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Ricerca e studio dei colori tipici (in ottico e infrarosso) di un campione di 420 AGN osservati dal satellite dell'ESA INTEGRAL nella banda dei raggi X duri

Search and study of the typical colours (in optical and infrared) of a sample of 420 AGN observed by the ESA satellite INTEGRAL, in the hard X-ray band

Andrea Ricciardelli[1], Benedetta Bortolini[2], Dario Mazzacurati[3], Lorenzo Piegaia[3], L.Bassani[4], A.Malizia[4]

[1] IIS F.Alberghetti, Imola (BO)
[2] IIS E.Maiorana, San Lazzaro di Savena (BO)
[3] IIS Belluzzi - Fioravanti, Bologna
[4] IASF - INAF, Bologna

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ISTITUTO DI ASTROFISICA SPAZIALE E FISICA COSMICA - BOLOGNA
Tel. (+39) 051 6398688 - Fax (+39) 051 6398724 - Cod. Fisc. 97220210583 - Part.IVA 06895721006
Area della Ricerca di Bologna - via Piero Gobetti, 101 - 40129 Bologna - ITALY
e-mail: segreteria@iasfbo.inaf.it - PEC: inafiasfbo@pcert.postecert.it - www.iasfbo.inaf.it

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Introduction to INTEGRAL

INTEGRAL was launched by the European Space Agency into Earth orbit in 2002, and it was designed to detect some of the most energetic radiation coming from space.
It consists of four instruments that are coaligned to study a target across a large energy range:

- IBIS (Imager on-Board the INTEGRAL Satellite)
  The INTEGRAL imager, observes from 15 keV (hard X-rays) to 10 MeV (gamma rays). Angular resolution is 12 arcmin, enabling a bright source to be located to better than 1 arcmin.
- SPI (the SPectrometer for INTEGRAL)
  The primary spectrometer aboard INTEGRAL. It observes radiation between 20 keV and 8 MeV, with an angular resolution of 3 arcmin.
- JEM-X (Joint European X-Ray Monitor)
  Dual units which provide additional information on targets. They observe in soft and hard X-rays, from 3 to 35 keV. Aside from broadening the spectral coverage, imaging is more precise due to the shorter wavelength.
- OMC (Optical Monitoring Camera)
  It observes the optical emission from the prime targets of the INTEGRAL main gamma-ray instruments with the support of the X-Ray Monitor JEM-X.

One of the main goal of INTEGRAL is to map the entire sky at energies higher than 10 KeV. So far INTEGRAL has detected about 1000 objects in the 20-100 KeV band (Bird A. et al, 2016).
Thanks to the data obtained by INTEGRAL from 2002 onwards the INTEGRAL team (Malizia et al., 2012; Malizia et al., 2016) was able to collect a list of 420 Active Galaxy Nucleii (AGN) which allowed us to participate to this project.

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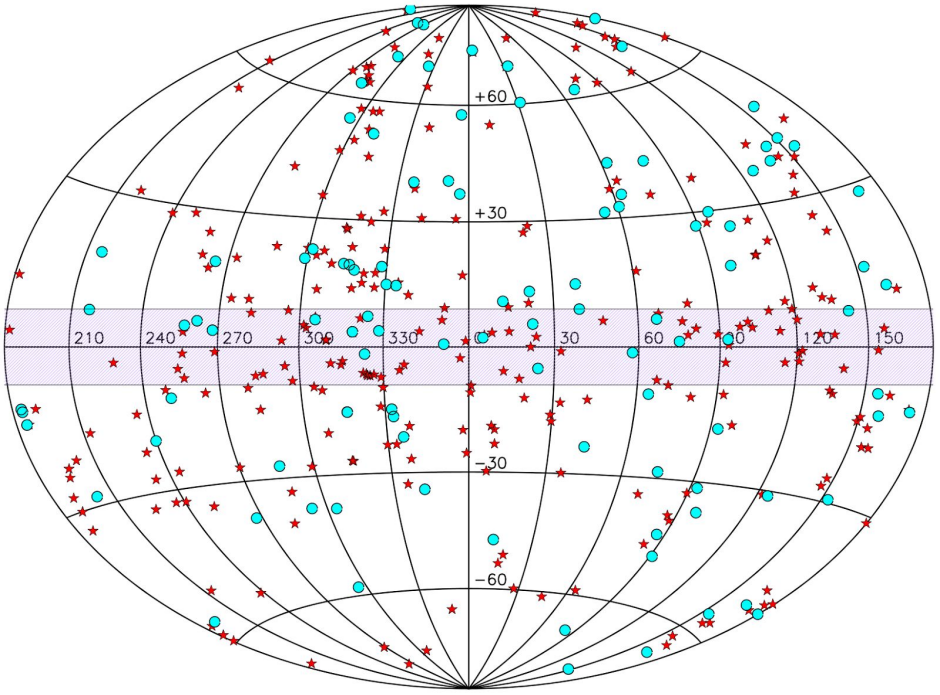

The location of all these AGN on the sky sphere can be viewed in the figure above.

