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Research Article

A STUDY AND DISCUSSION OF THE 1983 METER DEFINITION

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Abstract

In 1889, the first International Metrology Conference (CGPM-1) provided the earliest definition of meter based on the international meter original instrument. In 1960, Krypton-86 wavelengths were used to define the meter. In 1983, the CGPM-17 adopted a new definition of the basic unit of length (meter): "The meter is the length of the travel of light in vacuum in $(299792458)^{-1}$ seconds". This is to take the speed of light in vacuum as an accepted convention, that is c=299792458m/s. Since the value c is specified, length units can be derived from time (frequency) units. The improvement of the definition is a reflection and result of the continuous improvement of measurement accuracy, and it is understandable that the metrology community has a sense of accomplishment.

It has been 38 years since 1983, and the problems of the current definition of meter have gradually emerged. First, experimental studies in the first decade of this century actually falsified the invariable principle of the speed of light, seriously undermining the theoretical basis of the current definition of the meter. Secondly, there are many doubts about the constantcy and stability of the speed of light in vacuum. For example, the definition of "in vacuum" does not specify what the vacuum is, and in 1983 it could only have been an engineering vacuum. Now we know that when we think about the concept of vacuum in quantum physics, c is a fluctuating value, not a constant. It is also confirmed that the Casimir effect plays an important role in the quantum vacuum, which leads to the superluminal phenomenon. If the effect of vacuum polarization is added, it can be concluded that the speed of light in vacuum cannot keep its constant value and stability. Furthermore, it is simply impossible that the speed of light in a vacuum, once specified, will never change. In addition, the unit of length (meter) and the unit of time (second) are both basic units. They are independent and have no influence on each other. However, according to the current definition of meter, it contains the saying of "how many seconds", which makes the definition of meter lose its independence. This cannot be allowed.

This paper also holds that it should not be absolutized and idealized to set up the basic units from the basic physical constants, for there has long been a saying of "inconstant constants" in the physical circle. The improvement of the metre definition could be linked to the proposed "improvement of the second definition". In recent decades, optical frequency measurement technology has developed rapidly. Atomic clocks have developed from hydrogen clocks, cesium clocks and fem to second optical combs to strontium lattice clocks. The uncertainty can reach 10^{-16}(or even lower), and the problem of redefining "second" has been put on the agenda. The second definition can be modified, as can the meter definition.

Keywords: Meter definition, The speed of light in vacuum, Basic physical constants, Invariable principle of the speed of light, The physical vacuum.

INTRODUCTION

In 1960, the 10th International Conference on Metrology (CGPM-10) decided to name the Metric Convention established in 1875 the International System of Units (SI).It has seven basic units, they are: length unit "meter" (m), time unit "second" (s), current unit "ampere" (A), temperature unit "Kelvin" (K), mass unit "kilogram" (kg), material quantity unit "mole" (mol), luminous intensity unit "candela" (cd). These basic units and many derived units make up the entire system of units of measurement.[1]The earliest definition of the meter was approved by the French Academy of Sciences in 1799: $1/4\times10^7$ of the earth's meridian is called a meter, which was defined in 1875.Later, it was found that it could not meet the needs of industrial development for measurement accuracy, so in 1889, the International Congress of Metrology adopted the distance between the two lines of the platinum-iridium alloy meter ruler as the definition value of 1m.A platinum-iridium meter No.6 is called the "International Meter Original". Each country participating in the Metric Convention has an identical platinum-dependent alloy meter, which is regularly compared with the international meter original instrument.

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The relative accuracy of the international original meter prototype is 10^{-7} [2]. After world War II, the German Federal Bureau of Physical Technology (PTB) successfully developed the Krypton-86 low-pressure gas discharge lamp. The vacuum wavelength of the orange line radiated from the Krypton-86 isotope is a fixed value. So in 1960, the International Metrological Conference adopted a new definition of the meter: "the meter is 1650763.73 times the length of the vacuum wavelength of the $2p_2$-$5d_5$ transition radiation of the Krypton-86 atom"...... The above historical situation shows that the definition of the basic unit is not static and will change constantly with the progress of science and technology and the needs of industrial development.

In 1983, the international metrology community took a new step by adopting fundamental physical constants as the basis for establishing a new definition of the meter.[3] The reason for this situation, is due to the invention of laser in 1960, the rapid development of laser technology, including the measurement of optical frequency technology to achieve a very high precision. In 1972, the National Bureau of Standards (NBS) scientist K. Evenson [4] published the research work of his team -- to achieve the frequency measurement of methane (CH_4) laser with highly complex technology, and obtain accurate frequency value f_{CH_4}, which has never been done before. Since the wavelength of the laser had been measured with considerable accuracy, it was possible to multiply this by the wavelength of the methane (λ_{CH_4}) to get the speed of light in vacuum. On this occasion, the international metrology circle tried to formulate a new definition of the meter "based on the basic physical constants" (in fact, based on the speed of light in vacuum), which we called "the 1983 definition of the meter" or "the current definition of the meter". Of course, there was a transition period from 1972 to 1983, and the current definition of the meter was not immediately decided.

There are two outstanding problems with the definition of the meter using Kr-86 spectral line (wavelength λ =605.7nm) as the basic unit. First of all, there is a contour asymmetry in the spectral line, resulting in a wavelength difference of 1×10^{-8} between the center and the maximum light intensity. Secondly, the new laser frequency stabilization technology makes the frequency stability and reproducibility better than 1×10^{-9}, which is more than 100 times higher than that of Kr-86 orange line[2].Thus, the sheer technical appeal of metrology prompted the international metrology community to abandon the 1960 metre definition and switch to the 1983 metre definition. We stress that this is not a rational decision based on basic scientific principles. Problems with the current meter definition have been exposed since 1983, which is why we are writing this article.

