Project report

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1 Abstract

This project highlights the study of Black hole-galaxy co-evolution using the DAE-funded GMRT and RAD@home Inter-University Citizen-Science collaboratory for astronomy and astrophysics.We studied various kinds of galaxies and their origin as well as various other astrophysical details and successfully achieved a training for radio astronomy discovery by the end of the camp.

2 RGB-C image processing of astrophysical objects

At the very beginning we learn the basic of any astronomy project which is constructing processed image by selecting particular surveys (each having its specific wavelength) for particular channels (namely Red Green and Blue).An example of a basic RGB imaging with Red corresponding to IR (Wise 3.4) Green corresponding to Red wavelength (DSS2 Red) and Blue corresponding to UV (Galex NUV) of the sombrero Galaxy is given below.All these images are made with the help of NASA skyview tool. (http://skyview.gsfc.nasa.gov/)

Figure 1: The Sombrero Galaxy

Then we moved on to contour making which would provide us more data in the same image of the astronomical object as we would have four channels to work in.Later we get to know that the contour channel is specially used for radio wavelengths.Below shown image is that of NGC 6872 which is the largest barred spiral galaxy.Here Red corresponds to Wise 12, this helps in showing regions of dust as the survey mainly detects thermal radiations in dust.Green corresponds to DSS which helps in seeing the optical region which indicates region of old to sun-like stars.Blue corresponds to Galex Near UV which shows UV regions, UV regions being specifically high energy regions and indicating active star forming regions.We can see its spiral arms in the image clearly,confirming this to be a spiral galaxy and the arms stretching out much farther in comparison to the other arms of the galaxy.

Figure 2: NGC 6872

Now two images of Centaurus A are analyzed in Optical IR Radio and UV wavelengths.

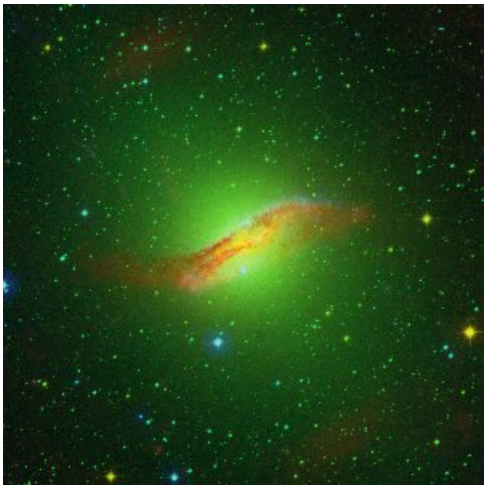


Figure 3: Centaurus A in IR optical and UV wavelengths

In this image we can see the North and South cap emissions clearly,suggesting a peculiar shape of the galaxy.This somewhat looks like an elliptical or a lenticular type of galaxy and this maybe formed by the merger of two galaxies.

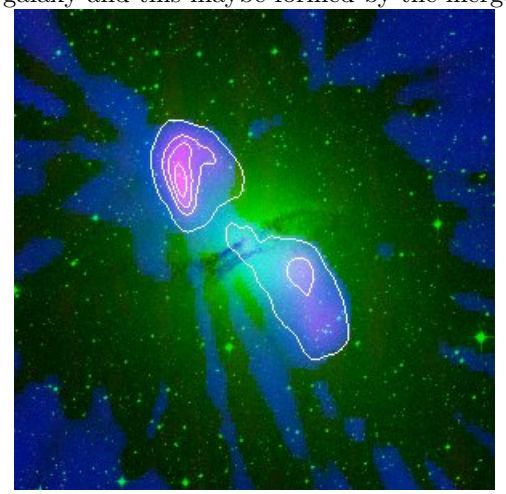


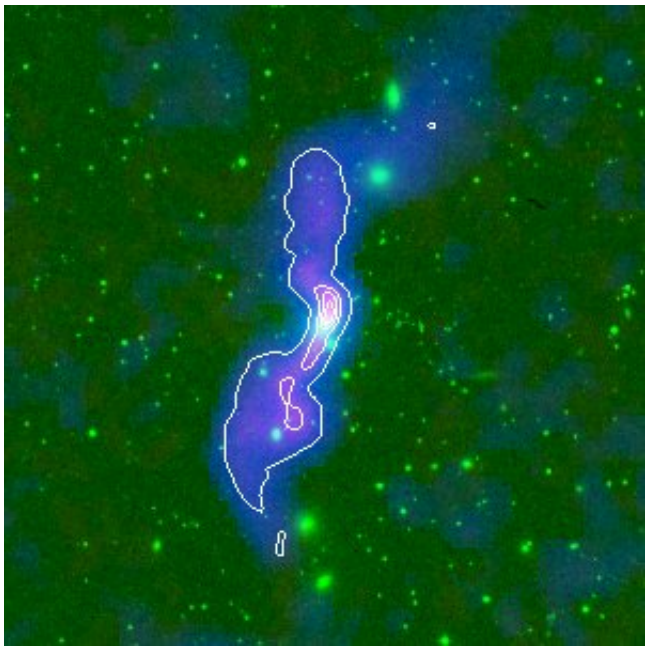
Figure 4: Centaurus A in Radio and Optical wavelengths

In the radio analysis,we could see the radio lobes coming out,originating from the centre of the galaxy clearly in TGSS while we can also see patches of radio frequency from the SUMSS survey.This arises mainly due to the activity

of the central region of the galaxy which hypothetically should be the site of a supermassive black hole.

