Galaxy Anatomy: Instructions for the General Public

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Abstract:
Do you believe you live in some state of darkness, full of worry and uncertainty? Do you want to make a change of your life? Scientific progress may help you. The simplest way to achieve this change is for you to forget the misery that comes from the miniature world of your immediate life, zoom out of this world, look at the large natural structure of the universe, and find its meaning. As you know, the large scale structure is not relevant to humans' activity. Unfortunately, the meaning has not been identified. Now, with Dr. He's study on galaxies, the meaning of the universe may emerge. The good news is that people, whatever their origin (politician, lawyer, doctor, musician, or beggar), could claim a big discovery on the meaning by playing a computer software of galaxy anatomy. This article is a simple instruction for the design of such a program.

1. What is a galaxy image?

Everyone needs attention from others. Businessmen know this fact, and they developed the commercial digital cameras. Now, we pay attention to galaxies and take their images with telescopes. Spiral galaxies are flat, and a digital image of a face-on spiral galaxy is three arrays of numbers. Each array corresponds to a density distribution of one color (e.g., red). However, we study the stellar distribution of galaxies, and their images are taken with longer wavelength electromagnetic radiation. Usually, we take one color of this radiation and the resulting images are black and white (see explanation in paper [1]). The brightness at each point of the image is proportional to the stellar density at that point. The brighter the point is, the greater the stellar density. Galaxy anatomy is based on this single array of positive numbers taking from the digital image.

A computer software of galaxy anatomy must show some buttons. As explained in the paper [1], the anatomies of ordinary spiral galaxies and elliptical galaxies are completed. Our computer software focuses on the analysis of barred spiral galaxies. The first button we create represents the above-said original image of a face-on barred galaxy:

A: original image of a barred galaxy.

2. Galaxy ABC: the basic program of galaxy decomposition

A barred spiral galaxy is mainly composed of the exponential disk and the bar. Therefore, another button is created which represents the simulated galaxy bar:

B: simulated galaxy bar.

Thus, A minus B is mainly the galaxy exponential disk, whose button is

C: the original image with its simulated bar deleted.

We can use the following formula to represent this process of galaxy decomposition:

$C = A - B$ or $A = B + C$

Therefore, C should look like an ordinary spiral galaxy because it is mainly composed of an exponential disk! The stellar density distribution of ordinary spiral galaxies is circularly symmetric. Therefore, we should testify if the image C is circularly symmetric too. To do so, we create a button:

Resolution: image resolution.

Pressing the button makes a change in brightness for each point on the image. This button can effectively testify if the image C is circularly symmetric or not. If it is, the original bar is artificially deleted.

Likewise, we can simulate the exponential disk. The summation of the simulated bar and the simulated disk is displayed by pressing the button:

Bd: the image of combined bar and disk.

Thus, A minus Bd is mainly the galaxy central bulge, whose button is:

Cd: the original image with its bar and disk deleted.

We can use the following formula to represent this process of galaxy decomposition:

Cd = A – Bd   or   A = Bd + Cd

If we create a piece of computer software, we would provide nine examples of galaxies: NGC 3275, 4548, 4643, 4665, 4930, 5701, 5850, 5921, and 6782. The software would give a default simulation of the nine galaxies. They would be shown by the button:

defau-sim: the default simulation of galaxy bars and disks.

However, the parameter values of the simulation may not be optimal. By pressing the button:

curr-sim: the current simulation,

you can change the parameter values. As explained in paper [1], a galaxy bar is composed of several pairs of double-humped structures. Usually two pairs are enough, but sometimes it requires three. We can change the number of pairs by pressing the button:

sub-bars: the number of pairs of sub-bars (i.e. double-humped structures).

Each sub-bar has four parameters:

angle: the position angle of the sub-bar,

b0: the density strength of the sub-bar,

b1: the length of the sub-bar, and

b2: the sharpness of the sub-bar density distribution.

We can also simulate the exponential disk with two parameters:

d0: the density strength of the exponential disk and

d1: the sharpness of the exponential disk.

In fact, the images of galaxies taken by astronomers are similar to the typical digital cameras' photos. The light displayed in the image is not completely from the stars of the galaxy in the image. Part of the light comes from human activities on the Earth. It needs to be deducted from the original galaxy image. This light is called:

sky-level: the background light on the sky created mainly by human activity.