The establishment of the definition of meter in 1983 and its spiritual essence

Physics has long known that light has wave-particle duality, which has the characteristics of particle (the photon), but light wave is also a kind of electromagnetic wave; in fact, there is a broad electromagnetic spectrum. Therefore, any idea of that light is simple is wrong. If the experiment is carried out in an engineering vacuum without air, the following formula holds:

$$c = f\lambda \quad (1)$$

Where, f 、 λ are respectively the frequency and wavelength of light wave, and c is the speed of light wave (the speed of light in vacuum). This thinking is entirely based on the understanding that light is a wave, and has nothing to do with the particle nature of light.In fact, no one has ever directly measured the speed of photons.

Now consider the work of Evenson's team in 1972 and how things have evolved in the years since. 1972 to 1975, Evenson built a complex optical frequency measurement system using a laser frequency chain starting from the cesium atom frequency standard, including six different lasers and five microwave klystrons, the results were obtained

$$f_{CH_4} = 88.376181627\times10^{12}\ \text{Hz} \quad (2)$$

The measurement accuracy is 6×10^{-10}; The known wavelength value of methane is about 3.39μm, which can be calculated using the best value at that time, then we obtained:

$$c = \lambda_{CH_4}\ f_{CH_4} = (299792456.2\pm1.1)\ \text{m/s} \quad (3)$$

That is, the accuracy is 3.6×10^{-9}. For that alone, the accuracy of measuring the speed of light in vacuum has improved by a factor of 100. This created a great attraction for the International Bureau of Metrology. So what is the measurement of λ_{CH_4} ? From 1972 to 1973, the following precise measurements were obtained by the international famous metrological institutions [2]:

American Bureau of Standards (NBS): 3.392 231376(12) μm
International Bureau of Measurement (IBS): 3.392 231 376(8) μm

National Research Council of Canada (CNRC): 3.392 231 40(2) μm

The first two are defined in terms of barycentric points, and the last is defined in terms of intermediate points. The International Advisory Committee on Definition of Meters (CCDM) decided in June 1973 to use the following data as standard values (recommended values) for methane spectral line wavelengths

$$\lambda_{CH_4} = 3.392\ 231\ 40\ \mu\text{m} \quad (4)$$

The uncertainty is 4×10^{-9}. Therefore, the standard value was determined by CCDM in 1973:

$$c = (299792458\pm1.2)\ \text{m/s} \quad (5)$$

The uncertainty is 4×10^{-9}. Later (1972~1974), several new measurements appeared, but they were all within the uncertainty range of the above standard values. This value was thus endorsed by the International Astronomical Union (August 1973) and the International Metrology Conference (1975). In 1983, the CGPM-17 made the following statement on the unit of length: "The travel length of light in vacuum in the period of $(299792458)^{-1}$s is called 1 meter". Obviously, this is defined by taking the result of formula (5) as the most accurate value of the speed of light in vacuum.

However, the meter definition adopted and promulgated by CGPM-17 in 1983 must be understood as a universal physical constant without error, i.e.

$$c = 299792458\ \text{m/s} \quad (5a)$$

In this statement, ±1.2m/s is removed, which means that the uncertainty of the value c is zero. Such coercion is questionable; Moreover, since 1983, for nearly 20 years, the situation in the international metrology community is that it is very difficult to indirectly realize the definition of meter according to the formula $c = \lambda f$ [5]. In order to achieve the definition of meter with certainty, the wavelength value of the specified frequency stabilized laser is required as the standard spectral line. At that time, director of International Bureau of Metrology, Dr. T. Quinn, personally issued a "Notice on the realization of the definition of meters" (Metrologia, Vol.36, No.2, 211) in 1999, indicating that there are finally 12 kinds of lasers available. This situation shows that the implementation of the 1983 meter definition is not smooth. Dr. Quinn later elaborated on the indirect realization of the metre definition several times.[6,7]

Let's consider the essence of the 1983 definition. Write formula (1) as follows:

$$\lambda = \frac{c}{f} \tag{1a}$$

If c immobilized, units of length can be derived from frequency (that is, time). Then, the measurement technology can depend not on (not pursue) reducing the uncertainty of the wavelength, but on the high level of light frequency measurement. Therefore, the International Bureau of Metrology is actively promoting the 1983 meter definition, not out of scientific considerations, but for the convenience and need of measurement technology. After the definition of meter was published in 1983, many metrologists in the world said, "The measurement of the speed of light that has lasted for 300 years can come to the end." They also said that "this was a perfect full stop".[8] The author thinks that such view and practice are wrong. Science has no limits and endless development. No one can "ban research" or "ban testing" on a certain academic topic or direction. This is decided by the essence of natural science. When it comes to the speed of light in vacuum, measurements that have been going on for more than 300 years should not stop. This is not only because of the never-ending nature of scientific development, but also because of the existing problems in the definition of meter......We would even go so far as to say that the 1983 "ban" has done science a disservice. The author's view is clear: the measurement and research of the speed of light should not stop after more than 300 years.

