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On the Hafele-Keating Experiment and the Geostationary Orbit Satellite Problem Further Analysis and Discussion

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Abstract: In this paper, the Hafele-Keating experiment and the geostationary orbit satellite of related physics problems of are analyzed and discussed in detail. If researchers read the paper and think about it, It will be found that the Hafele-Keating experiment and the geostationary satellite problem prove that some of the core ideas and theories of relativity are seriously wrong. Isn't that a very serious problem in physics? Can't this cause the academic circles to pay great attention to it? Isn't this worthy of in-depth analysis and research? The core of the paper is to point out that there are problems with the space concept and the reference system theory of classical physics and relativity, And that would bring up a whole host of physics problems. It takes a concerted effort from the academic community, Do further in-depth analysis and research. Strive for the further discovery and perfection of physics theory.

Keywords: frame of reference; anisotropy; relativity; absolute airspace

1. Introduction

The author in its thesis "Discussion on Physical Space Issues" [1] and "An Analysis of the Basic Principles of Relativity and the Elaboration and Demonstration of Different Concepts of Space and Time" [2,3] put forward the concept of absolute airspace. And negate the space concept of relativity and the principle of special relativity. But that doesn't negate the space-time effect, It is only a fundamental modification of the space-time transformation effect formula of special relativity.

The physical experiments and physical phenomena that support the concept of absolute airspace are mainly the physical problems of the Hafele-Keating experiment [4,5] and the geostationary orbit satellite. However, limited by the length, the depth and breadth of the discussion on the two physics experiments and problems are not enough in the papers of author. It may be difficult for the reader to understand without further deep thought and research on his own.

At present, the academic circles have not paid enough attention to the deep physical significance of Hafele-Keating experiment and geostationary orbit satellite problem. Some scholars have done some research, but it is only at the level of general mathematical derivation and explanation, There is no deep dissection of physics principles and ideas. These two physics experiments and problems pose serious challenges to the concept of space and frame of reference in physics theory, as well as a series of related core problems in physics.

The Hafele-Keating experiment was intended to test general relativity, and under certain conditions, the experimental results agree well with the theoretical predictions. The reason why the author adds a preattribute of "under certain conditions" is that the theoretical prediction of the experiment adopts a completely different spatial reference system from the relativity theory, which is in fact a negation of the space concept of relativity and the principle of relativity. Moreover, the experimental results prove that the earth's physical space-time exists anisotropy (clocks with the same parameters, due to the different direction of movement and the different latitude of the Earth, resulting in different timing speed), However, special relativity denies the existence of anisotropy in earth's space-time, which poses a serious challenge to special relativity.

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Geostationary orbit satellite problem First proposed in 1928 by Herman Potosinick, it has been demonstrated by hundreds of geostationary orbit satellites. This problem is in good agreement with classical Newtonian mechanics. However, it also implies a reference system which is different from the classical physics concept and is ignored by most people. However, if we use the relativistic reference system of special relativity to explain it, there will be serious physical core problems and logical contradictions in the principle of mechanics. It also poses a fundamental challenge to the special relativity concept of space and the corresponding physical theory.

Therefore, the author makes a special analysis and discussion on these two physics experiments and physics problems. The intention is to attract the attention and great attention of the academic community, and carry out corresponding research and development, Create a new world for the further discovery and development of physical theory.

2. Analysis and Discussion of Hafele-Keating Experiment

2.1. Introduction to the Hafele-Keating Experiment

In 1971, in the United States, J.C. Hafele and R. E. Keating used four cesium atomic clocks to fly around the world twice on regular commercial flights, once east and once west. According to the actual path of each flight, theoretical analysis and prediction were made. Compared to the reference clock of the United States Naval Observatory, the flight clock should be 40±23 nanoseconds (ns) slower for eastbound travel and 275±21 ns faster for westbound travel. The actual results showed that the flight clock was 59 ± 10 ns slower for the eastbound flight and 273 ± 7 ns faster for the westbound flight. This experiment will be referred to as the Hafele-Keating experiment.

