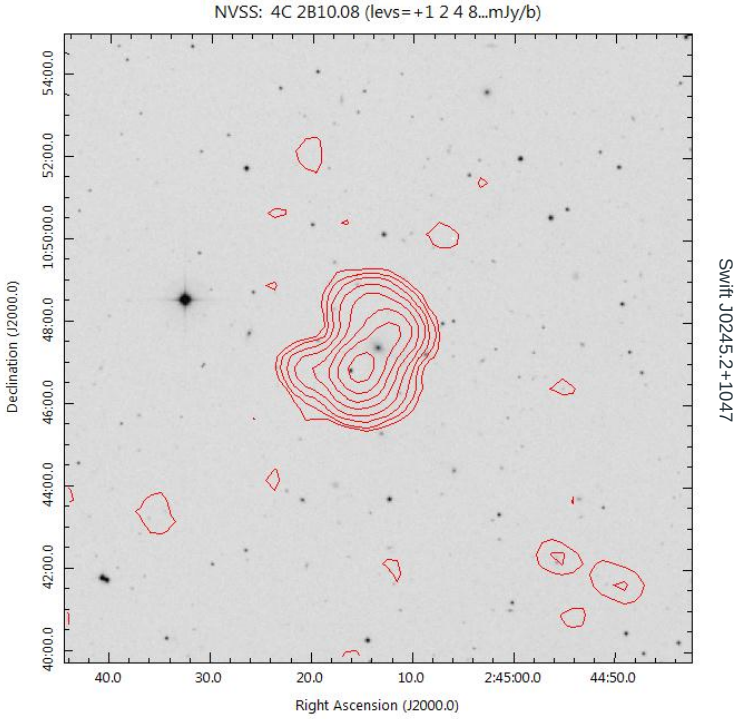

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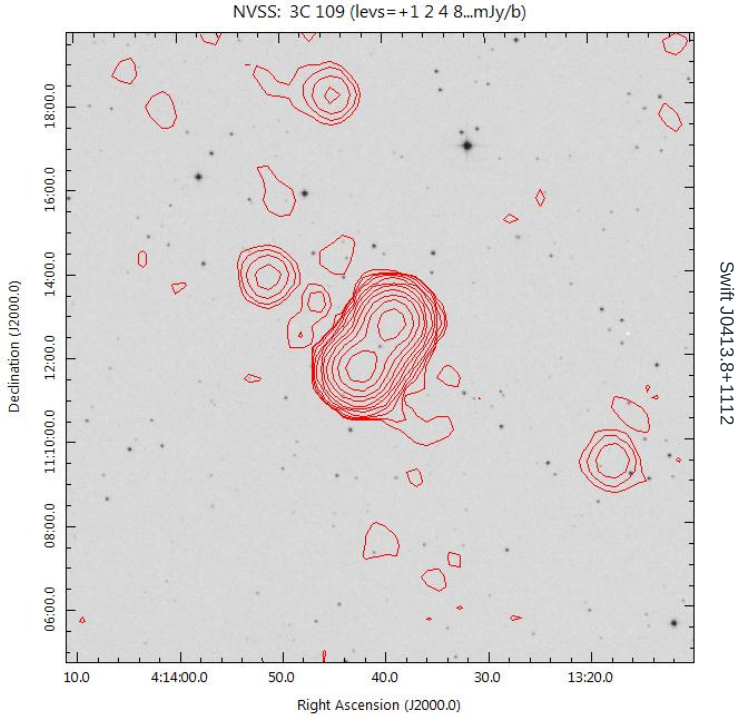

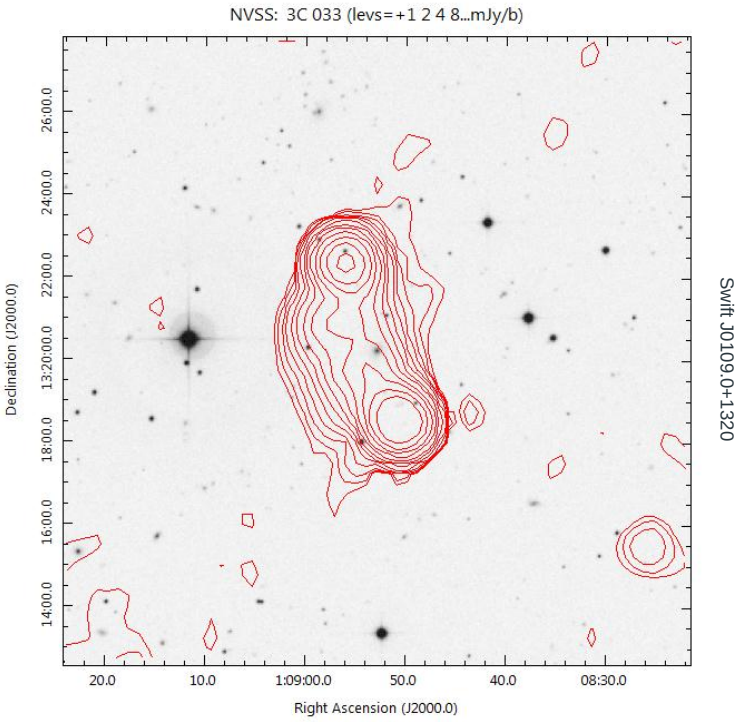

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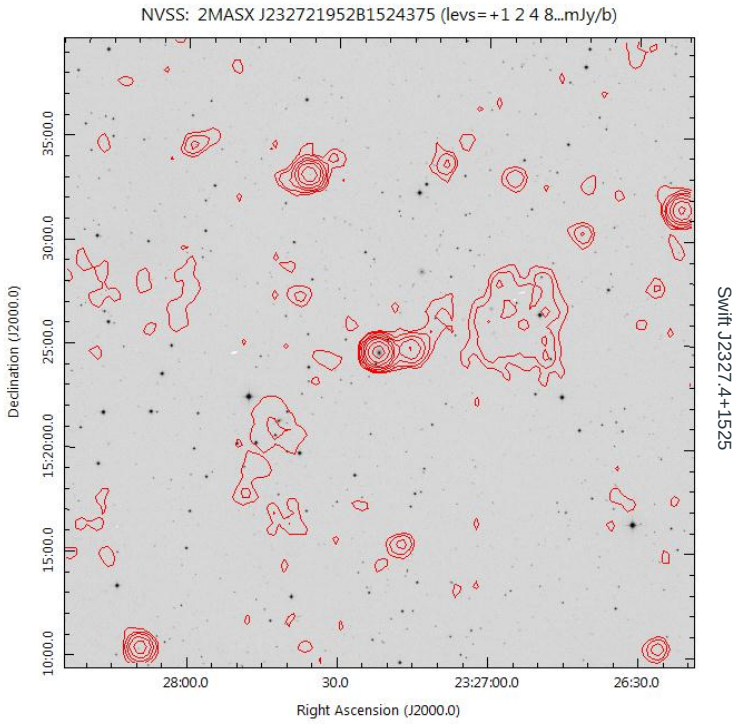

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