New Universal Gravity and Rational Galaxy Structure

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Abstract New Universal Gravity: To any point on a rational structure, there correspond three proportion surfaces which pass the point and are orthogonal to each other. To any proportion surface there exists the corresponding component of the gravitational force at the point whose direction is normal to the surface (pointing to the larger matter density) and whose magnitude is proportional to the Gaussian curvature of the surface at the point and proportional to the total mass contained in the closed surface. The new gravity generalizes Newtonian theory and gives a unified explanation to both discrete and smooth natural structures (i.e., Solar system and galaxies). It is the inevitable truth of nature if gravity must satisfy divergence theorem and galaxies must be rational structure.

keywords: Spiral Galaxy; Rotational Curve; Rational Structure; Proportion Surface; Newtonian Gravity; Divergence Theorem

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1 Introduction

Longer wavelength galaxy images reveal that galaxies are smooth, continuous structures. We humans live in such a spiral galaxy called the Milky Way. However, the immediate environment of human life is not smooth or continuous. The Solar system which is a discrete structure, is composed of the Sun, eight planets, and other small objects. Newtonian universal gravity is a theory which describes the orbital motion of such discrete bodies. The theory fails when applied to the study on galaxy structure and dynamics [1]. The purpose of this article is to generalize Newtonian universal gravity so that it is applicable to both discrete and smooth structures. It is called New Universal Gravity.

2 Jin He's Rational Galaxy Structure

Much observational evidence has been found which supports Jin He's concept of rational galaxy structure. A planar rational structure is defined as follows

Rational Structure: In the plane of two dimensional distribution of matter, there exists an orthogonal net of curves. For each curve, the matter density on one side of the curve is in constant ratio to the density on the other side of the curve. Such a curve is

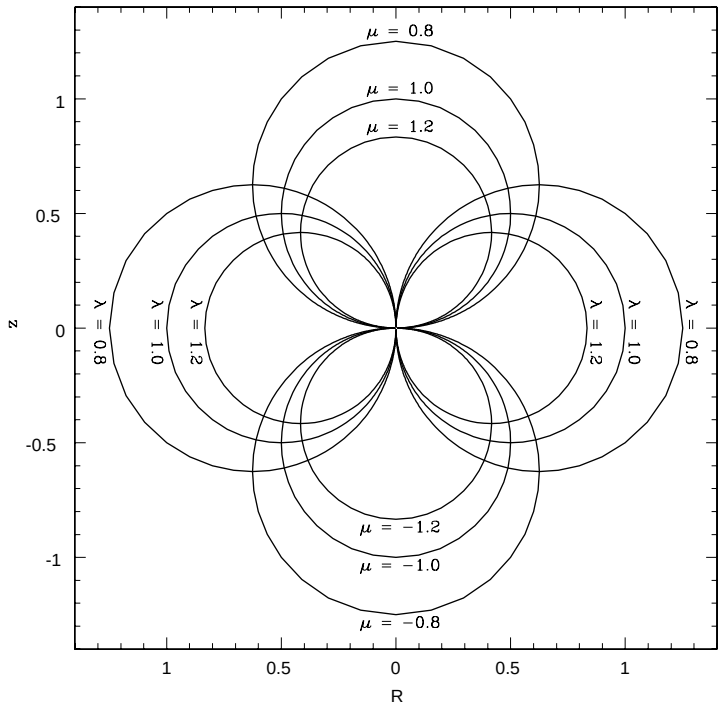

Figure 1: A planar section of the proportion spheres of rational elliptical galaxy structure. Depending on the assumption of axi-symmetric shape or triaxial shape, an elliptical galaxy has either an orthogonal net of spheres, tori and planes, or an orthogonal net of 6-spheres. The graph is taken from the reference [3].

called a proportion curve or a Darwin curve. Such a distribution of matter is called a rational structure.

Spiral galaxies are planar distribution of stars. There are two kinds of spiral galaxies. The spiral galaxy with a barred pattern is called a barred spiral. The spiral galaxy without a barred pattern is called an ordinary spiral. The stellar distribution of an ordinary spiral galaxy is axi-symmetric with respect to the galaxy center, and its stellar density decreases exponentially in the radial direction. Therefore, it is called the exponential disk. Certainly the exponential disk is a rational structure. Any orthogonal net of proportion curves of an exponential disk is composed of golden spirals. However, there is the trivial net of proportion curves which is composed of all concentric circles centered at the galaxy center and all radial lines. As we know, spiral galaxies have a definite thickness and can be considered a three-dimensional structure. Astronomers observed that all straight vertical lines perpendicular to the galaxy disk are proportion curves too [2]. Therefore, when an ordinary spiral galaxy is considered to be a three-dimensional structure, these concentric proportion circles become coaxial proportion cylinders and the radial lines becomes coaxial radial planes. That is, the orthogonal net of proportion surfaces of ordinary spiral galaxies is composed of all coaxial cylinders and coaxial planes which are perpendicular to the galaxy disk, and all planes which are parallel to the galaxy disk.

In the universe, there is a third kind of galaxies which are called ellipticals. Jin He has proved that elliptical galaxies are a rational structure too [3]. Their orthogonal net of proportion surfaces is composed of all spheres (see Figure 1).