3 Basic concepts and other theoretical aspects

After learning the basics of RGB-C image making,we moved on to the theoretical aspects of galaxies in general.We understood the different types of galaxies and their method of formation including the Hubble tuning fork diagram.We categorically went through different types of galaxies including elliptical and spiral galaxies.In the end we also covered aspects of active galactic nuclei and how they are radio galaxies.The characteristic property of AGN being non-stellar and having UV/Optical continuum .After this we learnt about FR1 and FR2 type of radio galaxy,being classified by the structure of the radio lobes they show.The former having diffusing plumes with bright centre while the latter having hotspots and plumes away from the centre.We also got to know some correlation between the brightness and the radiation in both these types of galaxies.


Radio image of 3C31

The above image shows a typical FR1 type of radio galaxy which has plumes originating from the centre and the jets getting gradually diffused as moving out from the centre,this probably happens due to resistance from IGM over the radio jetstream.

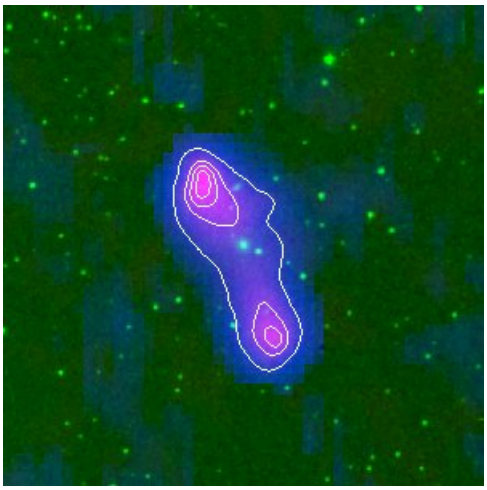


Figure 5: Radio image of 3C98

This image is of 3C98 a typical FR2 type of galaxy which has characteristic hotspots present at the two ends of the jetstream.In this case instead of diffusing out,we observe a peak emission region around the arms of the jetstream and this occurs mostly due to recoiling of the jetstream after passing through dense IGM.

Then we moved on to understanding Wide angle tailed and Narrow angle tailed radio galaxies and understanding their various aspects and origins.