Our Goal:

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 (millions of solar Mass) in the source nucleus which is capable of converting gravitational energy into electromagnetic radiation.

The 420 galaxies collected by Malizia et al.(2012, 2016) are clearly objects hosting a supermassive black hole due to their brightness in the hard X-ray band that allow their detection by INTEGRAL.

Aim of the present project is to collect a database of optical and infrared magnitudes of these 420 hard X-ray selected AGN. In astronomy, magnitude is a logarithmic measure of the brightness of an object.

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This work was done by querying various online catalogues from the NASA archive HEASARC (High Energy Astrophysics Science Archive Research Center). The data collected in this way are used to create colour-colour charts to better characterize the source physics.

Method:

We are four students that have attended the 4th year of high school in different institutes across Emilia Romagna. We attended the summer stage on the “Colours of Supermassive Black Holes” having Malizia and Bassani as tutors. We decided to work as a team and therefore divided the workload in 4 parts so that each member of the group could gather data from the online database of HEASARC (https://heasarc.gsfc.nasa.gov/) at the same time.
Our tools were our laptops; we used excel and openoffice to calculate data and write the scientific report. We took the magnitudes from the optical USNO B1 catalogue (Monet et al., 2003), the near infrared 2MASS catalogue (Cutri et al., 2003) and the far infrared allWISE catalogue (Cutri et al., 2014).
We combined the data into a single excel worksheet divided in three tables:

- The first one contains the B1-R1-B2-R2 values from the USNO B1 catalogue, together with other source properties (name, coordinates, distance and class).
- The second one contains, for each source, the J-K-H values from the 2MASS catalogue.
- The third one contains, for each source, the W1-W2-W3-W4 values from the allWISE catalogue.

We worked on data collection for one week and then produced a couple of colour-colour diagrams as an example of what can be done with our dataset:

- In the first one we plotted the WISE colours (W1-W2 versus W2-W3) dividing the AGN by source type (Fig.1).
- In the second one we plotted the WISE colours (W1-W2 versus W2-W3) divinding the AGN in absorbed and not absorbed (Fig.2).

We have chosen this particular diagram for comparison with the BAT AGN sample presented in Ichikawa et al. (2017).
With respect to their Figure 9, our Figure 1 indicates that INTEGRAL AGN populate a similar region in the diagram but extend up to lower values in both colours, W1-W2 and W2-W3.

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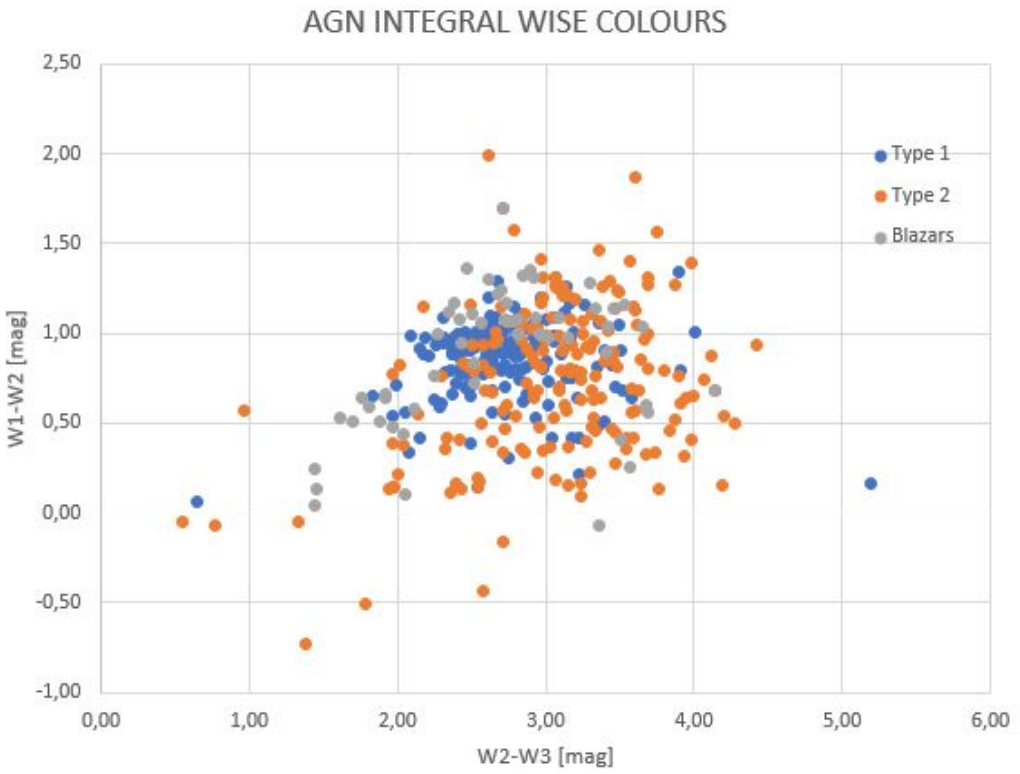
We also note that a number of our AGN are located in a region where no AGN are expected (W1-W2 ≤ 0.5). This is due to contamination from the host galaxy in the WISE band. From the figure it is evident that this contamination affects more Type 2 than Type 1 sources.

