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Observational Evidence for that Newtonian Theory of Orbit Perturbation Is Fundamental to Galactic System

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Observational Evidence for That Newtonian Theory of Orbit Perturbation Is Fundamental to Galactic System

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Abstract: In recent, Chae found that, at weak gravitational acceleration $g_N \lesssim 10^{-9} ms^{-2}$, the observed orbit of the wide binary stars is not accordant with current theory of binary star. Here, we present, this finding should be an observational evidence for that Newtonian theory of orbit perturbation is still valid in galactic scale.

Keywords: wide binary stars; Newtonian theory of orbit perturbation; observation; orbit in a galaxy; three-body problem

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In recent, "A gravitational anomaly is found at weak gravitational acceleration $g_N \lesssim 10^{-9} ms^{-2}$ from analyses of the dynamics of wide binary stars selected from the Gaia DR3 database".[1] Chae[1] claimed that this finding should be "Breakdown of the Newton-Einstein standard gravity"; while some other authors[2] presented that it should be because of an unresolved or unseen third star. Chae's[1] conclusion is based on the current theory of binary system. In this theory, two stars is treated as an isolated system which is not affected by other objects.[3,4] But, in fact, the two stars system is always being perturbed by many other objects. So, the current theory of binary system is only a roughly approximate theory.[4] It is well known that, an orbit can be known accurately and precisely with the Newtonian theory of orbit perturbation.[3] We found, Chae's[1] finding can be directly explained with Newtonian theory of orbit perturbation. It indicates that the Newtonian theory of orbit perturbation is needed to completely understand the orbit in the galactic scale.

Binary star system is an observed conclusion. It was observed early in 1700s.[5] But, the mechanics and dynamics for the system is unclear in the early time. Currently, the Earth-Moon system[6] and the Pluto-Charon system[7] are thought to be the binary planet system. Therefore, it was presented that the mechanics and dynamics for the binary star/planet system could be understood from the two systems.[4]

From the Newtonian theory of orbit perturbation,[3] we know, the moon in the two systems is always being acted by both the Sun and planet, the total acceleration is:

$$g_{total} = G\frac{M_p}{R_{pm}^2} + 2G\frac{M_s}{R_{sm}^3}\boldsymbol{R_{pm}} \quad (1)$$

Where, p, m and s refer to the planet, moon and Sun, M and R are the mass and distance, $\boldsymbol{R_{pm}}$ is a vector.

Although it is well known that the force of the Sun on the planet is different from on the moon,[3] and, the planet has an orbit around the Sun while the moon has not,[4] the Earth-Moon and the Pluto-Charon system just appear as binary system as the Sun is not considered; and the two systems can be approximately described with current theory of binary system.[6,7] Therefore, in current theory for binary system, the perturbation force by the Sun is omitted. And, because the perturbation force is relatively little, the current theory of binary system appears valid by the two systems. But, it is well known, in the solar system, the moon is perturbed by the Sun with $g_{perturb} = 2G\frac{M_s}{R_{sm}^3}\boldsymbol{R_{pm}}$, the orbit of the moon around the planet cannot be determined only with $g_{central} = G\frac{M_p}{R_{pm}^2}$ by the planet. It is easy to know that, as $\delta = \frac{g_{perturb}}{g_{central}}$ is a little value, the orbit of the moon around the planet is mainly determined by the planet with $g_{central} = G\frac{M_p}{R_{pm}^2}$; the variation of the orbit perturbed by $g_{perturb} = 2G\frac{M_s}{R_{sm}^3}\boldsymbol{R_{pm}}$ is difficult to be observed, especially as the orbit in very distant place. In this case, within the current theory of binary system, the orbit in the binary system is roughly accordant with the prediction of current theory. While, as $\delta = \frac{g_{perturb}}{g_{central}}$ is large, the difference between the observed and predicted orbit shall can be observed. It is well known that the variation of the orbit of the Moon around the Earth perturbed by the Sun can be precisely known although this variation is very little.[3] Therefore, the current theory of binary system is not accurate and complete because the perturbation force is omitted. It only can be a rough approximation to the system with that $\delta = \frac{g_{perturb}}{g_{central}}$ is a little value while it is invalid to the system with that $\delta = \frac{g_{perturb}}{g_{central}}$ is a large value. And, it is well known that, the Newtonian theory of orbit perturbation is such a theory that can know all of the orbits accurately and precisely, even if $\delta = \frac{g_{perturb}}{g_{central}}$ is a very little value.[3] So, factually, the reason that the observation of the orbit in wide binary systems is not accordant with theoretical prediction is that the current theory of binary system has not been right understood. But, instead to right understand a theory, some of physicists prefer to modify the Newtonian theory of gravity by following a misunderstanding way as discussed in the end of the work.

Applied the above conclusion to Chae's work,[1] we could have the conclusion that Newtonian theory of orbit perturbation is still valid to the binary star in a galaxy.