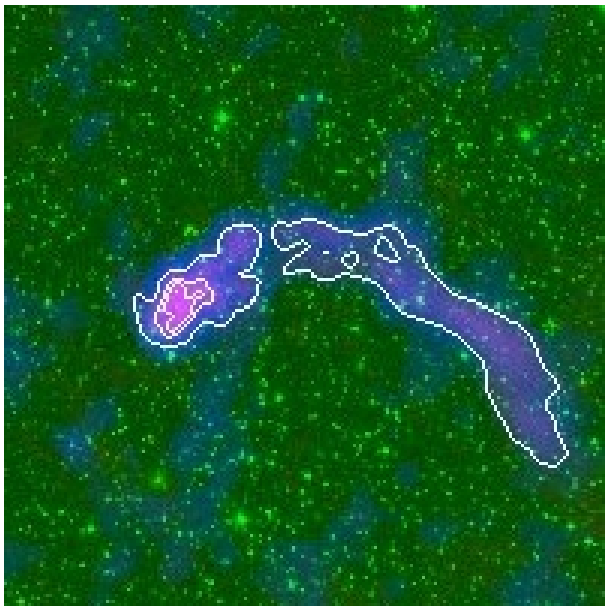


Figure 6: A wide angle tailed radio galaxy

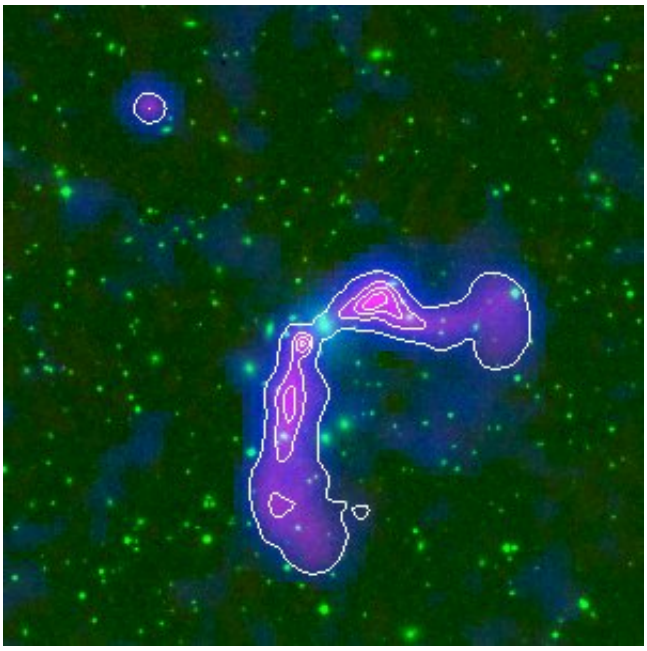


Figure 7: A narrow angle tailed radio galaxy

4 Studying Atlas of Peculiar Galaxies under various radio surveys

We then moved on to analyzing interesting galaxies from the atlas of peculiar galaxies and whether they show any interesting feature in TGSS adr1 survey.I analysed quite a few of them but the most interesting source I found is

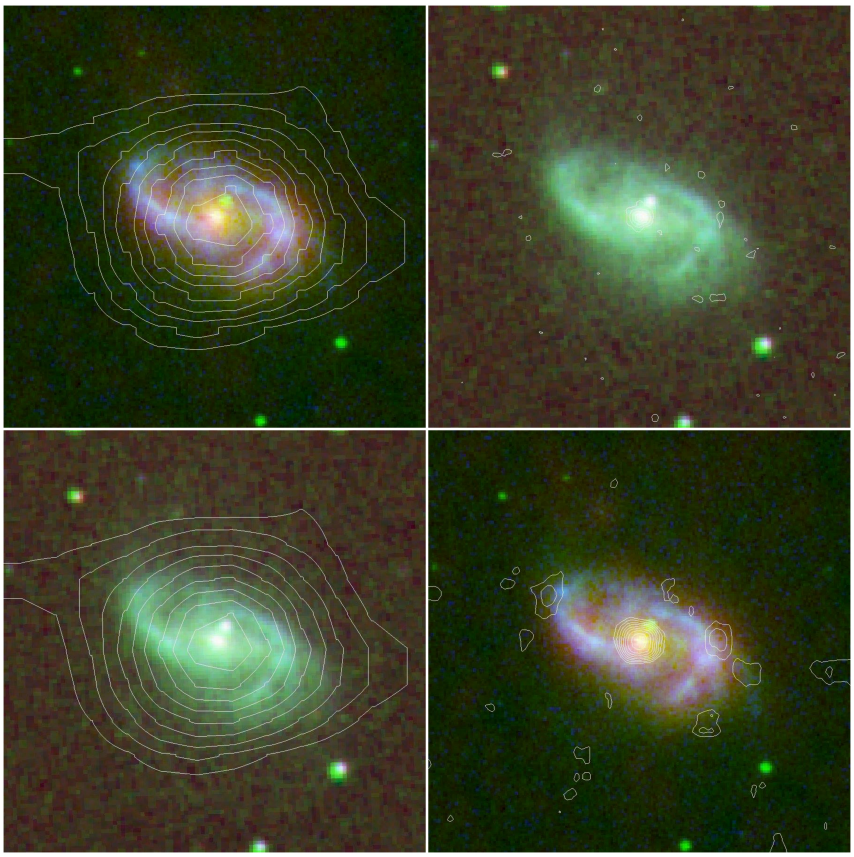


Figure 8: The arp object as seen with standard optical RGB, TGSS and NVSS contours

Here we can see a galaxy which on first glance may look like a spiral galaxy with extended spiral arms on both sides but on close observation of the Wise and galex survey emissions,we see that only two of the spiral arms are prominent and there are infact two cores, one being radio loud while the other isn't.We can hypothesize that they are infact a pair of merging galaxies with the tails from each of the cores extending outwards till the edge of the galaxy.The blue parts in the first and third images also indicate regions of new star formation in the tails.We can also say that these were spiral galaxies which have begun the merging process, as evident from the extended arms.

5 A step further into advanced concepts

After the arp analysis we dive deeper into the astrophysical concepts including studying graphs which would give us a value of the span of the bulge of galax-

ies compared to the theoretical expectation.With this we also moved into an introduction of dark matter and its proof of presence by these methods.

6 Analyzing Mosaics from GMRT database and what should be looked for

In the end each of us were assigned particular mosaics from the GMRT database for analysis using the DS9 software and we were asked to look for faint and fuzzy objects because those are the ones which would not be possibly detected and catalogued by program.These objects may have much interesting aspects in them and may also help in new discoveries,being unexplored.