This paper emphasizes that the seven basic units of metrology should be independent of each other and should not cross influence each other. This is a fundamental principle of modern metrology. The current definition of the meter violates this principle by using the unit of "seconds". This means that the meter definition depends on the second definition. Some people think it's good, but we can't laugh at that. Each of the base units should exist independently of other units. Many metrologists have sadly overlooked this. Another problem with the current meter definition is the confusion of the relationship between the basic unit and derived unit. According to formula $\lambda = c/f$, since frequency (corresponding time) is the basic unit, wavelength can only be derived unit. Thus, this definition effectively makes length lose its status as the fundamental unit and become the derived unit; This is very inappropriate. A closer look at the 1983 meter definition reveals more problems. If it is a light wave (light is, firstly an electromagnetic wave), then the definition should specify that it is a plane wave. But the ideal plane wave is not technically available, so what to do? In other words, the speed of light should be the ideal velocity of a plane wave; If not, there will be effects such as curvature effect; and so on. In addition, there are some theoretical and experimental problems in the current definition of meter, which will be discussed one by one.

The speed of light cannot be constant in a real physical vacuum

"A vacuum is empty space without matter", this is an old saying in classical physics. In fact, we can never be sure if a space is really empty, even if the air is pumped out of it first to achieve the so-called "ultra-high vacuum". That's because there are plenty of photons that are constantly being created and then annihilated, albeit briefly, but virtual photons can do just as much physical action as ordinary photons. Evidence has long been available, such as Spanish scientists who found in 2011 that rotating bodies (graphite particles with a diameter of 100nm) slow down in an engineered vacuum, indicating that the vacuum also has friction. In fact, there are plenty of photons in space that are constantly being created and annihilated before we can measure them directly. Although they appear only briefly, these "virtual photons" can exert electromagnetic effects on objects just like ordinary photons. Scientists at the Institute of Optics of Spain's National Research Council say this electromagnetic action can slow down the rotation of objects. Just as two cars collide head-on with more force than rear-end, a "virtual photon" colliding with a rotating object in the opposite direction produces more force than it does in the same direction. The degree of deceleration also depends on temperature, because the higher temperature, the more "virtual photons" are created and annihilated, creating more friction. At room temperature, it takes about 10 years for a 100nm diameter graphite particle, which is abundant in interstellar dust, to spin down to about a third of its initial speed; At 700℃(the average temperature in the hot region of the universe), the process takes just 90 days.

The findings reported in 《New Scientist》, suggest that a vacuum does not guarantee constant values for precise measurements. Now, there are three situations when we are faced with a physical vacuum:

1. The effect of quantum vacuum oscillations is that the speed of light in a vacuum may not be a constant, but rather fluctuate, albeit slightly, around an average value.
2. Quantum vacuum polarization also has a similar effect and is periodic.
3. Casimir effect not only shows the correctness of quantum vacuum view, but also brings the diversity of vacuum and the possibility of faster-than-light speed(superluminality).

First look at the effects of quantum vacuum oscillations, which are related to the physical effects of virtual particles. Quantum field theory (QFT) considers that all quantum fields in the vacuum state are still moving, that is, all modes are still oscillating in the ground state, which is called vacuum zero-point oscillation. Virtual particles appear, disappear and transform into each other constantly in vacuum because of the interaction between quantum fields. the Website of Science Daily reported that French scientists and German scientists respectively put forward their research results, the content is that the speed of light is a real characteristic constant, and the quantum theory holds that the vacuum is not empty, but a flickering particle. This causes the speed of light not to be fixed, but to have fluctuating values. So today physicists are starting to get it right thinking.

However, when the interaction between particles and vacuum is considered, the physical phenomenon of vacuum polarization appears.For example, positively charged particles attract virtual electrons in vacuum and repel virtual positrons in vacuum. That changes the way the virtual cloud's charge is distributed. This situation is similar to the phenomenon of dielectric polarization in classical physics. There are four physical interactions in nature; electromagnetic interaction and weak interaction belong to the same mechanism and are described by the same equation, so it is called weak-electric unified theory. But in the vacuum polarization effect of electromagnetic action (also known as the electron field Dirac vacuum polarization effect), photons polarize the vacuum, creating pairs of electrons (electron e^-, positron e^+) that create charges and currents, which then return to photons. In the weak action vacuum polarization effect (also known as the neutrino field Dirac vacuum polarization effect), Z^0 bosons polarize the vacuum, producing neutrino pairs, resulting in weak charges and weak flows, and then returning to Z^0 bosons. Feynman diagram can be drawn in both cases. The difference is that the former has no static mass and the latter has static mass. This comparative study can deepen the understanding of vacuum polarization. American physicist J. Franson published a paper in June 2014, which attracted wide attention in the physics circle. The paper claimed that it had been proved that the speed of light was slower than the value thought in the past. His argument is based on observations of supernova SN1987A in 1987, when photons and neutrinos were detected on Earth from the explosion. photons arrived 4.7 hours later than neutrinos, a phenomenon that had previously been only vaguely explained. Franson thinks this may be caused by the vacuum polarization of the photon—it splits into a positron and an electron and recombines into a photon in a very short time. Under the gravitational potential, the particle energy changes slightly during the recombination, making the speed slow.As the particles travel 168,000 light-years (SN1987A to Earth), this constant merging and splitting will cause the photons to arrive late.

Another factor is the Casimir effect on the speed of light. If two parallel metal plates are put in a vacuum, the inner and outer states of the plates are not the same. The vacuum degree between the two plates is higher and deeper, so it has the force to make the two plates close to each other.[24] This Casimir effect has been experimentally demonstrated, so the above statement of "two vacuums" is correct.[25] This makes it logical that the speed of light inside and outside the plate may be different. Thus, it is the change in boundary conditions that affects the vacuum and thus the propagation speed of electromagnetic waves. In other words, the propagation of light depends on the structure of the vacuum, which is the basic idea of quantum physics. Due to the Casimir effect, we can distinguish between the following two: (1) normal vacuum (also known as free vacuum); (2) The vacuum between the plates with plates is characterized by a reduced vacuum energy density, so the author believes that it can also be called negative energy vacuum.