Figure 1



- Type 1 refers to Seyfert 1-1.5
- Type 2 refers to Seyfert 1.8-2.0

From Figure 2 we note instead that absorbed AGN tend to occupy a region of the diagram with higher W2-W3 values.

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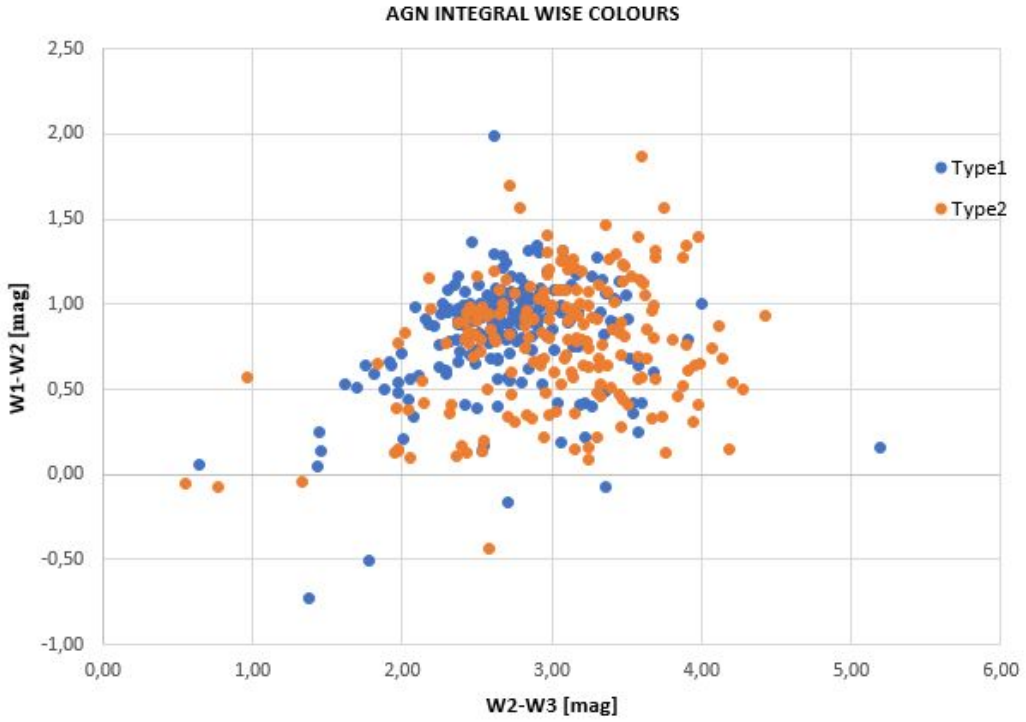
Figure 2



- Type 1 refers to galaxies which absorb
- Type 2 refers to galaxies which don't absorb

Images:

As a final step of our project we viewed the images of our 420 AGN in each waveband analyzed. For the infrared we used WISE and 2MASS images, while for the optical we viewed DSS2 pictures (http://archive.stsci.edu/dss/acknowledging.html) since the USNO B1 catalogue does not provide images.
These images were taken from the Aladin Strasburg database (http://aladin.u-strasbg.fr/AladinLite/), which contains images with different filters taken by various satellites / telescopes. Some examples of the most visually appealing images are reported in these following pages.

