PRESENCE OF DOUBLE NUCLEUS IN M83

1. INTRODUCTION AND DATASET

Nucleus is the centre part of the galaxy around which all the objects of the galaxy revolve. Detection of abnormalities in the nucleus of galaxies tells us about the nature of the galaxy and past events which may be the cause of such abnormalities.

For our project, we are observing M83 galaxy also known as the Southern Pinwheel Galaxy and NGC 5236. The galaxy which is a remarkable grand-design spiral with Hubble type SAB(s)c and is located about 15 million light-years away in the constellation Hydra, is one of the most striking galaxies of its type in our sky [1]. However, the centre of our galaxy is odd and mysterious. It is believed to have a possible hidden nucleus or a visible nucleus that is simply offset, by some 80 pc in the projected distance, from the photometric and kinematic centre of the galaxy [2]. The visible nucleus containing a black hole is also surrounded by a semicircular starburst arc orbiting around it and giving the appearance of a dual-core nucleus which is our hypothesis for this project [3].

The images of this galaxy are available in FITS (Flexible Image Transport System) format which is an open standard defining a digital file format. The FITS data from five different telescopes, namely Near Infrared, Optical, XMM Om Optical, XMM Newton Soft X-ray and ISO, are available for analysis. Open-source programming platforms and Data Science tools like Filtering and Feature detection are used to get a significant idea of the nucleus. These tools have been helpful in enhancing images, detecting certain features and processing all the data.

Data Science in Astronomy is an emerging field as technological advancements have generated alot of data in the field of astronomy to work upon.

2. METHODOLOGY

As the importance of Astronomical data science was discussed earlier to get a clear picture of objects like the nucleus of a galaxy. In this regard, we use an open source programming platform to process the image using Image Processing and Feature Detection operations.
Image Processing Operations that we have used are Sato, Meijering and Gaussian. Where Sato is a filter which works on double differentiation using a hessian matrix, Meijering calculates the eigenvectors of the Hessian to compute the similarity of an image both of which detect continuous ridges and Gaussian is a smoothening filter which passes a gaussian kernel through the image.

Few of the Feature Detection operations we have used are Corner Foerstner which detects corners using the Foerstner algorithm and Specgram which converts an image into a spectogram and the filtered images on which we applied all these operations were visualised in different colormaps.
The features which were detected helped us in proving our hypothesis as it gave us clear ideas upon which we can conclude.

3. RESULT

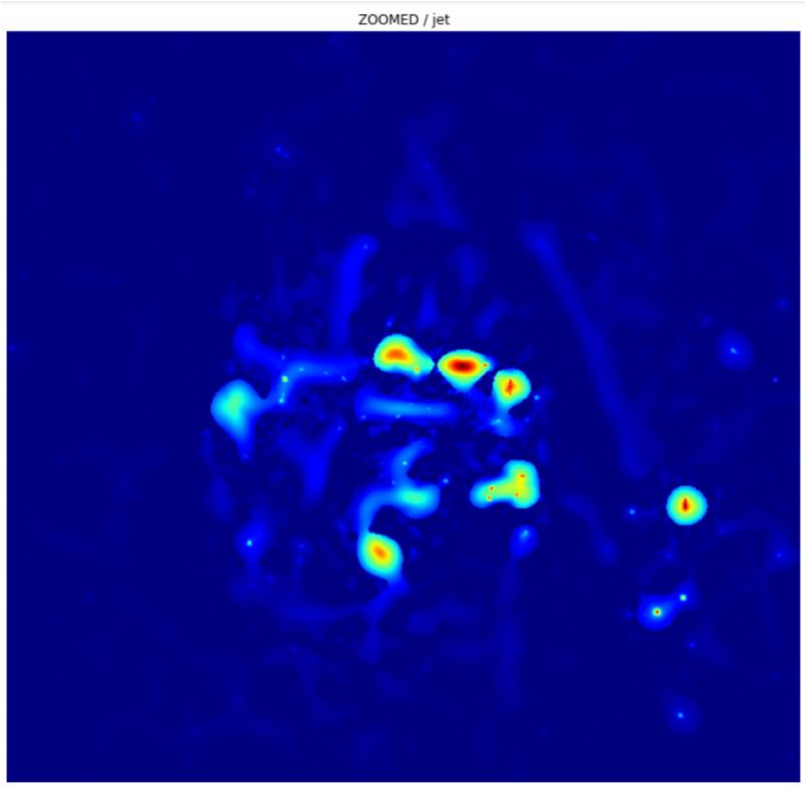

Fig1. M83 High Scale Optical filtered Image in gist_ncar with Meijering filter.