Now, considering vacuum as a unique medium, its refractive index and wave velocity can be calculated:

Phase velocity

$$v_p = \frac{c}{n} \tag{6}$$

Group velocity

$$v_g = \frac{c}{n_g} \tag{7}$$

Where, n is the phase refractive index, referred to as the refractive index; n_g Is the group refractive index. The relation between phase refractive index and group refractive index is

$$n_g = n + f\frac{dn}{df} \tag{8}$$

For non-dispersive media, dn/df =0, so $v_g = v_p$, group velocity is consistent with phase velocity.

In 1990, K. Scharnhorst [9] published the paper "Light propagation in vacuum between bimetallic plates". The Casimir effect structure is analysed. Two metal plates close together; This imposes certain boundary conditions on the photon vacuum fluctuation. Scharnhorst calculated by quantum electrodynamics (QED) method, and obtained that the refractive index perpendicular to the direction of the plate surface is:

$$n_p = 1 - \frac{11}{2^6 \times 45^2}\frac{e^4}{(md)^4} \tag{9}$$

Note that the interplate is in vacuum state, and the above formula represents n_p<1; In formula (9), d is the distance between two ideal conductive plates, and m is the mass; m Is defined as the speed of light in normal vacuum or free vacuum, then the c is

$$c = \left\{1 + \frac{11}{2^6 \times 45^2}\frac{e^4}{(md)^4}\right\}c_0 \tag{10}$$

Where, c is the speed of light in the vertical direction of the plate surface under the condition of interplate vacuum, and the difference is of c and c_0 due to the change in the vacuum structure, which is caused by the placement of double plates. The result is $c > c_0$, here c_0 = 299792458m/s, c is faster than the speed of light. Further calculation gives:

$$\frac{\Delta c}{c} = \frac{c - c_0}{c} = 1.6\times10^{-60}\mathrm{d}^{-4} \tag{11}$$

if d=1μm, $\Delta c / c$ =1.6×10^{-36}, it is very small; but even this it is not consistent with special relativity (SR). d can be reduced again, for the 1nm gap (d=1nm), the increment Δc =$10^{-24} c$; This data is also very small, but theoretically important. In short, Scharnhorst did not calculate "the speed of a photon traveling between two metal plates," but the speed of a wave traveling vertically between two plates, and found that the phase velocity was slightly higher than the speed of light ($v_p > c$). When the frequency is not high, the dispersion can be ignored and the group velocity is equal to the phase velocity, so the group velocity is slightly higher than the speed of light ($v_g > c$). To sum up, "vacuum" changes the speed of light through a variety of physical processes. Therefore, how to understand and define the "vacuum" of "the speed of light in vacuum" becomes a problem.

On the theoretical basis of the current definition of metre

The International Bureau of Metrology did not say that the 1983 definition of the meter was based on the theory of special relativity (SR), but we can conclude that this is the case because SR has a principle of invariance of light speed.[10,11] This paper points out two important points: first, the principle of constant speed of light has its own shortcomings, that is, it is not satisfactory in logic self-consistency; Secondly, as a postulate of SR, "the principle of invariance of light speed" lacks real experimental proof. In recent years, however, some experimental results may falsify the invariance of light speed. This undermines the theoretical basis of the 1983 definition of metre. SR is based on two postulates and a transformation. The first postulate states that "the laws of physics are the same in all inertial systems", that is, in all inertial systems, not only the laws of mechanics are equally true, but also the laws of electromagnetic and optics. The second postulate states that "light in vacuum always has a certain speed, independent of the motion of the observer or the light source, and independent of the colour of the light". This is what Einstein called the L principle. In order to eliminate the apparent contradiction of the above two postulates (relativity of motion and absoluteness of optical propagation), SR holds that "principle L is true for all inertial systems". In other words, the coordinate transformation between different inertial frames must be Lorentz transformation (LT). On the second postulate, Einstein said in 1905 that "light in empty space always travels at a certain speed, independent of the motion of the emitter"[4]. The 1921 statement reads: "At least for a certain inertial system K, the hypothesis that light travels at speed in vacuum is also confirmed. According to the principle of special relativity, we must also assume that this principle is true for any other inertial system". In 1949, it was stated that "light always travels at a constant speed in vacuum, independent of the colour of light and the motion of the light source".[6]

Another core concept associated with the second postulate is the relativity of simultaneity. If clock at point A can define the time t_A of an event at A, and clock at point B can define the time t_B of an event at B. But how does the compare of t_A and t_B? A definition of simultaneity is needed. For this reason, Einstein proposed the assumption that the speed of light is constant.If an optical pulse is being sent at t_A, the time indicated by the clock at B is

$$t_B = t_A + \frac{L}{c_{AB}} \quad (12)$$

Where L is the distance between two points, and c_{AB} is the one-way speed of light from A to B. But c_{AB} is unobservable, because it depends on the prior synchronization of clocks A and B (one-way speed of light is related to the definition of simultaneity). Einstein now defines simultaneity in terms of $c_{AB} = c_{BA} = c$, as opposed to the principle of constant speed of light in the loop (experiments so far have only shown constant speed of light in the loop, not in one direction). If the principle of invariance of the speed of light is correct, time and simultaneity are not absolute, and length measurements lose their absoluteness (they give different results in different inertial systems). It must be pointed out that the invariable absoluteness of the speed of light is incompatible with the principle of relativity in a narrow sense, which emphasizes the relativity of motion. There is an irreconcilable contradiction between the two basic assumptions of SR, which was demonstrated by E. Silvertooth in the 1970s.Einstein himself had doubts about this and tried to prove that there was only an apparent contradiction, but it did not solve the compatibility. Einstein actually put the cart before the horse and looped logic when he proved compatibility by using two inferences derived from postulates: relativity and length contraction. Einstein asserts that there is no absolute motion to adhere to the principle of relativity, and introduces light, which has no rest system and therefore is absolute motion, to construct a second postulate. The two postulates are extremely incompatible.

