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Calculating star formation rate (SFR) of ~100 galaxies

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Can we understand how Galaxies evolve by finding a correlation between the SFR and Magnetic field ordering of Galaxies?

Calculating Star Formation Rate (SFR) of ~100 Galaxies

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1 Introduction

1- Galaxy evolution is based on the evolution of its constituents namely stars – specially the newly born. New born stars are traced through the **ultraviolet** (UV) photons they emit. But …

2- UV Photons on their way to us can be trapped by dust and gas called **Interstellar extinction.** Interstellar extinction is strongest at small wavelengths such as UV. The extinction can be accounted for by considering dust emission into account that emits radiation in **Infrared** (IR). So …

3- To get a true count of UV photons from new born stars, both UV and IR have to be taken into account. The **Star Formation Rate**[1] (SFR) expression therefore is :

$$SFR_{dust+UV} = SFR_{dust} + SFR_{UV}$$

4- UV emission is not uniform in all directions, unlike IR emission, because of interstellar extinction. The **Inclination angle*** of the galaxy could therefore make a difference into UV photon count as most galaxies are similar to a disk.

If the SFR derived from UV-IR is independent of inclination angle, all the galaxies in our data set could be compared to each other for **future project.****

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* Inclination Angle: The angle between our line-of-sight and the plane of a galaxy.

** The remaining project requires correlating SFR of the galaxies to Magnetic field ordering. Why do we want to compare SFR to Magnetic field ordering? Massive stars go through their life cycle fast, releasing enormous energy in the form of fast-moving plasma called **stellar winds** and finally explode in a **supernova blast.** The joint stellar winds and supernova explosion of groups of massive stars create expanding bubbles of hot plasma that sweep up the interstellar gas with its associated magnetic field. The charged particles in the bubble interact with the magnetic field in the galaxy rendering it twisted, called **Stellar feedback.** A higher rate of star formation implies more stellar winds and supernovae, and for such galaxies we expect a more turbulent magnetic field.

References:

1- Buat et. al. (2004), *UV and FIR selected samples of galaxies in the local Universe*, Astronomy & Astrophysics

2- Optical and IR images in Fig. 5. retrieved from : McGlynn, T., Scollick, K., White, N., *SkyView: The Multi-Wavelength Sky on the Internet*, McLean, B.J. *et al.*, *New Horizons from Multi-Wavelength Sky Surveys*, Kluwer Academic Publishers, 1996, IAU Symposium No. 179, p465.

2 Methods

1- Aperture size set to twice the optical size:

ISSUE: The size of the galaxy aperture was taken from the optical images of the galaxies from NED database (see Fig. 5.). Growth curve showed optical size was too small, see Fig. 4a.

SOLUTION: Changed the Galaxy aperture to 2X the optical size (see Fig. 4b). Helpful for blurred & invisible galaxies too.

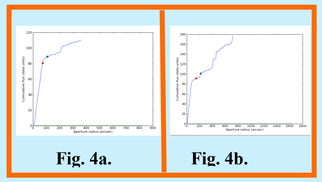


Fig. 4a. **Fig. 4b.**

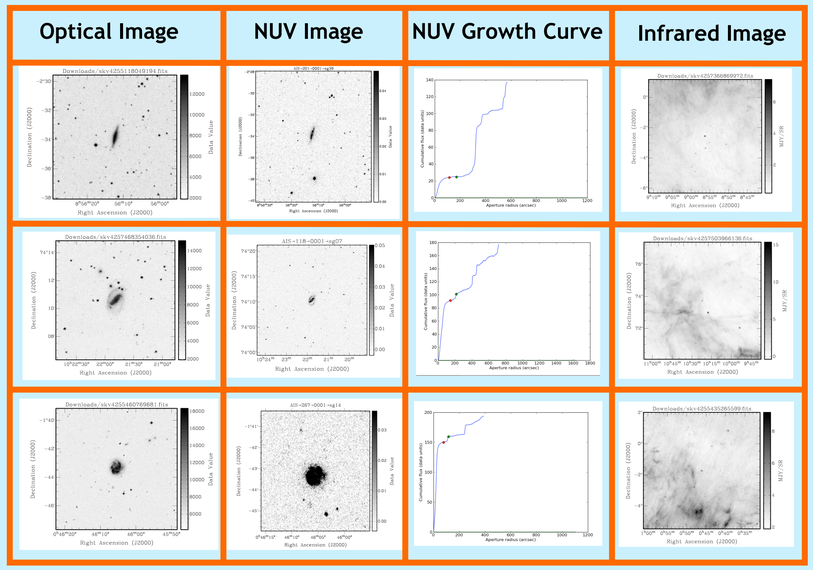


Fig. 5. Three galaxies at three different inclination angles: edge-on (top most), intermediate (bottom second) and face-on (last) are seen in optical, Near Ultraviolet (NUV) and Infrared (IR). The third column shows the NUV Growth Curve for these galaxies.

