LITTLE THINGS report

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Abstract

This is a detailed, comprehensive report on the Sharif University of Tehran's LITTLE THINGS (Local Irregulars That Trace Luminosity Extremes, The HI Nearby Galaxy Survey) photometry project, under advisement of Dr Reza Rezei.

The objective of this project is to analyse the contributing factors to star formation in dwarf galaxies.

1 Introduction

The LITTLE THINGS Survey[1] focuses on star formation in dwarf galaxies. It obtained deep HI-line maps of dwarf galaxies using the Very Large Array (VLA) in New Mexico. The survey observed 21 dwarf irregular (dIm) and Blue Compact Dwarf (BCD) galaxies, with additional data from the VLA Archives for another 20 dwarfs. These observations provide insights into star formation by revealing clouds, shells, and turbulent structures within these small galaxies. The LITTLE THINGS sample includes 94 dIm, 24 BCDs, and 18 Sm galaxies, drawn from a larger multi-wavelength survey spanning 15 years of observations. More details about these galaxies can be found on the National Radio Astronomy Observatory website.

2 The reasons for studying dwarf galaxies

2.1 Star formation in dwarf galaxies

Our current star formation model, also known as the standard large-scale gravitational model, is only applicable to ares where the gas density surpasses a threshold called the critical density. In dwarf galaxies and the outer disks of spirals this requirement is not met. In the outer borders of these dwarf galaxies and spirals, densities are sub-critical by more than an order of magnitude yet star formation still occurs, Which leads to the question: Why do giant cloud complexes and stars form at all in sub-critical gases?

2.2 Sequential triggering for star formation in dwarf galaxies

Since sub-critical gas is stable to spontaneous perturbations, there must be other mechanisms that perturb the gas to such degree that stars are able to form. One if these mechanisms is the death of the stars from a previous generation. Supernovae explosions can rearrange the gas to this extent. But, how big a role does this process have? HI and optical observations of dwarfs show a better correlation between the star formation rate and the V-band surface brightness, show that existing stars can trigger even more stars to form.

2.3 Star formation at breaks in the exponential light profiles

In 20 to 40 percent of the dwarf irregular galaxies, spiral galaxies and disks at high redshifts, there is a break in the exponential surface brightness light profiles of the outer disks, which points to a transition in the star formation process at the break radius.