More people think that the current statement of the principle of the invariable speed of light is a hypothesis, so far the lack of real experimental proof. Even relativistic scholars acknowledge this, for example as Prof. Y. Zhang[12] pointed out, saying that "the invariable speed of light has been experimentally proved" is not true. Einstein's principle of invariance of light speed refers to the one-way speed of light, that is, the speed at which light travels in any direction. But many experiments measure not the isotropy of one-way light but the invariance of loop light speed. In addition, the 1994 reprint of [12] emphasizes the unpredictability of one-way speed of light because "we have no prior definition of simultaneity, and the definition of speed of light depends on the definition of simultaneity." Zhang believed that Newton's absolute simultaneity could not be realized in reality. Einstein proposed the assumption that the speed of light is constant, that is, the optical signal against the clock; ... It is a hypothesis because it is not an empirical result, because the isotropy of the unidirectional speed of light has not (and cannot) be proved experimentally. To measure the speed of light in one direction, one has to check two clocks in different places, and to do this one has to know the exact value of the speed of light in one direction. This is a logical cycle, so attempts to test the speed of light in one direction are futile. (Many experiments listed in reference [12] are to prove the principle of constant speed of light in the loop).

In terms of experiments, literature [12] lists 12 experiments on "invariance of light speed" (from 1881 to 1972) and 16 experiments on "independence of light speed and motion of light source" (from 1813 to 1966). But the former only shows the loop speed of light invariable principle, the latter only applies to $v \ll c$ case. Some people believe that SR theory has been firmly established over the centuries and can't be wrong. This is not true. In fact, there have been people in the scientific community for many years who have put forward ideas that are different from the invariable principle of the speed of light. In 1936, A. Proca [13] proposed the modification of Maxwell equations considering the rest mass of photon ($m_0 \neq 0$). However, in the theoretical system of Proca equations, the invariable principle of light speed is no longer correct, and the speed of light will be related to the frequency of electromagnetic waves.

Chinese scientists falsify the principle of invariable speed of light with experiments

It must be emphasized that in recent years, Chinese scientists have made the unique contribution of using well-designed experiments to obtain reliable data after long-term study, thus falsifying the principle of the invariable speed of light.We are only going to talk about two things here; First, Prof. R. Wang used modern technology to reproduce the Sagnac type experiment, using moving fiber, hollow fiber, zigzag moving fiber and segmentation fiber, at different speeds. It is proved that the speed has an effect on the propagation of light in the fiber moving back and forth, and that the propagation time of light is different."Our results falsify the principle of the light-speed constancy", Wang said in 2005.[14] Now we will focus on the large distantance deterministic experiment of Chinese scientists on the assumption that the speed of light is constant. Now we review the theory first; since the principle of invariance of the speed of light comes from the static ether, and the Michelson-Morley experiment denied the ether, should the principle of invariance of light speed still exist? Einstein's approach not only preserved the hypothesis that the speed of light does not change, but enhanced it. He said: "the first step is to reject the ether hypothesis: then the second step is to make the principle of relativity accommodate the fundamental lemma of Lorentz's theory, because to reject this lemma is to reject the basis of the theory. The following is the lemma: 'The speed of light in vacuum is constant, and light is independent of the motion of the luminous body. 'We raise this lemma to principle. For simplicity we'll call it the principle of invariance of the speed of light. In Lorentz's theory, this principle is only true for a system in a special state of motion: that is, the system must be static relative to the ether. If we want to preserve the principle of relativity, we must allow the invariable principle of the speed of light to hold for any system of non-acceleration motion".

Einstein added, "As a rule of thumb, we also put the following values

$$\frac{2\overline{AB}}{t'_A - t_A} = c \qquad (13)$$

as a universal constant, the speed of light in empty space. It is essential to define time by means of a stationary clock in the stationary system. We call the time now suitable for the stationary system definition 'stationary time'."

Obviously, there are some hypotheses that need to be tested experimentally. Einstein's 1905 paper had no such experimental proof, so Einstein called his approach a hypothesis "aided by some physical experience." For a hundred years people have mostly accepted it immediately, without considering whether there is a problem with it. To summarize, Einstein stated in 1905: place an identical clock in two places (A, B) in space, and the event at A corresponds the time t_A, event at B corresponds the time t_B. But there is still no definition of public time. It is now stipulated that the time required for the optical signal A→B is ($t_B - t_A$), which is equal to the time required for the optical signal to reflect back to point A, i.e.($t'_A - t_B$); then

$$t_B - t_A = (t'_A - t_B) \qquad (14)$$

so these two clocks are in synchronization. ...... Einstein's above "regulation" is in fact a description of his second postulate (the invariable principle of the speed of light), since Eq. (14) is actually equal to

$$\frac{L}{c_{AB}} = \frac{L}{c_{BA}} \qquad (15)$$

namely, $c_{AB} = c_{BA}$; But this hypothesis required experimental proof, and Einstein could not come up with one. In 2004, Prof. J.Lin[15] pointed out that modern technology is capable of measuring t_A、t_B、t'_A, using space technology. The problem can be looked at another way, Einstein's equation is actually:

