We are Looking for Modern Newton

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Abstract Newton discovered the dynamic law of universal gravity, based on his principles of kinetic physics and Kepler's three laws of planetary motion in the Solar system. However, astronomers observed larger material systems in the universe that are galaxies. If Newton's theory was applicable to galaxies then stars would rotate around the galaxy center at a speed decreasing with the distance from the center. However, astronomical observation shows that the speed is constant regardless of the distance. This is called the problem of constant rotational curves. It is the dark cloud hanging over twentieth century physics. Fortunately, Dr. Jin He found out that the observational galaxy structure is rational. This suggests Jin He might be a modern Kepler. In this article we present Cylindrical Conjecture on galaxy force field based on Jin He's observational result. The conjecture simply proves constant rotational curves. We are looking for a modern Newton who will develop the conjecture into a systematic theory on galaxy dynamics, be the conjecture a cosmic truth.

keywords: Spiral Galaxy, Rotational Curve, Rational Structure, Cylindrical Conjecture, Divergence Theorem

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1 Dark Cloud Hanging over Twentieth Century Physics

According to Newton's theory of universal gravity, the gravitational force F between two bodies of masses M and m is

$$F = \frac{GMm}{r^2} \tag{1}$$

where G is the gravitational constant and r is the distance between the two bodies. If Newton's theory was applicable to galaxy dynamics then a star of mass m in a galaxy would suffer a gravity described by the above formula, where r is the distance of the star from the galaxy center and M is the mass of the whole galaxy (note that galaxy stellar density decreases exponentially outwards from the galaxy center). If we suppose the star rotates in a circle around the galaxy center, then its acceleration is

$$a = \frac{v^2}{r} \tag{2}$$

According to Newton's principle of kinetic physics

$$\mathbf{F} = m\mathbf{a} \tag{3}$$

we have

$$F = \frac{\sqrt{GM}}{\sqrt{r}} \tag{4}$$

Here we see the speed of the star decreases as its distance from the galaxy center increases. However, astronomical observation shows that the speed is approximately constant. This is the famous problem of galaxy constant rotational curves. It is the dark cloud hanging over twentieth century physics.

2 Divergence Theorem and the Flux of Force

Why is Newton's universal gravity inversely proportional to the squared distance between two bodies (see formula (1))? In fact, most familiar forces in the nature obey the square law, for example, Coulomb's force law and Ampère's force law. It is straightforward to resolve the secret of square law.

Suppose there is a sphere whose center is the sun. We calculate the flux of solar gravity through the sphere. The flux is

$$\Phi = F \cdot S \tag{5}$$

where S is the surface area of the sphere and F is the gravitational force on the sphere. Because S is proportional to the squared distance from the solar center and F is inversely proportional to the squared distance from the center, the flux is constant regardless of the distance

$$\Phi = \frac{GMm}{r^2} \cdot 4\pi r^2 = 4\pi GMm = \text{constant} \tag{6}$$

Therefore, the secret of the square law is the requirement of constant flux of force. In fact, the constancy of the flux is resulted from the famous Divergence Theorem.

3 Spiral Galaxies are Cylindrically Structured

Although spiral galaxies are flat and considered to be two-dimensional, they still have a certain thickness (see Figure 1 and the reference [1]). What is the vertical structure? We use z to describe the vertical direction and r to describe the horizontal direction as seen on an image of horizontal edge-on spiral galaxy. Astronomical observation shows that the stellar density distribution on an edge-on spiral galaxy image of longer-wavelength can be described by a formula whose variables z and r can be separated

$$\rho(r, z) = \sigma(r)\, \tau(z). \tag{7}$$

This means that the ratio of galaxy light from two sides of each vertical straight line is constant along the line. This is the further evidence of rational galaxy structure [2,11].

Rational Evidence: Spiral galaxies considered to be 3-dimensional are still rational structure.

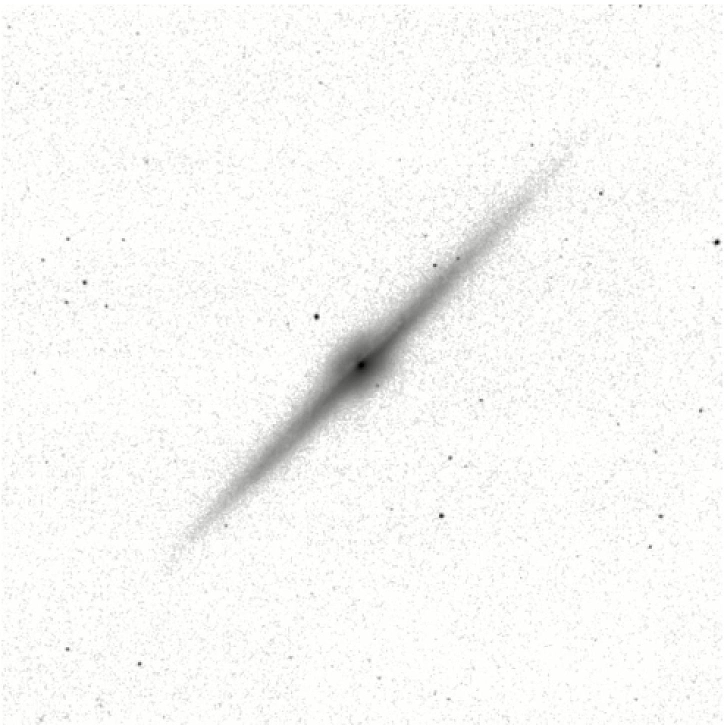

Figure 1: A longer-wavelength image of edge-on spiral galaxy NGC 4565 (Courtesy of [1])

We know that the level curves of stellar density on an edge-on spiral galaxy image are not cylindrically structured. However, the Rational Evidence suggests that the distribution of density-ratios is cylindrically structured. That is, the vertical proportion curves (Darwin curves) are straight lines perpendicular to the galaxy disk.

