

Morphological study of elliptical galaxies

Silvia Guerra⁽¹⁾, Matteo Mannino⁽²⁾, Enrico Paccagnella⁽³⁾

⁽¹⁾ ITIS “F. Severi”, Padova

⁽²⁾ Liceo “I. Nievo”, Padova

⁽³⁾ Liceo “Tito Livio”, Padova

E tenebris tantis tam clarum extollere lumen (Lucrezio, “De rerum natura”, III)

ABSTRACT

The analysis of the brightness profile is a method that allows to study the morphology of galaxies. The aim of our work was to identify elliptical galaxies using this method. We chose galaxies with redshifts between 0.01 and 0.05, in order to work with relatively nearby objects.

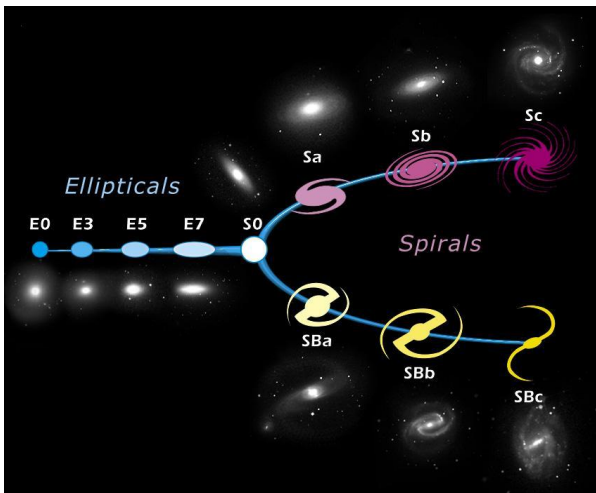
I. INTRODUCTION

Galaxy morphological classification is a widely used system in astronomy; following this method galaxies are divided into four groups, based on their shape:

- Ellipticals
- Spirals
- Lenticulars
- Irregulars

give them red colors; their brightness decreases from center to boundaries.

Visual classification of elliptical galaxies might not be so easy, especially in case of low resolution images. To be sure of a correct morphological classification, we had to compare our data with an experimental law, discovered by the French astronomer De Vaucouleurs.



Edwin Hubble classification scheme (also known as Hubble tuning-fork diagram).

We decided to work on elliptical galaxies, so called because of their ellipsoidal shape, which range from circular (E0) to elongated, narrow, and cigar-shaped (E7). This type of galaxies is mainly composed of old stellar populations, distributed homogeneously, which

II. OBSERVATIONAL DATA

Because of bad sky conditions we could not make any direct observation at the telescope. Instead, we based our research on archival data we extracted from the website of the Sloan Digital Sky Survey (<http://www.sdss.org/dr7/>). We made the first selection looking for galaxies that seemed to be elliptical, without bars or any spiral structure. We chose galaxies with redshift between 0.01 and 0.05 to study nearby objects.

Galaxy name	Redshift
SDSS J135039.09+350217.9	0.021
SDSS J133440.34+325704.0	0.024
SDSS J161845.79+392004.0	0.032
SDSS J153215.71+092755.9	0.033
SDSS J162754.90+403621.9	0.033
SDSS J105807.60+091634.0	0.034
SDSS J080550.30+372736.1	0.034
SDSS J093118.81+444647.3*	0.035

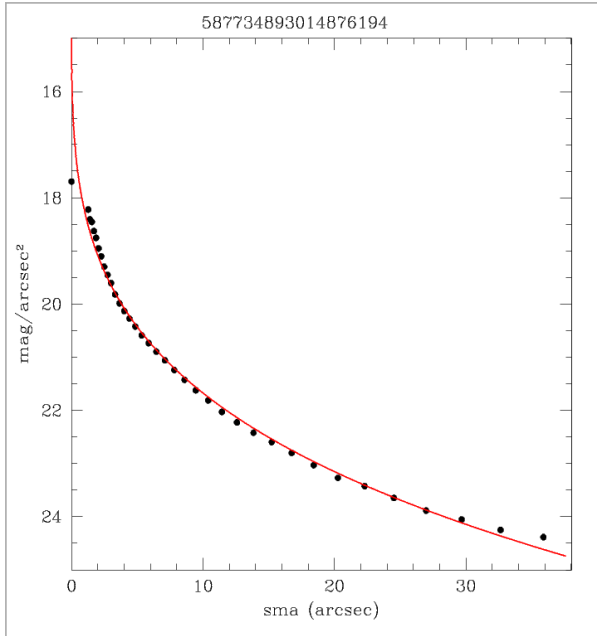
Then we calculated the magnitude of each galaxy, considering the total intensity within the most external isophote. We also removed the brightness of the sky and we took into account the exposure time of the image, using this formula:

$$m = -2.5 \log \left(\frac{I - I_{\text{sky}} \cdot N_{\text{px}}}{T_{\text{exp}}} \right) + \text{cost}$$

where I is the intensity within the isophote that contains all the galaxy, I_{sky} is the average intensity of the sky, N_{px} is the number of pixels contained in the isophote and T_{exp} is the exposure time.

Then, we obtained the graph of the surface brightness profile (mag/arcsec²) as a function of the radius, by calculating the intensity of the galaxy in each ring between an isophote and the following one, and taking into account the area of the sky covered by each pixel (in our case 0.4 x 0.4 arcsec):

$$\mu = -2.5 \log \left(\frac{I - I_{\text{sky}} \cdot N_{\text{px}}}{T_{\text{exp}} \cdot \text{Area}_{\text{px}}} \right) + \text{cost}$$



Graph of the De Vaucouleurs' equation for the galaxy SDSS J105807.60+091634.0.