$$t_B = \frac{1}{2}(t'_A + t_A) \qquad (16)$$

This is the time definition of the arithmetic mean, based on the assumption that the speed of light does not change. If formula ($t_B - t_A = t'_A - t_B$) is correct, that light takes the same oneway time of "forward" and "back" the same way, then, "the speed of light is independent of the direction in which it travels". Thus, the "principle of invariance of the speed of light" (or "principle of constancy of the speed of light") becomes an essential theoretical assumption. But that, of course, is a thing of necessary experimental proof. In short, the principle of invariance of the speed of light, one of the two cornerstones of SR, was simply Einstein's way of preserving the mathematical form of the original physical equations based on the static ether; That is, the time of light signal passing through "forward" and "back" is defined to be equal, and the concepts of "stationary system" and "stationary clock" are introduced. So how did a team of Chinese scientists design a large-distance experiment using satellite technology to falsify the principle that the speed of light does not change? First, the research team, led by J. Lin, he is a distinguished scientist at the Chinese Academy of Launch Vehicle Technology, and he is Member of the International Academy of Astronautics. Prof. Lin is a famous expert in satellite navigation technology. His original and novel ideas and methods of redefining space and time based on rocket measurements have received attention and praise in the scientific community.[15] The team also includes experts from the National Time Research Center of the Chinese Academy of Sciences. The team did not specialize in physics and did not deliberately "find faults with relativity". They decided to do the research after discovering problems with SR theory during their long spaceflight practice. The relevant work received financial support from the state, and finally the achievement appraisal meeting was held under the auspices of China Aerospace Science and Technology Corporation, which was approved. A paper on the results was published in January 2009.[16] The title of the paper is "The Crucial Experiment for Checking Einstein's Postulate of the Constancy of light Speed".

It is a unique work for Lin's team to carry out experiments on large distances with the help of satellites by using high-tech aerospace technology. As we know, the world entered the space age in 1957. Time technology (atomic clocks and time signals travel over long distances) and satellite communications (navigation messages) make one-way optical (electromagnetic) signals a reality. Experimental conditions were then available to test whether Einstein's 1905 paper's hypothetical defining equation $t_B - t_A = t'_A - t_B$ was true or not. In 2008, Prof. Lin completed a decisive experiment on Einstein's 1905 definition of simultaneity on the TWSTT (Two-way Satellite Time Transmission) facility of National Timing Research Center, Chinese Academy of Sciences. (Former Shanxi Observatory). Experimental observations show that Einstein's postulated equations are not valid in the presence of relative motion! The principle of experimental verification is based on the principle of special relativity and the definition of one-way optical (electromagnetic) signal simultaneity. By comparing the measurement mechanism of the simultaneity definition of one-way optical signal with that of Einstein's two-path optical signal, it is proved that, under the condition of relative motion between A and B, the signal transmission time of the two-path optical signal is necessarily not equal when it is decomposed into two one-way optical signals "forward" and "back". In the experiment conducted by Prof. Lin, the cesium atomic clocks of Xi'an Lintong Ground Observation Station and Urumqi Ground Observation Station carried out bidirectional time transmission through Sinosat and Zhongwei I satellite respectively. The observation data proved that although the relative speed between the satellite and the ground station was only 1m/s, the distance of signal transmission through the synchronous satellite reached 72,000 km, resulting in the time difference between the "forward" and "back" one-way signals between Xi'an Lintong station and Urumqi station, with a difference of 1.5ns. The observational results confirm the conclusion of Lin's theoretical analysis, and the uncertainty in the experiment is ±0.01ns. The results of this decisive experiment, carried out by the Space System and impossible to carry out in a ground-based laboratory, have shaken one of the cornerstones of SR. Therefore, Lin believes that the traditional time and space theory should be reconsidered from the perspective of satellite system and inertial navigation measurement principle. From the perspective of one-way light (electromagnetic wave) signal characteristic of satellite navigation, the Galilei transform should be restored to its position. On the face of it, all it takes a ground station (for point A) and a satellite (for point B). We can to do the experiment. But they don't work that way; The development of modern atomic clock technology and aerospace technology makes it possible to synchronize time using one-way optical signals. The TWSTT concept synchronizes the time of two atomic clocks at a distance by sending electromagnetic signals (pulses of seconds from different clocks at the same time) to each other at the same time. Now, Lin and his colleagues are using two atomic clocks that A_I 、 A_k, in principle, should send light signals to each other at the same time. In fact, the observation stations which are far away from the earth and rotate with the earth in the geocentric inertial system cannot realize the direct line of sight observation and communication. Therefore, the time synchronization observation model of the two direction one-way optical signal of the clock and clock is realized by the transmission of the geosynchronous fixed-point communication satellite S_n. FIG. 1 is a schematic diagram of the decision experiment arrangement.

In practical experiments, there are many factors to consider, such as the influence of the motion of ground stations and satellites in the geocentric inertial system on the observation equation, and other complex problems. There's even a Sagnac effect to consider. Lin's team finally obtained the observation equation of two-way satellite time transfer. In principle, one-way signal observation consists of clock difference, Sagnac effect and signal transfer time. The clock difference and Sagnac effect are corrected for the actual one-way observations before the two basic elements of Einstein's one-way optical signal simultaneity definition can be obtained: the optical signal's arrival reading on the time clock and the time required for the signal to travel this distance.