Two papers [4,5] published by the Hafele-Keating experiment showed that the experiment was not in an ideal physical environment, There are many physical factors affecting commercial flight, and the paper does not provide detailed experimental raw data. Nevertheless, the experiment has theoretical basis, theoretical analysis and prediction, and the theoretical prediction is in good agreement with the experimental results. The reliability of the experimental results is relatively high, and it has very practical physical significance.

2.2. Problems Caused by Experimental Results

As a direct result of the Hafele-Keating experiment, clocks traveling east were 59 ± 10 ns (nanoseconds) slower than the reference clock, and clocks traveling west were 273 ± 7 ns faster than the reference clock. The author believes that both east-bound and west-bound flights (clocks) have uncertain factors such as relative speed and altitude differences, but these differences will cancel each other and cause some errors. From the average point of view, it can be roughly considered that the relative speed and altitude parameters of the east-west course are basically the same. This brings two questions, First is why the same parameters of the clock, due to the opposite direction of flight, its timing speed will be significantly different; Second, in the same flight of about 50 hours or so, why the clock time in different directions will differ by 332±17ns. Moreover, this time difference is based on theory and cannot be explained by the difference in clock parameters of east-west travel, so there must be physical principle reasons. These two problems are ultimately the anisotropy of the earth's space-time, that is, what is the reason for the existence of anisotropy in the earth's space-time?

2.3. Theoretical Basis of the Experiment

The nature of Hafele-Keating experiment is the time effect problem, and its theoretical basis cannot be separated from general relativity and special relativity.

2.3.1. Theoretical Basis of General Relativity

According to general relativity, the mass of the Earth causes a difference in the curvature of space-time, which causes the speed of time to vary. The greater the curvature of space-time, the

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slower time will move. On the contrary, time will go faster; That is, clocks with a higher curvature of space-time at a location run slower than clocks with a lower curvature of space-time at a location.

To paraphrase the concept of classical physics, the greater the gravitational force (or gravitational acceleration), the slower time will go; On the other hand, the less gravity, the faster time will go. That is, clocks with a high gravitational pull move more slowly than clocks with a low gravitational pull.

To put it in plain English, a clock at a lower altitude runs slower than a clock at a higher altitude.

Next, according to the equivalence principle of general relativity, acceleration will have a corresponding gravitational effect, that is, it will change the curvature of spacetime, and it will also have a time effect. The motion of the clock around the earth produces centripetal acceleration; In a certain velocity range, the greater the linear velocity of circular motion, the greater the centripetal acceleration will be. So, the faster a clock moves in a circle, the slower time will be; That is, a clock with a higher linear speed moves more slowly than a clock with a lower linear speed in the same circle. However, the magnitude of the centripetal acceleration generated by circular motion is only related to the magnitude of the velocity, and has nothing to do with the direction of the velocity (meaning that circular motion has two directions to choose). That is, it is not spatiotemporal anisotropy.

To sum up, there are two theoretical principles that induce the time effect of general relativity, one is the change of static gravity (such as the change of altitude, resulting in different gravity); One is the change in the corresponding gravitational effect (or equivalent gravitational force) due to the difference in acceleration. For the problem of centripetal acceleration due to circular motion, neither of these two factors will produce anisotropy of spacetime.

2.3.2. Theoretical Basis of Special Relativity

According to special relativity, clocks in an inertial frame of reference (a frame that is moving in constant linear relative motion) have a time-slowing effect compared to clocks in a frame that is relatively stationary. That is, clocks that are moving at a constant speed relative to a straight line run slower than clocks that are relatively stationary. Similarly, special relativity requires that as long as the relative motion of a uniform straight line should produce a corresponding space-time effect, independent of the choice of the direction of the velocity; That is, there is no anisotropy of space-time.

In a strict sense, the theoretical basis for special relativity does not fit well with the Haffeler-Keating experiment. Some scholars believe that the earth is large enough that from a macro point of view, the clock moves in a uniform circle around the earth; However, from the local microscopic analysis, the clock can be regarded as a uniform linear motion. Therefore, special relativity can be used as a theoretical basis for the motion of the clock.