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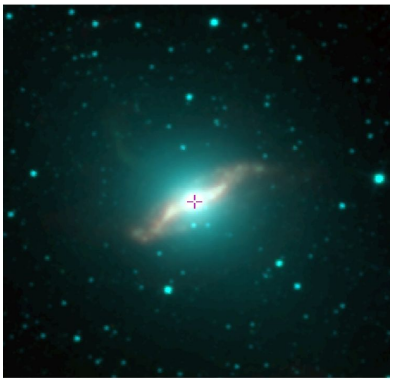
← Cen A DSS2

NGC 4945 DSS2 →

← Cen A 2MASS

NGC 4945 2MASS→



← CenA allWISE

NGC 4945 allWISE→

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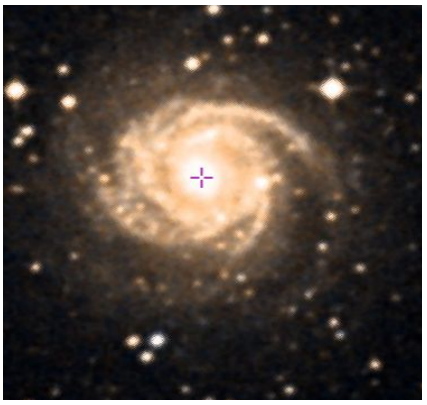
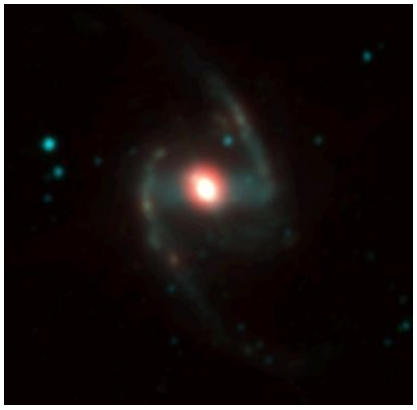
←NGC 1365 DSS2



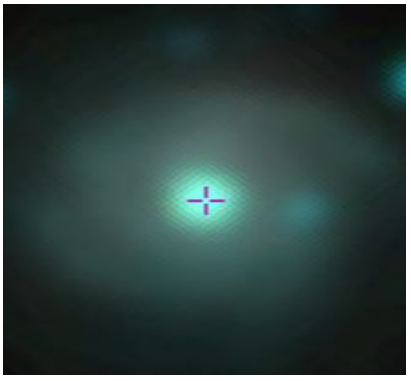
NGC 6814 DSS2→

←NGC 1365 2MASS

NGC 6814 2MASS→



←NGC 1365 allWISE



NGC 6814 allWISE→

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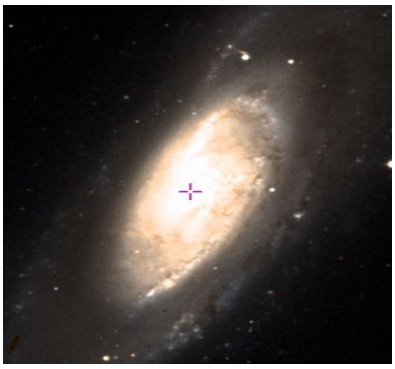
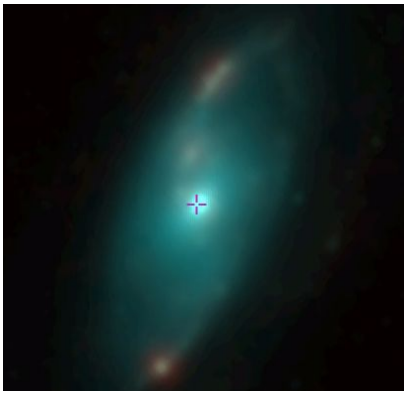
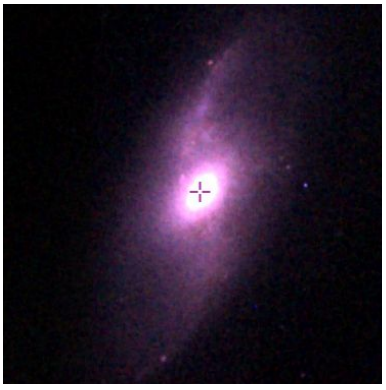


←NGC 4258 DSS2

NGC 4258 allWISE→





←NGC 4258 2MASS

Examining the various images of our 420 galaxies we noticed that, in the different wavebands, each source appears differently indicating that each magnitude highlights different components in the galaxy.

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Conclusions:

We queried various catalogues to collect the magnitudes in optical and infrared of a sample of 420 AGN detected by INTEGRAL.
We have also viewed the images of these AGN in various bands and tested one colour-colour diagram (W1-W2 versus W2-W3).
This database will be used by the INTEGRAL team to study these hard X-ray selected AGN in the future.

References:

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