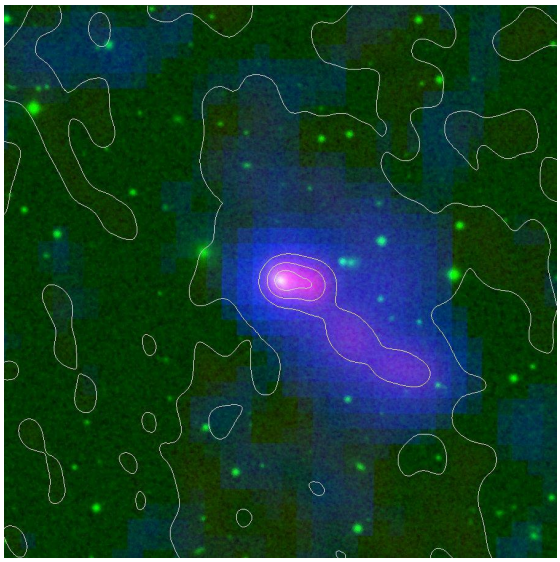


Figure 9: The mosaic object as seen with standard optical RGB and TGSS contours

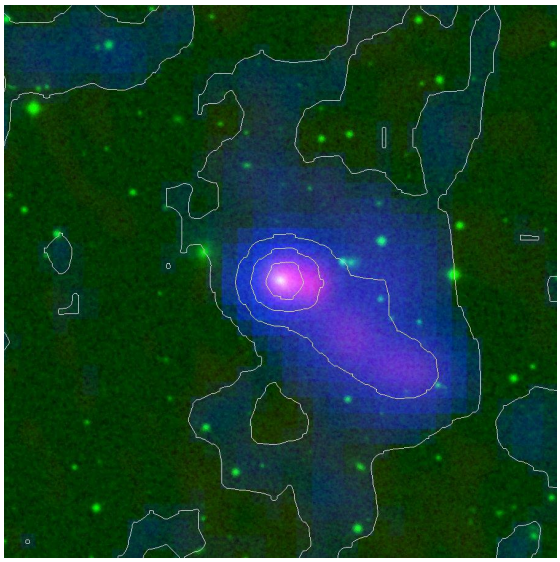


Figure 10: The mosaic object as seen with standard optical RGB and NVSS contours

In these two figures we could clearly see that the host galaxy may be a narrow angle tailed galaxy or it may have more than one centre at different planes,as evident from the NVSS image.But,the TGSS image suggests something otherwise,showing a clear and distinct maximum contour region in the top lobe while the bottom two has none of them.This may possibly a new head-tail source which is observed for first time using TGSS data.

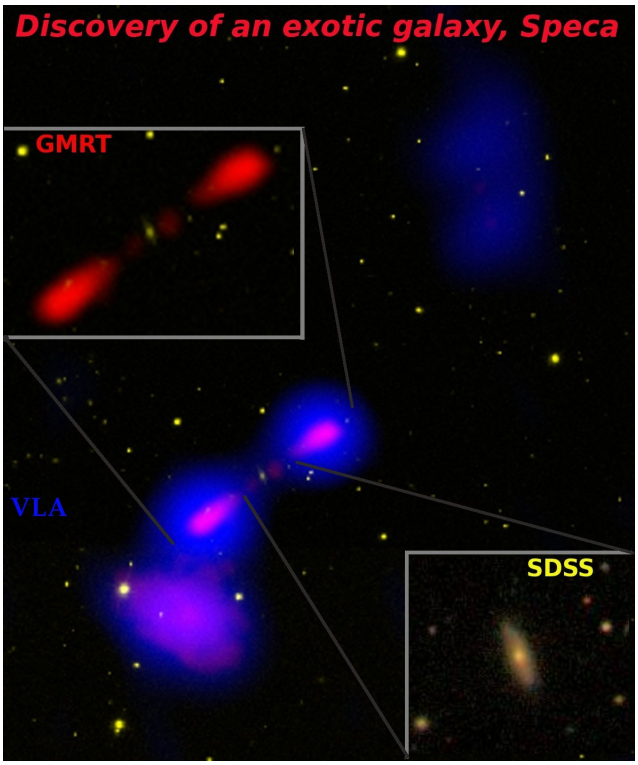


Figure 11: Image of Speca (https://www.nrao.edu/pr/2011/spiralradio/)

7 Conclusion

After this training project, we would be able to conduct the same basic radio astronomy research from home,which is the basic motivation of this RAD@home campaign.This project provided me the basic understanding of astronomy and we got to know the active areas of research in this field currently, in addition to getting trained for doing research in radio astronomy in particular. Search is still ongoing with addition of more files from GMRT, with the goal of discovering more speca-like galaxies.The collaboratory is almost there and every week with three hours spent with a network of 100 e-astronomers,the process is ongoing.

8 References

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