Combining general relativity and special relativity, there are three main physical factors that affect the time effect of Hafele-Keating experiment: gravity, velocity and acceleration. But none of these three factors are responsible for the anisotropy of Earth's space-time.

2.4. Theoretical Derivation and Predictive Analysis

Hafele-keating's paper gives theoretical formulas and theoretical predictions; In his book General Relativity and Gauge Theory of Gravitation, Professor Duan Yishi, a famous theoretical physicist in China, derived the problem of clocks moving around the Earth from the perspective of general relativity, and made an idealized hypothesis prediction calculation [6]. In his book Experimental Basis of Special Relativity, Zhang Yuanzhong, a researcher at the Institute of Theoretical Physics of the Chinese Academy of Sciences, also made theoretical derivation and analysis of the round-the-world atomic clock experiment from the perspectives of special relativity and general relativity [7]. This paper mainly analyzes the theoretical derivation of [6] and [7].

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2.4.1. Theoretical Derivation and Analysis of [7]

The author divides the time effect of Hafele-Keating experiment into kinematic effect and gravitational effect. The kinematic effect is deduced from the special relativity theory. Gravitational effects are deduced from the perspective of general relativity. All theoretical derivations use of Hafele's assumptions: "The Earth is assumed to be rotating at an isometric velocity Ω in a non-rotating reference frame Σ."

The formula of kinematic effect derived from special relativity is:

$$d\tau \approx [1-(v^2+2\Omega Rv)/2c^2]d\tau_0 \qquad (01)$$

Note: Formula (01) is come from [07]p165, formula (9.1.16), and it is a highly approximate relation assuming that the atomic clock moves in the equatorial plane of the Earth with the omission of higher-order terms.

Where: dτ is the proper time interval of an atomic clock traveling eastward around the earth with speed v; $d\tau_0$ is the proper time interval of an atomic clock resting on the Earth's equator. Don't know why, the authors at this time did not take into account the proper time interval of the atomic clock flying west. Ω is the angular speed of the Earth's rotation, R is the radius of the Earth's equator, and c is the speed of light.

The time effect formula derived from general relativity and special relativity is as follows:

$$d\tau \approx [1+gh/c^2-(v^2+2\Omega Rv)/2c^2]d\tau_0 \qquad (02)$$

Note: Formula (02) is come from [07]p166, formula (9.1.16), and it is a highly approximate relation assuming that the atomic clock moves in the equatorial plane of the Earth with the omission of higher-order terms.

Where: g is the acceleration of gravity, $g=GM/R^2$; G is the universal gravitational constant, M is the mass of the Earth, and R is the (equatorial) radius of the Earth; Other parameters are the same as formula (01). However, the clock v traveling east takes a positive value, while the clock v traveling west takes a negative value (the author's original statement is more vague, but in essence this is the case).

Formula (02) can be divided into two parts; The first part is the gravitational effect, which is gh/c^2 in formula (02). The second part is the kinematic effect, namely $-(v^2+2\Omega Rv)/2c^2$ in formula (02).

The author did not make a theoretical prediction calculation, but directly cited the [5] of the theoretical prediction value. According to its theoretical predicted value, due to gravitational effects, the eastbound clock will be 144±14ns faster than the reference clock, the westbound clock will be 179±18ns faster than the reference clock, and the east-west heading clock will be 35ns different. Since [5] is based on the actual parameters of the east-west voyage, the theoretical calculation and prediction are made. According to the relationship between gravitational effects gh/c^2, It shows that the actual parameters of the east-west distance are different, that is, there is a practical difference between the two parameters gh, which leads to the difference of the east-west heading clock.

Due to kinematic effects, a clock heading east will be 184±23ns slower than the reference clock, a clock heading west will be 96±10ns faster than the reference clock, and the east-west heading clock will differ by 280ns. According to the relationship of kinematic effects $-(v^2+2\Omega Rv)/2c^2$, There are two main reasons for the east-west heading clock difference, one is due to the positive value of the clock v sailing east, and the negative value of the clock v sailing west, resulting in the east-west heading clock difference, which should be the main reason. Second, the actual physical parameters of the east-west voyage are not the same, leading to the difference in the east-west heading clock, which should be a secondary reason.