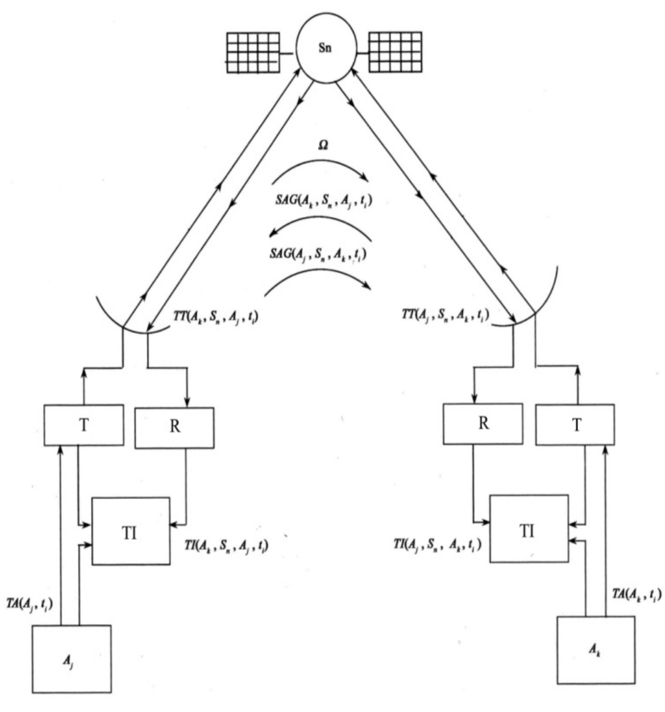

Fig. 1 Block diagram of the experiment by Prof. Lin
(S_n—satellite, R—receiver, T—transmitter,
TI—time interval computer, A—atomic clock)

However, in the two-way satellite time transmission, both parties have mastered the observation values of the two direction one-way signals sent by both parties through communication means. The two direction one-way signal observation sum clock difference and Sagnac effect cancel automatically due to the asymmetry in principle, so the relationship between the one-way signal transmission time and the reading on the clock of both parties is finally obtained. Finally, the conclusion of Lin is:"The crucial experiment for checking Einstein's postulate of the constancy of the speed of light was performed at the high precision TWSTT (Two Way Satellite Time Transfer) facility of the National Time Service Center, Chinese Academy of Sciences. The principle of the crucial experiment was based on the principle of special relativity and the definition of simultaneity by means of one way light signal. By comparison the measurement mechanisms of one way light signal simultaneity and 'to-and-fro' two way light signal simultaneity, the principle of the crucial experiment has proved: if there exists relative motion, the 'uplink' and 'downlink' light signal passage times of the 'to-and-fro' two way light signal are not equal. The cesium atomic clocks at Xian station and Urumuqi station transferred and exchanged pps time signals via Sino satellite and China Sat-1 satellite. The observation uncertainty is the order of 0.01 ns. The observed data have proved the equality $t_B - t_A = t'_A - t_B$, which was introduced by definition in Einsteins 1905 paper, is not valid in case if there exists relative motion between A and B".

But, is the time difference measured by Lin due to the different "forward" and "back" distances of optical signals caused by satellite drift? Prof. Q.Ma is an expert on SR theory, and his two monographs (Chinese book published in Shanghai and English book published in New York).[17,18] The author suggested that he study this problem, and after reading the relevant materials, he wrote an article "On the Significance of Lin Jin's Experiment" (to be published), in which he said:

"In the dual-path signal transmission experiment conducted by Lin's team with satellites published in 2009, it was found that the one-way signals 'forward' and 'back' did not take the same time to pass through. We analyze the significance of Lin's experiment. Many past experimental measurements have shown that the speed of light varies in rotating systems, and that the speed of light varies from east to west on the Earth's surface, known as the Sagnac effect. After excluding Sagnac effect, Lin's experiment measured the time difference between 'forward' and 'back' one-way optical signals caused by the drift speed of 1m/s satellite. Some people think that the time difference is caused by the difference in the transmission distance of the forward and back light signals caused by the satellite drift. However, the change of relative velocity is the change of actual distance caused by the movement of relative objects, so the time difference measured by Lin experiment is caused by the difference of relative velocity of forward and back light signals. Based on the estimation of the theoretical value of the Lin's experiment based on the different relative velocities of the forward and back light signals caused by the satellite drift, we accurately obtain the measured value of this experiment (1.6ns). Therefore, it is concluded that the Lin's experiment clearly does not support Einstein's assumption of constant speed of light." Therefore, after detailed analysis, Prof. Ma concluded that the time difference measured by Lin's team was not caused by the satellite's drifting motion. He said that the experiment proved that electromagnetic signals transfer satellites drift under the condition of one-way variable speed of light.The time difference calculated by Ma is 1.6ns, which is very consistent with the 1.5ns measured by Lin. He also suggested better experiments in space.

Our conclusion is that Chinese scientists, standing at the starting point of a new era, have deepened and interpreted the problem. The title of the paper of Lin et al. indicated that he wanted to do a deterministic experimental test of Einstein's hypothesis that the speed of light is constant. They did successful experiments on a very large distance (72000km) to test whether the one-way speed of light is isotropic, and came to a negative conclusion, answering the long-standing question. Therefore, the author believes that the Lin's experiment may have shaken the foundation of SR. The author also believes that this is a bold experiment, and very important; The space powers, such as the United States and Russia, have not done. At the same time, it also proves the thesis of this paper that the current definition of meter needs to be improved. Einstein rejected the invariable principle of the speed of light as early as 1911 on the grounds that gravitational potential slows the speed of light down. Einstein is often incongruous and confusing; the speed of light is just one example.