[1] https://science.nrao.edu/science/surveys/littlethings

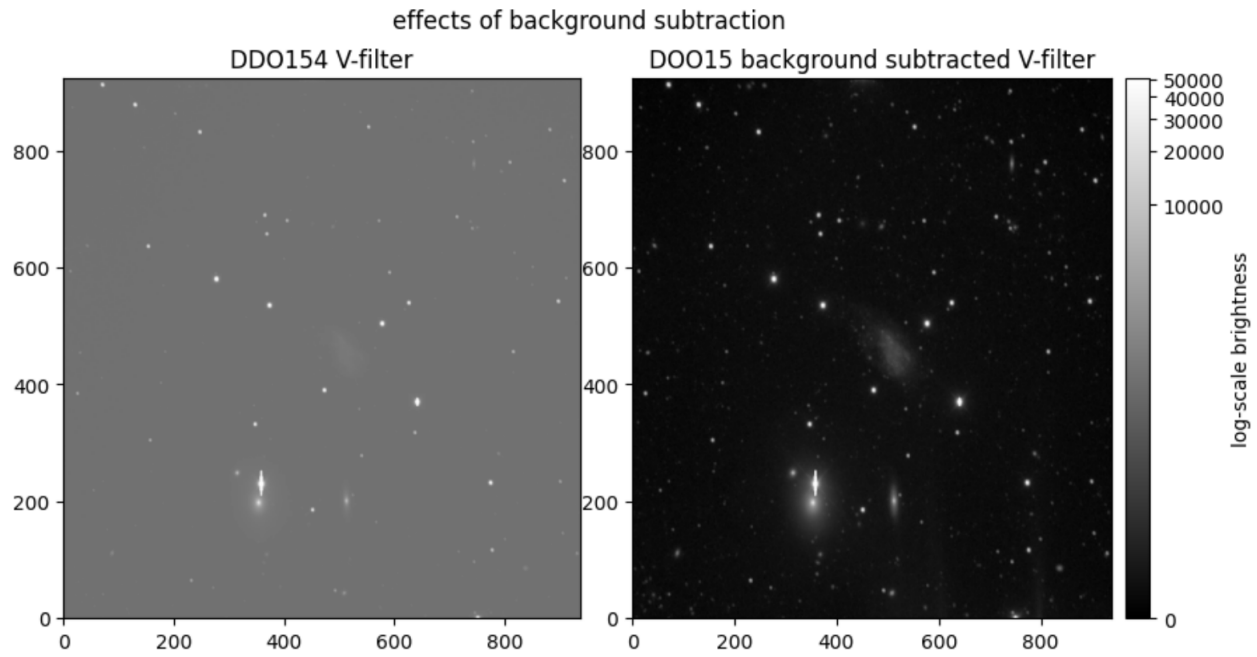

Figure 1: Background correction

3 Our work

The following sections cover our work on the LITTLE THINGS data. This project, so far, is about finding the semi-major and semi-minor axes of some the galaxies, half-light, semi-major and semi-minor axes of those galaxies, the ratio of the semi-minor to semi-major axis or b/a and the Position angle also know as the P.A. But first, some changes have to be made to the orginal fits files.

3.1 Background correction

This fits files on the LITTLE THINGS website have been dark current and flat corrected, but since the galaxies are very faint in some of the images, it is beneficial to find the background of each images and subtract it from the original fits. This process was done by the Background2D class from the photutils.background library.

Take DDO 154 for example, you can see the difference background subtraction makes in figure 1.

3.2 Subtracting the stars

Since the objective of this project is to study the galaxies themselves, we should subtract the stars from each image. This process was possible using starnet++ star removal tool which utilizes machine learning to find subtract the stars from the fits files. An example of this can be seen in figure 2.

3.3 Contour lines

After isolating the galaxy as a new image, contours for several levels were drawn as seen in figure 3.It is important to note that the box containing the galaxy has been smoothed using a Gaussian filter with

$$\sigma = 5$$

Then, The contour with the largest circumference without breaking into two pieces or more was chosen. See figure 4 .