2- Turned on software inherent background subtraction on some images

ISSUE: Growth curve for some galaxies exhibited a rising trend past the galaxy size, see Fig. 6a.

SOLUTION: Turn on background subtraction in Fig. 6b.

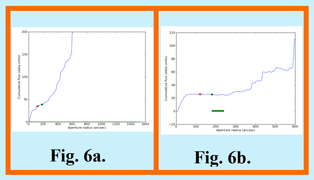


Fig. 6a. **Fig. 6b.**

3- Removing nearby stars falling into the Galaxy aperture

ISSUE: Nearby stars falsely contribute to the Galaxy flux, see Fig. 7a.

SOLUTION: Wrote a python program to remove the unwanted stars, see Fig. 7b.

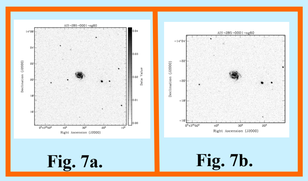


Fig. 7a. **Fig. 7b.**

4- Calculating UV flux error by devising a new test

ISSUE: The flux error calculated by the program was based on photon statistics. This method overlooks the presence of sky background structure.

SOLUTION: Devised a test where flux from four non-star regions of every galaxy was calculated. Then the standard deviation of the fluxes of one galaxy was then plotted against the respective galaxy size. See results in Fig. 8a, 8b.

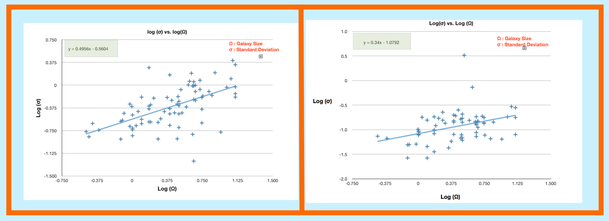


Fig. 8a. Data from NearUltraviolet (NUV) images of the galaxies. We use the fit from this graph to calculate flux errors.

Fig. 8b Data from FarUltraviolet (FUV) images of the galaxies. The FUV data was not used in SFR calculation.

3 Results

$$SFR_{dust+UV} = 4.7 \times 10^{-44} L_{dust} + 2.03 \times 10^{-40} L^{obs}_{0.2}$$

Fig. 9. Calculated SFR is plotted against radio luminosity.

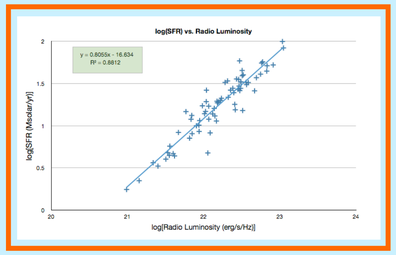
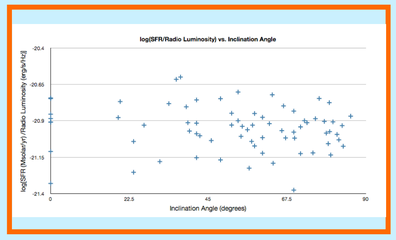


Fig. 10. SFR/Radio-Luminosity shows an no relation with inclination angle.



4 Conclusion

1- We calculated the SFR of ~80 galaxies using the NearUltraviolet (NUV) and Infrared flux. Some galaxies had to be dropped due to missing data.

2- In general, galaxies are considered to be transparent to radio emission and hence radio luminosity can be used to calculate SFR of galaxies. In our project, Fig. 9. suggests that SFR derived from UV and IR fluxes also gives us an accurate and independent account of SFR activity. And therefore, we can carry out the future work on sketching a correlation between SFR and magnetic field ordering of galaxies using different sets of electromagnetic radiation

3- From Fig. 10. we observe no relation between the inclination angle and SFR/Radio-Luminosity showing that SFR calculated through UV-IR doesn't depend on the inclination angle of the galaxy. For future work, we wouldn't have to split galaxies into groups based on inclination angles and all galaxies can be compared to each other.

Acknowledgements:

1- I would like to thank my supervisor Dr. Jeroen Stil for providing me the opportunity to work and making available all the tools necessary for the completion of the project.

2- This research has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

3- The UV images used in this research were obtained from the Mikulski Archive for Space Telescopes. http//galex.stsci.edu/GR6/