The luminosity profile of NGC 7606

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Overview

This project is aimed to study the luminosity profile of a galaxy (NGC 7606) in the r-band of SDSS.

Provided data

- An r-band image of NGC 7606 (file "NGC7606rmosaic.fits").
- IRAF scripts "doellipse.cl" and "fixellipse.cl".

Proposed procedure

- Open the image with ds9.
- The galaxy is surrounded by background galaxies and foreground stars. If we want to study the luminosity of our galaxy without interference from other sources, we must mask these contaminants. By left-clicking and dragging the mouse over contaminants, we can surround them with circles. In the "region" menu, we can select other shapes such as ellipses or rectangles.
- The right button of the mouse allows the user to play with the thresholds of the image. The "scale" menu also allows to select different stretchings of the image grey-scale (logarithmic, squared, and so on). Another interesting feature of the "scale menu" is the "scale parameters" option which allows to select the maximum and minimum levels to be displayed.
- Faint contaminant objects to be masked are better seen in a smoothed image ("analysis" and then "smooth"), with a rainbow colour-scale ("color" and then "rainbow"), and a logarithmic stretching, but you are free to play with other options.
- Once you have marked all the contaminants, save the regions ("region" and "save regions"). Save the regions in CIAO format. In what follows, it will be considered as it had been saved as "ds9.reg".

- In a terminal, activate "scisoft" and then open an "xgterm" terminal ("xgterm -sbr &").
- In the xgterm terminal, activate "scisoft" again, and then enter into the IRAF home folder and type "ecl" to open IRAF. When inside IRAF go to the working directory that contains the image.
- Open ds9 from inside IRAF ("!ds9 &").
- We are now going to check how uncertain is the background. Type the "imexam" command. This will allow the used to place the cursor into the ds9 image, and use the "m" key to obtain statistical information of some patch of the sky. The size of that patch can be set by typing the "rimexam" command. Try this with several sky patches. The "stddev" value (σ) will later be used to estimate how deep we can do our photometry.
- We are going to transform the mask into a format understood by IRAF. Type "plcreate ds9.reg "NGC7606rmosaic.fit" NGC7606mosaic". IRAF will have created a "pl" format image that will contain the information of the mask.
- Type "doellipse NGC7606mosaic.fits ell xc yc sma0 pa0 ee0 maxsma delta=delta fix_cen+". This will fit ellipses a different radii. "xc" and "yc" are the pixel coordinates of the centre of the galaxy, "sma0" the radius in pixels at which the fit is initiated, "pa0" an initial guess on the galaxy Position Angle, "ee0" an initial guess on the initial ellipticity, and "maxsma" the maximum radius to which we want to do the fit. "delta" sets the width of the elliptical coronæ used for the fit (values between 0.01 and 0.1 are reasonable). This will create a file "ell.txt" that will contain the luminosity profile as a function of the radius in pixels. This file also contains ellipticity and PA profiles as a function of the radius.
- We are going to make luminosity profiles with a fixed ellipticity and Position Angle. Therefore, the fits done by "doellipse" where the ellipticity and Position Angle were left free are not good for us. But we can use them to estimate the ellipticity and the PA of the galaxy in its outskirts, were no strong perturbing influence of the bar and spiral arms are found and the ellipticity and PA profiles should be almost flat (you should plot these two magnitudes to estimate this properly).
- Once we have found the ellipticity and PA values for the disc, we can type the following "fixellipse NGC7606mosaic.fits ell_fix xc yc sma0 pa0 ee0 maxsma delta=delta" where this time pa0 and ee0 correspond to the PA and the ellipticity found before. This will create a file called "ell_fix.txt" that will contain, among others, the surface brightness as a function of the radius.
- Plot the final luminosity profile. To transform the luminosity into magnitudes per arcsec use $\mu = -2.5 \log I + 26.27713$. The pixel size is $0\farcs396$.

- Now we can check how good our profiles are and what is their limiting magnitude. To do so, consider that a reasonable error of the photometric uncertainties is 5σ of the sky. If we now plot a luminosity profile using $I + 5\sigma$ and $I - 5\sigma$ to calculate μ, at which level do the luminosity profile differ by more than 0.2 mag from the one calculated previously?

- What kind of luminosity profile it is (Type I, Type II, or Type III)?

- Fit the following function to the luminosity profile to obtain the scale-length(s) of the disc(s):

$$I(R) = S\, I_0 \mathrm{e}^{-\frac{R}{\gamma}} \left[1 + \mathrm{e}^{\alpha(R-R_\mathrm{b})}\right]^{\frac{1}{\alpha}\left(\frac{1}{\gamma}-\frac{1}{\beta}\right)} \tag{1}$$

  where

$$S^{-1} = \left(1 + \mathrm{e}^{-\alpha R_\mathrm{b}}\right)^{\frac{1}{\alpha}\left(\frac{1}{\gamma}-\frac{1}{\beta}\right)} . \tag{2}$$

  It is recommended to fix the sharpness of the break (α) to $\alpha = 0.5/''$. R_b is the radius of the break. γ and β are the inner an outer scale-lengths. To transform the scale-lengths to kpcs, use $d = 31.78$ Mpc as the distance to the NGC 7606.