Researcher Zhang Yuanzhong, despite the detailed derivation of the theoretical relationship between Hafele-Keating experiments and some superficial analysis, wrote a very puzzling paragraph: "When two clocks are traveling in the same circular orbit at an equal speed in opposite directions,

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even though there is a relative motion between the two clocks, their readings are still the same when the two clocks rejoin."

This literally means that, in an ideal state, there should be no timing difference when the two clocks flying in opposite directions meet after a week of flying. That is to say, he is well aware that in this matter, relativity has no anisotropy of space and time. If this is the meaning, it is obviously inconsistent with the theoretical relation derived from it; It is also inconsistent with the actual results of the experiment. So there are two possibilities, either the Hafele-Keating experiment doesn't actually hold up, the experiment is bogus; Or there's something wrong with relativity. Why, then, did he use the Hafele-Keating experiment as an important experimental basis for verifying the time dilation effect of special relativity?

2.4.2. Theoretical Derivation and Analysis of [6]

The author uses the Schwarzschild metric to derive the time effect relationship of the Hafele-Keating experiment and gets the following results:

$$\delta=(T_2-T_1)/T_1=gh/c^2-v(v+2R\omega)/2c^2 \qquad (03)$$

Note: Formula (3) is come from [06]p69, formula (3.298) and (3.299), and it is a highly approximate relation assuming that the atomic clock moves in the equatorial plane of the Earth with the omission of higher-order terms.

Where: T_1 is the proper time interval of the reference clock on the ground that is relatively stationary; T_2 is the proper time interval of an atomic clock orbiting the Earth at speed v; ω is the angular speed of the earth's rotation; R is the radius of the Earth's equator; c is the speed of light; g is the gravitational acceleration, $g=GM/R^2$; G is the universal gravitational constant, M is the mass of the Earth; Similarly, a clock v traveling east takes a positive value, while a clock v traveling west takes a negative value.

Formula (03) looks slightly different from formula (02) on the surface, but with a little adjustment, you will find that the two relations are exactly the same. The authors state that the flight path of the Hafele-Keating experiment is not exactly the same as the conditions used in the derivation of formula (03), but the principle of calculation is exactly the same.

If h=104m and v=300m/s, then:

$$\delta_{west}=2.1\times10^{-12}$$

$$\delta_{east}=-1.0\times10^{-12}$$

Under the above ideal conditions, the theoretical reasons for the difference in time of east-west flight clocks are analyzed according to the kinematic and gravitational effects.

$$\delta_{west.gravitation}=gh/c^2$$

$$\delta_{east.gravitation}=gh/c^2$$

In the case of the same g and h parameters, $\delta_{west.gravitation}=\delta_{east.gravitation}$, that is, gravitational effects are not the theoretical cause of the time difference in the east-west flight clocks.

$$\Delta_{west.kinematics}=v(-v+2R\omega)/2c^2=(-v^2+2R\omega v)/2c^2$$

$$\Delta_{east.kinematics}=-v(v+2R\omega)/2c^2=(-v^2-2R\omega v)/2c^2$$

$$\Delta_{west.kinematics}-\delta_{east.kinematics}$$

$$=2R\omega v/c^2=2\times6378200\times7.292\times10^{-5}\times300/299792458^2=3.10\times10^{-12}$$

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$$\delta_{west}-\delta_{east}=\delta_{west.kinematics}-\delta_{east.kinematics}$$

From the analysis of kinematic effect, even if the parameters of east-west flight clock are completely consistent, the time difference of east-west flight clock will be generated. The core reason is that the clock v traveling east is positive, while the clock v traveling west is negative.

2.5. Comprehensive Analysis

The tripartite theoretical derivation and analysis and prediction cited in this paper have two common characteristics. The first is the fact that they adopt one of Hafele's assumptions: that the Earth is assumed to rotate at an isometric velocity Ω in a non-rotating reference frame Σ. The second is to take a positive clock speed for eastward sailing, and a negative clock speed for westward sailing.