In fact, Dr. He's idea on galaxy structure is a pattern theory. Therefore, it is somewhat geometrical origin, independent of the choice of coordinate lines' scale. Dr. He defined the scale of each image as 100x100. However, you can change the scale by pressing the button:

coor-scale: coordinate scale.

A simulation of a barred galaxy results in an analytic formula, Bd = ρ(x,y), which represents the simulated stellar density. Further analysis of the galaxy structure depends on the analytic formula. For example, we draw a curve on the galaxy image and calculate the variance rate towards the normal direction of the curve. If the variance rate is constant along the curve, then it is a Darwin curve. We can set a button for testifying Darwin curves:

Darwin curves: by clicking four points on the image, a yellowish simulated curve appears.

A pink curve appears simultaneously, which is the variance rate towards the normal direction of the yellow curve. If the pink curve is horizontal, then the yellow curve is a Darwin curve.

rot-img?: rotate the image
flat-img?: return to flat image after rotation
contrast?: contrast the image B/Bd with C/Cd/A
color: display of images with yellowish color, otherwise it is black and white
choose galaxy: switch to different galaxy
save data?: save current simulation for next start of the software
curr-sim -> defau-sim?: return to default simulation if not satisfied with current simulation

3. Galaxy anatomy: a living software (i.e., updatable with scientific progress)

Galaxy study is not finished. If Dr. He's study is on the right track, then his result is similar to Johannes Kepler's work. Likewise, a giant scientist like Newton is expected who will develop Dr. He's study into a foundational theory. In 2010, Dr. He achieved the breakthrough in rational structure study. He found the so-called instinct equation, followed by the discovery of a sufficient condition for rational structure. Based on the instinct equation, we can also find the orthogonal sets of Darwin curves for the stellar distribution which are called the spider curves, coined by Dr. He.

We know there are very few types of galaxies. Amazingly, there are only two types of rational structures which correspond to the solutions of the instinct equation. The instinct equation is a cubic algebraic equation at each point on the galaxy image (see paper [2]). Any cubic equation can be factored into a quadratic equation and a linear equation. A linear equation is trivial while the quadratic equation has two solutions. The solution with the positive square root is called the plus rational structure. The solution with the negative square root is called the minus rational structure. All sub-bars are minus rational structures. However, whether the summation of an exponential disk with several sub-bars is also rational is not resolved. If it is, is it a plus rational structure or a minus rational structure? Therefore, the computer software would display both solutions for you perusal. The variance rate for the Darwin curves of plus structure is displayed by pressing the button:

bask(+): the basket graph displaying variance rate for the Darwin curves of plus structure.

The variance rate for the Darwin curves of minus structure is displayed by pressing the button:

bask(-): the basket graph displaying variance rate for the Darwin curves of minus structure.

The basket graphs are the demonstration of the variance rates along the orthogonal nets of the Darwin curves. The level curves of the graph are the anticipated Darwin curves. The display of the level curves is called a spider graph:

spider: the orthogonal nets of Darwin curves.

Whether the summation of an exponential disk with several sub-bars is a rational structure is not resolved. If it satisfies a sufficient condition, then it is a rational structure. We can see the sufficient condition by pressing the button:

suff-cond: calculation of the sufficient condition

If the result is complete zero, the sufficient condition is satisfied and the corresponding plus structure or minus structure is really rational. However, the sufficient condition involves up to the fourth-order derivatives to the simulated logarithmic stellar density. A numerical calculation with computer cannot give the accurate values of the derivatives. The distribution of the values can be played by pressing the button resolution.

add-img & Darwin: transparently overlap an image of shorter wavelength to the original image.

All the images that come from the software must be longer wavelength which are smooth for stellar density simulation. However, we need testify galaxy arms if they follow Darwin curves. Shorter-wavelength images display galaxy arms in more details. Therefore, we overlap transparently an image of shorter-wavelength to the original image by pressing one of the following buttons:

img reflec: reflect the shorter-wavelength image

inmg spin: spin the shorter-wavelength image

img zoom: zoom in/out the shorter-wavelength image

img stretch: stretch/shrink the shorter-wavelength image horizontally

transparency: change the degree of transparency of the shorter-wavelength image

References:

[1] He H. & He J. (2012) viXra:1206.0041

[2] He J. (2011) viXra:1103.0110