In conclusion, relatively independent smooth structures in the universe are unique. They are either ellipticals or spirals. Dr. Jin He proved that all galaxies are ratio-

nal structures. Amazingly, the basic proportion surfaces are either planes, cylinders, or spheres. Therefore, if we find the geometric meaning behind Newtonian universal gravity, we may generalize it and use it to explain the gravitational dynamics of galaxy structure. This is discussed in the next Sections.

3 New Universal Gravity

New Universal Gravity: To any point on a rational structure, there correspond three proportion surfaces which pass the point and are orthogonal to each other. To any proportion surface there exists the corresponding component of the gravitational force at the point whose direction is normal to the surface (pointing to the larger matter density) and whose magnitude is proportional to the Gaussian curvature of the surface at the point and proportional to the total mass contained in the closed surface.

The new gravity generalizes Newtonian theory and gives a unified explanation to both discrete and smooth natural structures (i.e., Solar system and galaxies). It is the inevitable truth of nature if gravity must satisfy divergence theorem and galaxies must be rational structure. Divergence theorem is the conservation of force lines, which is the major principle of classical physics (see the paper [2]). On the other hand, much observational evidence has been found which supports Jin He's concept of rational galaxy structure (see the references in the same paper [2]).

First, let us prove that the new universal gravity is the generalization of Newtonian universal gravity. Newtonian universal gravity is not about smooth structure. For example, when applied to the Solar system, the Sun is considered to be a point mass. However, if we imagine the Sun as a larger spherically-symmetric ball whose radius reached the earth and whose total mass did not change, the orbit of the earth around the Sun would not change at all. In fact, the motion of all outer planets would not change either. We use r to denote the distance between the center of the Sun and the center of the earth. The mass distribution of the giant Sun would be a rational structure whose proportion sphere passing the point of the earth would have the radius r. Now, we apply the new universal gravity to the giant Sun. Then the Gaussian curvature of the sphere is $1/r^2$. According to the new universal gravity, the gravitational force at the point of earth due to the Sun is proportional to the curvature. That is, the gravitational force is inversely proportional to the squared radius r. The new gravity is also proportional to the mass contained in the sphere that is the mass of the Sun, M. Therefore, the new gravity is

$$f \sim \frac{M}{r^2} \tag{1}$$

Here we see that it is equivalent to the Newtonian universal gravity. Therefore, our new universal gravity is the generalization of the Newtonian one.

4 Preliminary Galaxy Application and Constant Rotational Curves

Firstly let us study spiral galaxies. The mass distribution of an ordinary spiral galaxy is an exponential disk. Considered to be three dimensional, it is still rational structure (see the above Section 2). Its proportion surfaces are coaxial cylinders, coaxial planes, and parallel planes. Because the Gaussian curvature of any plane is zero, the corresponding component of the gravitational force is zero. We need consider the gravitational force corresponding to the cylinders. The normal directions to the cylinders are all radial lines starting at the axis which passes the galaxy center and is perpendicular to the galaxy disk. Therefore, the gravitational field of spiral galaxy disk is two dimensional, which is parallel to the disk plane. However, the realistic environment of spiral galaxies is organic in that the disks are always accompanied by the central bulges and the spacious, faint yet observable halos. These bulges or halos provide the vertical component of the gravitational field. Compared to the disk component, the vertical one is very weak but critical for the development of disks. Here we study the disk only whose gravitational field is two dimensional according to our theory.

Because the curvature of the circle of radius r is $1/r$ and the new gravitational force is proportional to the curvature, the force is inversely proportional to the radius r (note that galaxy stellar density decreases exponentially outwards from the galaxy center),

$$f \sim \frac{1}{r} \tag{2}$$

Now we suppose a star rotates circularly at the radius r. Its acceleration is v^2/r. Therefore,

$$\frac{v^2}{r} \sim \frac{1}{r} \tag{3}$$

Finally, we proved the constant rotational curves of ordinary spiral galaxies [2],

$$v = \text{constant} \tag{4}$$

However, traditional galaxy study keeps Newtonian universal gravity and adds unobservable dark halo to galaxies to maintain the constant rotational curves.

The mass distribution of barred spiral galaxies is mainly an exponential disk too. According to Dr. Jin He's study, double-breast structures are attached to the disk to make a bar-shaped pattern. Therefore, circular cylinders are no longer their proportion surfaces. The sections on the disk plane of the non-circular proportion cylinders make a spider graph (see [4]). Our new universal gravity is applied to the new proportion surfaces and the conclusion of constant rotational curves is still true.

Although elliptical galaxies are three dimensional, they pose missing matter problems too. According to Dr. Jin He's study, elliptical galaxies are rational structure either [3]. Their proportion surfaces are spheres (see Figure 1). Let us study the triaxial model of elliptical galaxies. According to new universal gravity, the three components of the gravity are in the normal directions to the orthogonal net of 6-spheres. It is straightforward to show that the new gravity is larger than the Newtonian one. Therefore, the new

gravity may resolve the missing matter problem for elliptical galaxies. It deserves further investigation.

5 Discussion

New universal gravity is promising in that it generalizes Newtonian gravity and gives a unified explanation to both discrete and smooth natural structures (i. e., Solar system and galaxies). Note that our new gravitational law is based on the proportion surfaces of rational structure. Because rational structure is harmonically unique and its examples are extremely limited, the involved proportion surfaces are not mathematically arbitrary. They root in the natural beauty. We look forward to deep investigation of our new universal gravity.

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