Why is the clock speed positive for eastbound travel and negative for westbound travel? It is well understood according to the concept of classical physics, because the background reference frame is a coordinate system that is absolutely stationary relative to the rotation of the Earth, and all physical parameters and physical meanings must be determined according to this reference frame. The speed at which the east and west travel is a relative speed, assuming that it is relative to the surface of the earth. The Earth is rotating (spinning) with respect to this absolutely stationary coordinate system. Therefore, the relative speed at which the clock travels between east and west must be converted to absolute speed (absolute speed with respect to this reference frame) in accordance with this reference frame.

Eastbound clocks align with the Earth's rotation, To determine its absolute speed by reference frame, it is added to the rotation speed of the Earth. Similarly, the clock speed traveling west is in the opposite direction of the Earth's rotation, so it must be subtracted from the Earth's rotation speed. By converting the velocity to the absolute velocity of this reference frame, both the theory of special relativity and the theory of general relativity can be correctly performed in this experiment. The question of the existence of space-time anisotropy on the Earth has also been answered.

But the real core problem is not solved; That is, in this experiment, there can only be one frame of reference that is absolutely stationary relative to the Earth's rotation, and all the physical parameters must be determined according to this frame of reference. If we leave this absolutely stationary frame of reference, relativistic frame of reference and relative velocity of relativity lose their physical value. In other words, some of the core ideas and theories of relativity have lost their physical significance. If this experiment is correct, it proves that some of the central ideas and theories of relativity are seriously wrong.

3. Analysis and discussion of the problem of geostationary orbit satellites

Geostationary orbit satellites are always in the same position on the Earth's surface. Its orbital eccentricity and inclination are zero. The period of motion is 23 hours, 56 minutes and 04 seconds, which is consistent with the rotation period of the Earth, and the orbit radius is 42164.169km (35786km above the ground). Since the suborbital trajectory of a satellite moving in geostationary orbit is a single point, Therefore, an observer on the surface can always observe the satellite in the same place in the sky at any time and will find the satellite stationary in the sky. If there is a reference frame that is absolutely stationary relative to the rotation of the Earth, taking the Earth's center of mass as the origin, then the speed of the geostationary orbit satellite is 3.07km/s.

3.1. Newtonian Mechanical Analysis of Geostationary Orbit Satellite Problem

Geostationary orbit satellites (hereinafter referred to as satellites) are analyzed mechanically, The Earth's gravity is exactly equal to the centrifugal force generated by the satellite's own circular motion, At the same time, the angular speed of its own circular motion is exactly the same as the angular speed of the earth's rotation.

$$F_g=GMm/R_s^2$$

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$$F_c=ma$$

$$a=v_s^2/R_s=(\omega R_s)^2/R_s=R_s\omega^2$$

$$F_g=F_c$$

$$GMm/R_s^2=mR_s\omega^2$$

$$R_s=(GM)^{1/3}/\omega^{2/3} \qquad (04)$$

Where: F_g is the gravitational force on the satellite; G is the universal gravitation constant; M is the mass of the Earth; m is the mass of the satellite; R_s is the orbit radius of the satellite; The centrifugal force generated by the circular motion of the satellite by F_c; a is the centripetal acceleration caused by circular motion of the satellite; ω is the angular speed of the satellite in a circular motion, equal to the angular speed of the earth's rotation.

$$GM=3.986004418\times10^{14}(m^3/s^2)[8]$$

$$\omega=7.292115\times10^{-5}\ rad/s$$

Note: Data are from [8]p68, Table 2.1.
Then:

$$R_s=(3.986004418\times10^{14})^{1/3}/(7.292115\times10^{-5})^{2/3}$$
$$=42164172.93115m$$

This calculation result is about 4m more than the data found on the Internet, and the error is very small.