The above mentioned image shows output of Meijering filter in zoomed scale. The intensity of abrupt change of light is very evident and the presence of starburst arc can be seen.

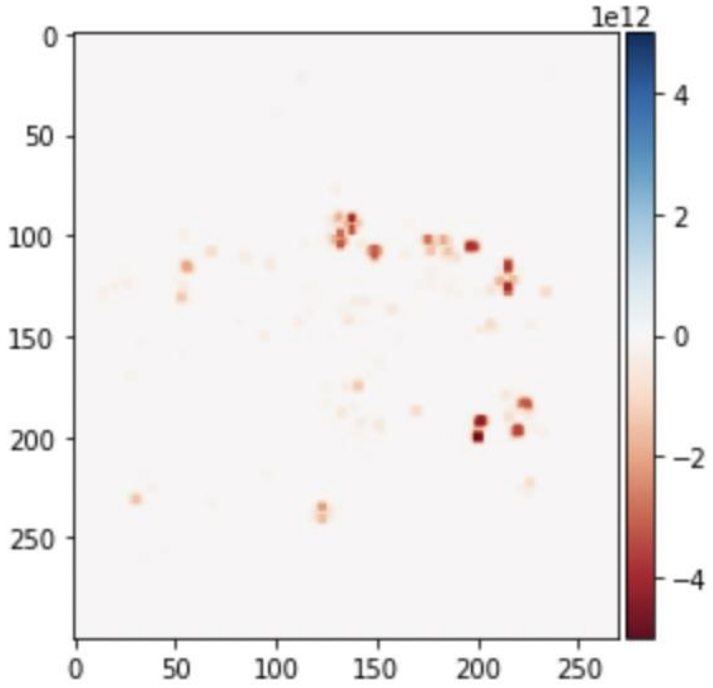

Fig 2. Enhanced image of features detected by Corner Foerstner in Nucleus scale M83.

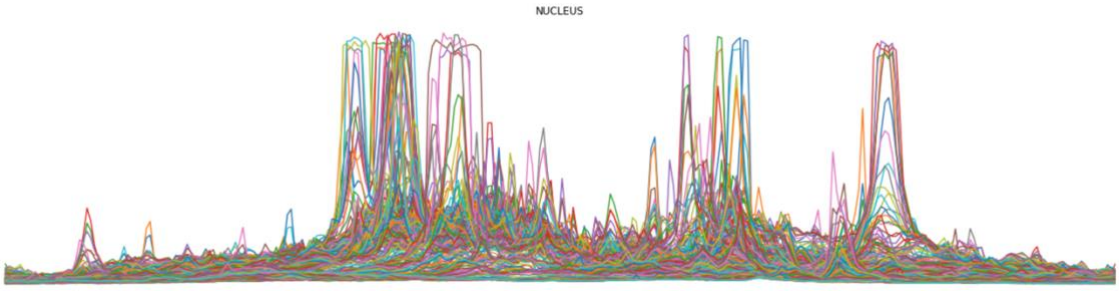

Fig 3. Specgram of M83 Nucleus scale.

The above mentioned images shows output of Corner Foerstner which detects corners and specgram which is a spectogram of M83 Nucleus scale image. The corners, which are places where there is a large change in intensity and spikes in spectogram detecting presence of object on that particular place further support our evidence.

DATA DESCRIPTION TABLE

Image	Filter/Feature applied	Image on which filter is applied	Aspect detected
FIGURE 1	Meijering	Zoomed scale HST	Continuous ridges
FIGURE 2	Corner Forester	Nucleus scale HST	Corner
FIGURE 3	Specgram	Nucleus scale HST	Spike in the graph

4. DISCUSSION

Meijering filter which detected continuous ridges detected them around the nucleus surrounding it. Corner Foerstner did the same in terms of corners and Specgram's spikes showed us the same fact. As the extreme change in intensities cannot be all black holes as it's not possible according to the laws of physics, we are sure that those are stars revolving the Black hole in the nucleus. And due to this, the appearance of a double nucleus is created. Hence, the double core is not actually the presence of two cores, but rather a black hole with a presence of semi-circular starburst arc revolving it.

5. CONCLUSION

In this work, we have used Data Science tools like image processing filters and feature detection algorithms to get a better visual of the nucleus in M83. Few of the papers in the literature have shown that there is a presence of starburst arc revolving the black hole in the nucleus and that could be seen from the results that we got. And like this, exploring more onto it can give more idea about the past unique events which happened in the such galaxies and hence improve our understanding of such galaxies.

6. REFERENCES

1] https://esahubble.org/news/heic1403/
2] https://academic.oup.com/mnras/article/408/2/797/1025378
3] https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.246.6687&rep=rep1&type=pdf