The Rational Evidence must set some constraints to galaxy dynamics. As a try, we present a conjecture on galaxy dynamics: the Cylindrical Conjecture.

4 Cylindrical Conjecture and Rotational Curves

Cylindrical Conjecture: The gravitational force field of spiral galaxies is cylindrically structured.

Although spiral galaxies are disks, they still have a certain thickness. As the above Rational Evidence suggests, the disk is composed of many similar layers. The Cylindrical Conjecture says that the gravitational force at any point on a spiral galaxy has no vertical component. That is, the force is always parallel to the layers. However, Newtonian theory suggests that the gravitational force suffered by a star always points to the galaxy center, and has a vertical component whenever the star is positioned outside the middle layer.

For spiral galaxies which are the large-scale system of many bodies, we assume the Cylindrical Conjecture is true and Newtonian theory is wrong. Now we show that the Conjecture simply endorses constant rotational curves. We imagine a right cylinder whose center is the spiral galaxy center and whose height is h (see Figure 2). The axis of the cylinder is perpendicular to the galaxy disk. That is, the radius r of the cylinder is parallel to the disk. We want to calculate the flux of gravitational force through the whole cylindrical surface. Because the gravitational force field of spiral galaxies is cylindrically structured, the flux contribution from the two bases is zero, because the bases are parallel

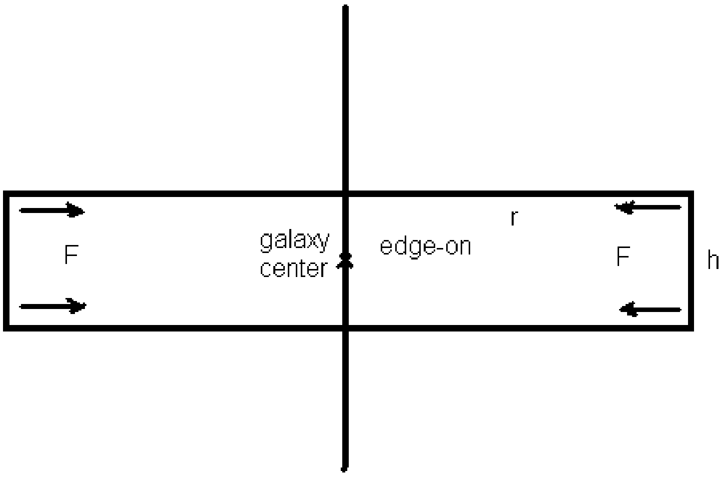

Figure 2: Right cylinder whose center is the spiral galaxy center and whose height is h. The axis of the cylinder is perpendicular to the galaxy disk.

to the gravitational force. Now we need to calculate the flux contribution from the lateral area of the cylinder. Because the gravitational force is always perpendicular to the lateral area, we have the flux:

$$\Phi = F \cdot S = F \cdot h \cdot 2\pi r \tag{8}$$

where r is the distance of the lateral area from the axis of the cylinder, not from the galaxy center. Because of the divergence theorem and the fact that stellar density decreases exponentially from the axis, the flux is approximately constant regardless of the distance r. That is:

$$\Phi = \text{constant} = F \cdot h \cdot 2\pi r \tag{9}$$

Therefore, F is inversely proportional to the distance r from the axis of the cylinder:

$$F = \frac{\text{constant}}{r} \tag{10}$$

Now we suppose a star rotates circularly at the distance r. Its acceleration is the formula (2). Therefore:

$$\frac{v^2}{r} = \frac{\text{constant}}{r} \tag{11}$$

Finally, we proved the constant rotational curves of spiral galaxies:

$$v = \text{constant} \tag{12}$$

5 Discussion

We proposed spiral galaxy Cylindrical Conjecture. That is, gravitational force inside spiral galaxies is always parallel to the disk plane. However, Newtonian theory assumes that the force always points to the galaxy center. Because Newtonian theory is only applicable to two-body system and galaxies are the result of many-body interaction, it is a reasonable assumption that Newtonian theory fails to the explanation of galaxy structure and dynamics. Furthermore, the conjecture is supported by the evidence that the distribution of stellar density-ratios is cylindrically structured. That is, spiral galaxies are cylindrically-structured rational structure.

However, galaxy bulges are not cylindrically-structured. Therefore, the gravitational force near the central bulge tends to pointing to the galaxy center. If we assume the Conjecture is true then the constant rotational curves of spiral galaxies can be easily explained by the disk and the non-constancy near galaxy center can be explained by the central bulge. We look forward to astronomers and physicists for further testification of the Conjecture with galaxy observational data. If the Conjecture is proved, a modern Newton is expected who will develop the Conjecture into a systematic theory on galaxy dynamics.

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