It is clear, the binary star systems studied in Chae's work[1] are orbiting around a big mass, such as the centre of the galaxy.[4] This big mass certainly has a force on the two stars. But, the force of the big mass was omitted in Chae's work[1] just as that, for the Earth-Moon system, as it is treated as a binary system, the force of the Sun on the orbit of the Moon around the Earth is omitted. But, it is well known, any orbit is always being perturbed by many factors, including both general and random ones. A real orbit cannot be described right and precisely as the perturbation theory has not been considered. Therefore, Chae's work[1] cannot describe the real orbit of the two stars system moving around the centre of the galaxy. As the Newtonian theory of orbit perturbation is considered for the real orbit of the binary system studied by Chae, we know, the orbit is always being perturbed by the centre of the galaxy with $g_{perturb}$. From Eq.(1) we know, as the distance R between the two stars is larger, the perturbation force is larger. Therefore, under the condition that R>1000AU and $g_{central}$ is only $g_N \lesssim 10^{-9}ms^{-2}$, $\delta = \frac{g_{perturb}}{g_N}$ can be relatively very large. Therefore, the orbit of the smaller star around the larger one can be no longer determined with current theory of binary star while the compact binary system with $g_N > 10^{-9}ms^{-2}$ and R<1000AU can be approximately described with this theory. From Eq. (1), it is easy to know that, for the wide binary system with $g_N \lesssim 10^{-9}ms^{-2}$, a little perturbation can make the orbit of the smaller star around the lager one varied largely. Therefore, many factors can make the orbit in the wide binary stars not accordant with the current theory of binary system. In fact, it was generally realized that the orbit in the wide binary star systems can be perturbed, especially by the galactic tidal field.[8–15] The galactic tidal field is one of the general perturbation factors that is always acting on the orbit in the wide binary system. As $\delta' = \frac{g_{tidal}}{g_{central}}$ is large, the orbit in the wide binary system also cannot be accordant with the current theory of binary system. For example, it was concluded that the external field effect could result in wide binary star orbital velocities exceeding the prediction by ~ 20%.[8] And, from Hill sphere,[16,17] we know, as one celestial object is positioned at the brink of the stable zone of orbit, the perturbative effect by a little force is very large, such as making the orbit disrupted. In fact, it was studied that the orbit in a wide binary star could be disrupted by the perturbation of the galactic tidal field and other stars. [8–15] Therefore, the observed orbital velocity in wide binary star can largely exceed the prediction by the current theory of binary star.

In the Newtonian theory of orbit perturbation, the value $\delta = \frac{g_{perturb}}{g_{central}}$ determines whether or not the current theory of binary system can be used to roughly describe a two stars system. Under the condition that $g_{perturb}$ can be taken as a constant (such as larger than one value), the value $\delta = \frac{g_{perturb}}{g_{central}}$ is only determined with $g_{central}$. In Chae's[1] work, $g_N \lesssim 10^{-9}ms^{-2}$ is a key value for $g_{central}$.

So, Chae's finding[1] could be highly accordant with Newtonian theory of orbit perturbation. And, dark matter can be excluded by Chae's finding,[1] therefore, the Newtonian theory of orbit perturbation should be the only theory to validly understand the orbit of the binary system.

In our previous work,[4] it was presented that it is the crucial problem to current theory of gravity, including the current theory of binary system, that the Newtonian theory of gravity has not been completely understood. For the convenience of the readers, we copy our previous sentence here:

Newton established the theory of orbit in 1660s. But, Newton's theory has not been completely understood till now. As soon as comparing Poincaré's equation of Three-body problem with Newtonian orbital perturbation theory, we shall know what is the problem in current understanding about Newtonian theory of gravity. The Sun-Earth-Moon system is the oldest Three-Body problem. It is clear, the orbits about it was well resolved by Newton. But, there is a famous old problems: calculating with $F = G\frac{Mm}{R^2}$*, the attractive force of the Sun on the Moon is almost 2.2 times that of the Earth, but the orbit of the Moon around the Earth cannot be broken off by the Sun. It is clear, as Poincaré's equation for Three-body problem is applied on the solar system, the orbits in it should be broken off in a short time. We think, this is the crucial evidence to show that the Poincaré's equation for Three-body problem is wrong. And, the triple star system and multiple star systems, including Six-star system, were observed. The orbit in these systems are stable and certain.*

The Poincaré's equation for Three-body problem is very strange. First, no orbit of the celestial body is chaotic. A broken orbit also is predictable. So, Poincaré's equation cannot be related with any real orbit. Second, the orbits of the typical Three-body system, such as the Sun-Earth-Moon system and Sun-Pluto-Charon system, are stable. Poincaré's equation is invalid to understand these orbits. Third, Poincaré's equation is invalid to design an artificial orbit. It is very clear, the Poincaré's equation is nonsense in understanding any real orbit. Additionally, the relationship between the Poincaré's equation and other theory is very weak. If there was not Poincaré's equation, the celestial dynamics could not be affected. But, very unfortunately, Poincaré's equation is the mainstream understanding about Newtonian theory of gravity. It results in that, the current theory of orbit about the galaxy is questioned.

Now, the orbit in a galaxy is fundamentally understood with the Newtonian theory of gravity. But, because of the misunderstanding by the Poincaré's equation, in current theory of gravity, the forces among the celestial objects are treated by analogy to the Poincaré's equation for Three-body problem.[18–22] It resulted in that many observations are not accordant with current theory. Therefore, different hypotheses, mainly including the dark matter[21,22] and modified gravity,[18–20] were presented to modify Newtonian theory. However, it is clear, before the mistakes in Poincaré's equation can be clearly known, it is nonsense to talk about modifying the Newtonian theory of gravity. So, here, it is emphasized that the current theory of gravity is misled by the Poincaré's equation. It is radically different from Newtonian theory of gravity. Therefore, it is not that the Newtonian theory is questioned by these observations; instead, it is that Poincaré's understanding about Newtonian theory of gravity is proven wrong by these observations. So, to right understand the observation in galactic scale, the theory of gravity need be reset on Newtonian original theory by excluding Poincaré's misunderstanding. Chae's finding[1] should be a directional observation to show that Newtonian theory of orbit perturbation is needed to right understand the orbit observed in a galaxy. And, in recent, the orbit in the wide binary system perturbed by galactic tidal field was understood in the way apparently analogous to the Newtonian perturbation theory.[8–13] The Newtonian theory of orbit perturbation could be advanced in the galactic system from the line studied in [4] and the observations in Chae's work.[1]

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