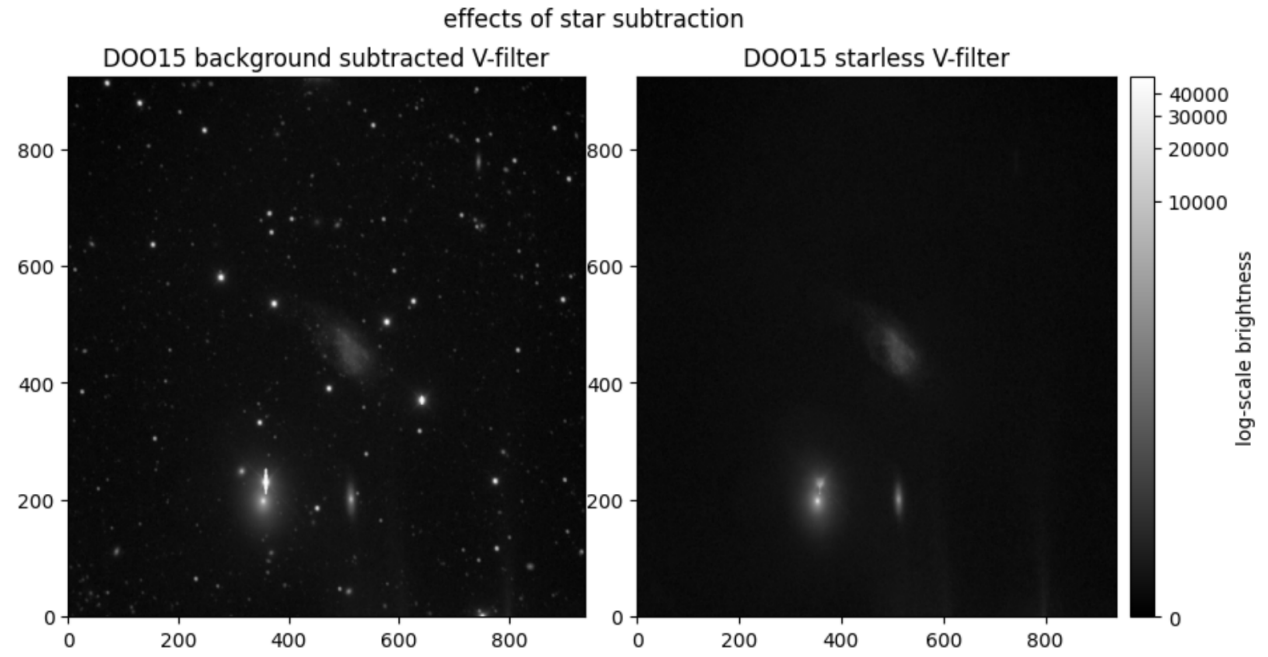

Figure 2: starless process

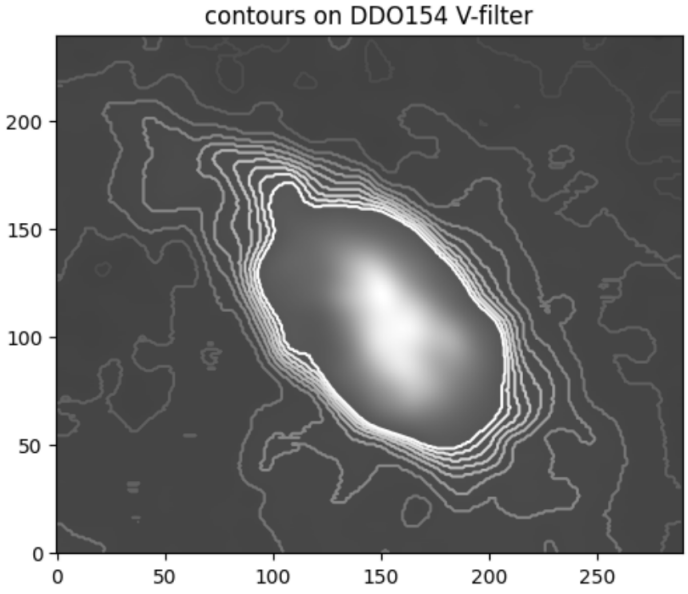

Figure 3: Multilevel contour lines

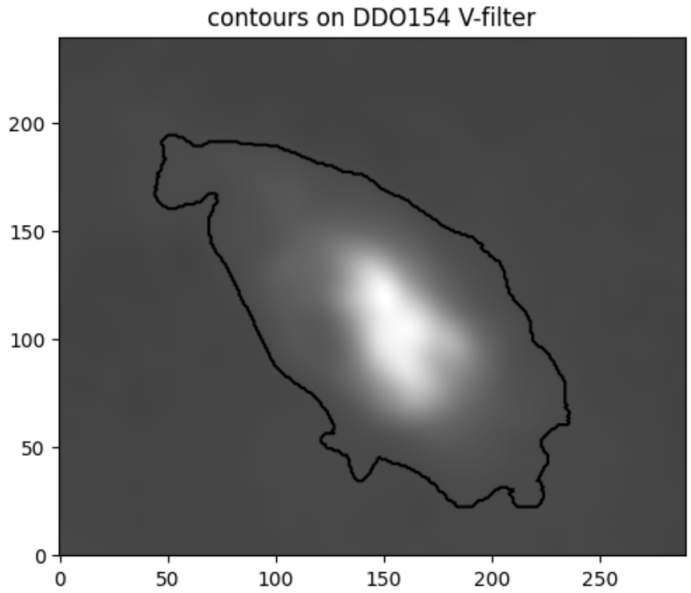

Figure 4: contour with the largest circumference

3.4 Ellipse fitting, full light and half light

We used the curvefit function from the scipy.optimize library to fit an ellipse to the contour line we obtained in the previous section (figure 5).Then, using the parameters of the optimal fit like the the center of the ellipse, b/a ration and theta, we drew concentric ellipses with the same b/a ratio and the same theta with varying values of a, the semi-major axis, and collected the sum of the values within each ellipse. The sum value vs. a, also known as the curve of growth is shown in figure 6.To understand where the galaxy ends and the background begins, we have to understand where in the curve of growth plot the derivative is at it's lowest. In other words, we need to find the point after which the plot acts linear, meaning we have entered the background. The derivative of the curve of growth is shown in figure 7

The point at which the derivative of curve of growth is the smallest, is taken to be where the galaxy ends, or the full light.

The ellipse containing half of brightness of the galaxy called the half light ellipse. In figure 8, The half light ellipse is shown in blue and the full light ellipse is shown in red.

3.5 Position angle

3.6 How to add Citations and a References List

You can simply upload a `.bib` file containing your BibTeX entries, created with a tool such as JabRef. You can then cite entries from it, like this: [Gre93]. Just remember to specify a bibliography style, as well as the filename of the `.bib`. You can find a video tutorial here to learn more about BibTeX.

If you have an upgraded account, you can also import your Mendeley or Zotero library directly as a `.bib` file, via the upload menu in the file-tree.

3.7 Good luck!

We hope you find Overleaf useful, and do take a look at our help library for more tutorials and user guides! Please also let us know if you have any feedback using the Contact Us link at the bottom of the Overleaf menu — or use the contact form at `https://www.overleaf.com/contact`.

References

[Gre93] George D. Greenwade. The Comprehensive Tex Archive Network (CTAN). *TUGBoat*, 14(3):342–351, 1993.