On the graph derived from the data of the isophotes (black dots) we fitted the De Vaucouleurs' equation (red line):

$$I = I_e \cdot e^{-7.67 \left[\left(\frac{R}{R_e} \right)^{\frac{1}{4}} - 1 \right]}$$

$$\mu = -2.5 \log I + \text{cost} = \mu_e + 8.32 \left[\left(\frac{R}{R_e} \right)^{\frac{1}{4}} - 1 \right] + \text{cost}$$

where R_e is the effective radius, within which half of the total light of the system is contained, I_e is the surface intensity at R_e and μ_e is the surface brightness at R_e .

We had to find experimentally the value of these two parameters, in order to find the De Vaucouleurs' equation which better approximates the brightness profile of elliptical galaxies.

IV. RESULTS

Experimental results confirmed our first selection. Only one out of the 14 studied galaxies was not an elliptical.

We managed to find effective radius and surface intensity with great accuracy.

Galaxy name	I_e (cts/arcsec ²)	r_e (arcsec)
SDSS J135039.09+350217.9	7.5	11.7
SDSS J133440.34+325704.0	5.5	10.5
SDSS J161845.79+392004.0	8.5	9
SDSS J153215.71+092755.9	8.5	7.7
SDSS J162754.90+403621.9	40	2
SDSS J105807.60+091634.0	5.2	12.5
SDSS J080550.30+372736.1	6.4	6.6
SDSS J093118.81+444647.3*	2	15
SDSS J030352.91+002454.9	4	15
SDSS J124622.67+115235.7	5.8	11.4
SDSS J141532.92+501051.7	8	7
SDSS J084051.14+315853.4	6	8
SDSS J075638.85+440741.0	1.5	20.5
SDSS J100910.07+541331.9	4	11.3

Inaccuracies were sometimes due to close bright sources that might be the cause of the presence of deviations from the De Vaucouleurs' profile.

Studying the galaxy 587732054858137697* we were not able to reproduce the brightness profile with the De Vaucouleurs' law, as clearly visible from the graph reported below.

Our conclusion is that this galaxy is not an elliptical, despite the initial hypothesis we made by analysing its image and spectrum.

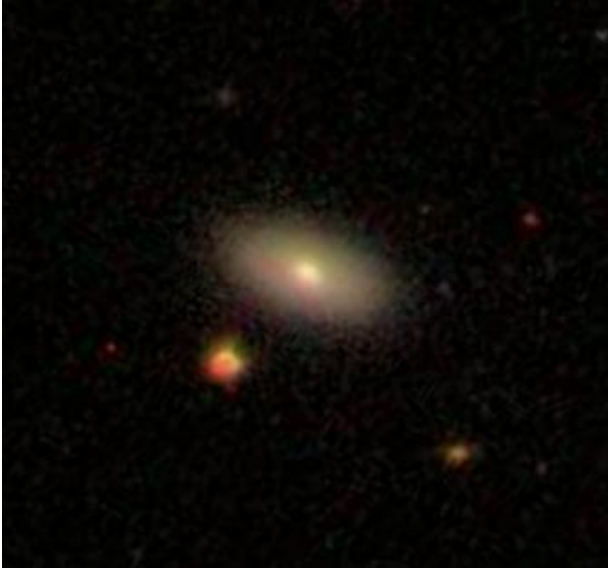
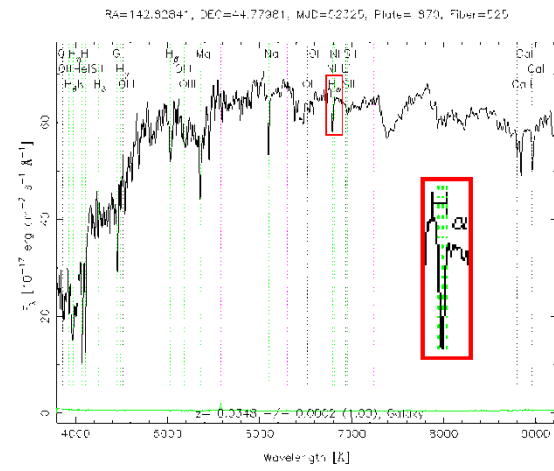
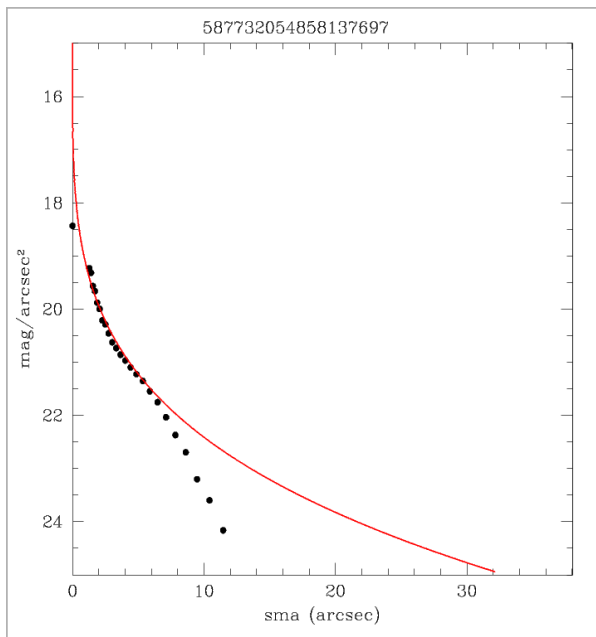


Image of the galaxy SDSS J093118.81+444647.3*.



Spectrum of the galaxy SDSS J093118.81+444647.3*.



Graph of the De Vaucouleurs' equation for the galaxy SDSS J093118.81+444647.3*.