It shows that the mechanical analysis of geostationary orbit satellite is completely calculated according to Newtonian mechanics. Note that in the above derivation and calculation, the implied reference system is a reference system with the Earth's center of mass as the coordinate origin and is absolutely stationary relative to the Earth's rotation. It also proves that the reference frame with the Earth's center of mass as the origin and absolute rest relative to the earth's rotation is objective and correct. This frame of reference is exactly the same as that assumed by the theoretical analysis predictions of the Hafele-Keating experiment.

3.2. Special Relativistic Analysis of Geostationary Orbit Satellite Problem

Relativity does not completely reject Newtonian mechanics, but argues that it is not accurate enough to work at low speeds in general (compared to the speed of light), and that Newtonian mechanics does not work when describing physical events moving at high speeds, and the errors are large. The fundamental difference between special relativity and Newtonian mechanics is mainly embodied in the concept of space-time and the frame of reference. According to Newtonian mechanics, spacetime is universally absolute, and there is also an absolutely stationary frame of reference. According to special relativity, there is no absolute space-time and no absolute stationary frame of reference. Space-time is universally relative, and the frame of reference is universally relative. In an inertial reference system of uniform linear motion, all physical laws are equivalent (the principle of narrow relativity).

Therefore, a coordinate reference system is established with the ground projection point of the geostationary orbit satellite as the coordinate origin. In this frame of reference, the relative velocity of the satellites is zero. It is clear that Newton's second law completely breaks down if we use these coordinates to describe the physical state of a geostationary satellite; Satellites don't have centrifugal force, but gravity does exist; As a result, satellites will soon fall to the ground; Of course, this is patently absurd.

However, if the motion mechanics of satellites are described in terms of the reference frame which is absolutely stationary relative to the rotation of the Earth, the time effect of special relativity will face a great dilemma. On the one hand, because the relative velocity of the satellite to the ground reference point is zero, there will be no time delay effect of special relativity. On the other hand, the speed of the satellite (relative to the rest coordinate system) is more than six times the speed of the ground at the rest coordinate point, which should produce a time delay effect. The same physical event, on the one hand, should has not time delay effect, on the other hand, should has time delay effect. Special relativity apparently contradicts itself in this physical event. Therefore, one of these two contradictory questions must be wrong. If no time delay effect is correct, a reference frame that is absolutely stationary relative to the Earth's rotation is problematic. And if times delay effect is true, then special relativity is problematic. The absolute stationary reference frame relative to the Earth's rotation has been confirmed by hundreds of geostationary orbit satellites and is clearly objectively real. It is therefore most likely that some of the central ideas and theories of special relativity have serious problems.

4. Brief Introduction and Summary of Reference System

In the analysis of Hafele-Keating experiment and geostationary orbit satellite problem, a core problem is the reference frame. They all use the same frame of reference, which has the following key points:

First, the origin of the coordinates of the reference system should be at the center of mass (or center of gravity) of the Earth;

The second is that the frame of reference is absolutely stationary relative to the Earth;

Third, because the Earth is moving with respect to other stars, the frame of reference will move with the Earth with respect to other stars;

Fourth, because the reference system moves with the Earth relative to other stars, it should be local; Therefore, it should also have a boundary;

The fifth is that this frame of reference exists objectively, and is by far the most accurate description of the moving physical events in this frame of reference.

Fifth, this frame of reference is objective and is the spatial background for the most accurate description to date of the physical events moving in this frame of reference.

Sixth, by extension, other Earth-like bodies (stars) should also have such a frame of reference.

The problem of reference system comes from the concept of space, so a new concept of space can be obtained from the above points of reference system: Around each star (celestial body) there is a local absolute space, the author calls it: absolute airspace; And in each absolute airspace, there is a corresponding local absolute stationary reference frame.

Space is neither universally absolute nor universally relative; The frame of reference is neither universally static nor universally relative; The absolute and the relative coexist. Therefore, the concept of space and the theory of reference systems in classical physics are wrong, and the concept of space and the theory of reference systems in relativity may also be wrong. The errors of space concept and reference system theory will bring about a series of physical problems. The academic circles need to work together for further in-depth research, development and improvement.

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