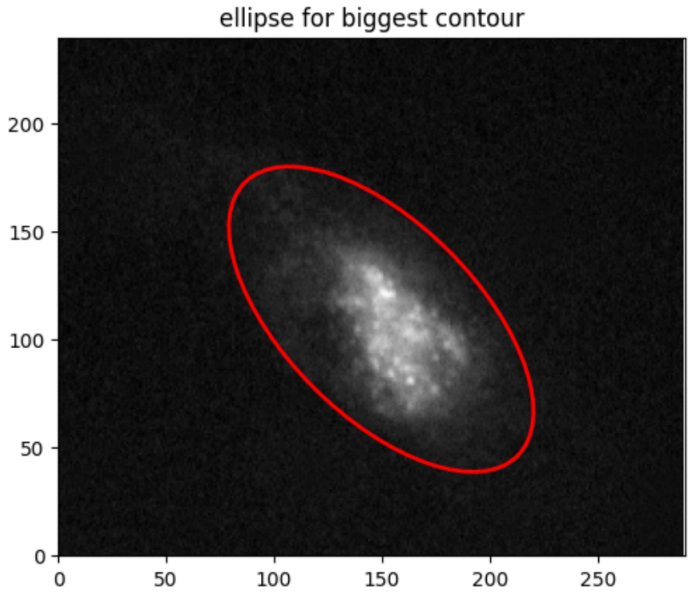

Figure 5: ellipse fitted to the largest contour

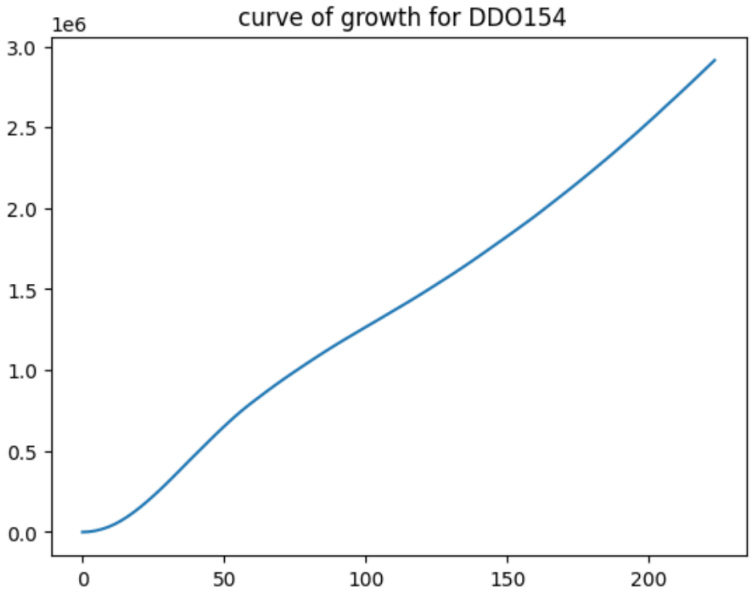

Figure 6: curve of growth

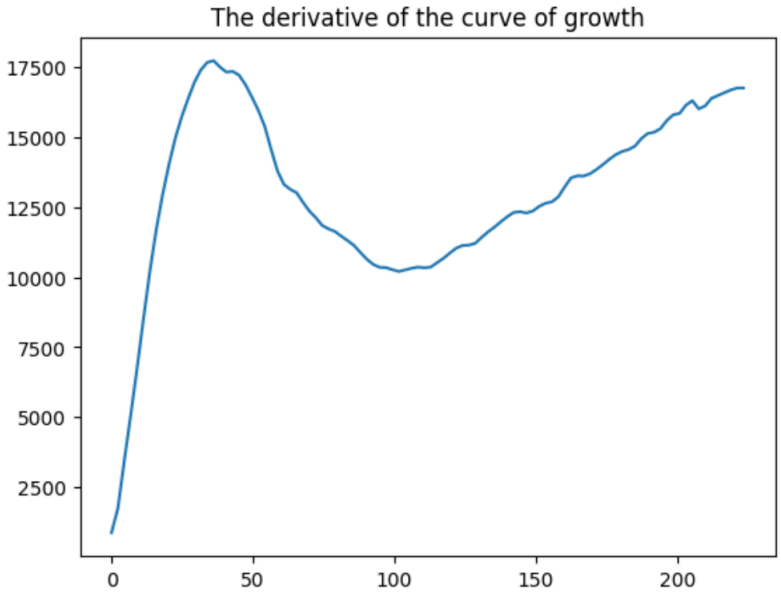

Figure 7: derivative of curve of growth

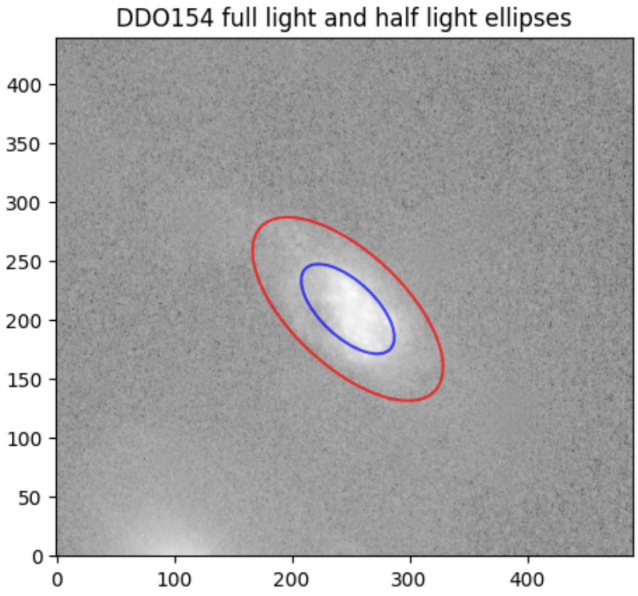

Figure 8: full light and half light