On "Inconstant Physical Constants"

Physical constants arise because new theories and laws are constantly emerging in physics. Some constants are very famous and are associated with the names of great physicists. For example, the universal gravitational constant (G) reminds us of I. Newton, who discovered the universal gravitational force. The mention of electron charge (e) reminds us of J. Thomson, who discovered electrons; Mention of the Planck constant (h) reminds us of M. Planck, the inventor of quantum theory; and so on. The metrology circle has always attached great importance to the basic physical constants, and in recent years it has been advocated to establish datum based on the basic physical constants. On November 16, 2018, the member states of the International Bureau of Metrology (more than 60 countrys) voted to adopt a resolution to revise the International System of units (SI); According to the resolution, four basic units of SI will be defined instead by fundamental physical constants:

Kilogram (kg) -- Planck constant h
Amperes (A) -- electron charge e
Kelvin (K) -- Boltzman constant k
Mol -- Avogadro number N_A

As for the other three basic units, the meter (m) was first defined in 1983 in terms of the speed of light in vacuum (c). There are also two units, the second (s) and the candela (cd), which are not yet defined in terms of fundamental physical constants.

This is the most significant change in metrology since 1960. The International Bureau of Metrology hopes to bring a new atmosphere to metrology, and also hopes that the SI system will be stable in the future....However, in recent years, there have been some new discussions about the fundamental physical constants in the international physics circle, among which two things are very interesting. First of all, why are known fundamental physical constant is that value? In other words, can all measurable dimensions that characterize the physical world be extrapolated as one parameter in principle? In fact, no one yet knows why these constants are these value. Although scientists have been able to determine these constants with great precision in the laboratory using highly sophisticated techniques, their origins remain unknown. One theory is that these values determine the conditions under which galaxies, stars and other cosmic formations can exist, and create the conditions for life to emerge and develop. But this is a bit like the anthropic principle, which sees everything as being in service of human birth and existence. But neither earth nor men is not in the center of universe, and their existence or absence is of little consequence to the cosmic universe. We can imagine god creating the world. Right before the big bang, God (the nature) is sitting at the console wondering:"What should I set for the speed of light?" "How much charge should I put on the electrons?" "How do I value the parameter h that determines the quantum size?" It is not clear whether "God" created everything in the universe after careful consideration or by grabbing at random numbers.

In addition, research suggests that the term "constant" may not be the right word, as they may vary over time and space.Since 1930, researchers have speculated that some constants are not constant. Two terms are now popular internationally: Inconstant constants, and Not so-constancy constant. These are based on related studies. In 2001, the international research team led by J.Webb[19] used the world's largest astronomical telescope set in Hawaii to observe and study some of the most distant quasars in the deep space of the universe, and found that the microscopic structure constant hundreds of millions of years ago was smaller than the current value, thus judging that the speed of light in the early stage of the evolution of the universe was larger than the current value. The fine structure constant (FSC) is defined as

$$\alpha = 2\pi \frac{e^2}{hc} \qquad (17)$$

The standard value given by international metrology circle is α^{-1}=137.03599761. Physicist J. Barrow was a member of the

Webb's team and participated in the study for two years, he says:"we look at the spacing of absorption lines for different chemical elements, which depends on any small change in the red shift as absorption occurs. Since the light leaves these stars (5~11)Ga earlier, it is possible to determine whether there α has been a change in the past 11Ga by comparing the observed line interval with the current laboratory line interval. In two years, 147 quasars were observed and the results were quite unexpected—the early values were about $\left|\Delta\alpha/\alpha\right|=7\times10^{-6}$ smaller than they are now". His words indicate that if averaged over a year, it is equivalent to $\left|\Delta\alpha/\alpha\right|=5\times10^{-16}a^{-1}$(the observation interval is 3Ga to 11Ga ago). That may not seem like much, but being a physical constant doesn't allow for such annual variations. So some in the international scientific community say this is one of the amazing discoveries of experimental physics in the last 50 years. New Scientist reported on 3 July 2004,[20] a reanalysis of data from the Oklo reactor in West Africa a month ago showed that it had grown 4.5×10^{-8} in the past 2Ga, so it was slightly smaller in the past than it is now, this conclusion is consistent with that of Webb's group. There are three elements that constitute the fine structure constant, namely h, e and c. So who is responsible for the change? For simplicity, consider only one possible case, where one of e, h, or c fails to hold constant. Even so, there are different views. In August 2002, physicist P.Davies[21] described the results of his team's study of Webb's paper in 《Nature》. To determine which physical constants are likely to change, Davies' team applied analytical techniques such as the second law of thermodynamics. It turns out that the speed of light c was not constant and slowed down over billions of years. If so, he thought relativity and the $E=mc^2$ formula might have to be abandoned! Webb's observations show that the atomic structure that emits quasar light is slightly different from that seen by humans, but the difference is significant....Recently, there are many other literatures on variable speed of light, such as [22] and [23].

It should be noted that we are not saying that these fundamental physical constants are not to be trusted; Nor is the leadership of the International Bureau of Metrology, which is at the helm of global metrology, all wrong. In this paper, the speed of light in vacuum is taken as an example to show that there are many factors affecting the constancy and stability of the constant, and they are not negligible. Fundamental physical constants cannot be oversimplified or idealized, because there is no absolute constant in practice. Whether the isotropy of the value is guaranted is also a big problem, reflected in the time difference has been ns class.

Conclusion

Length measurement is the basic measurement which is closely related to human life and its importance is beyond doubt. In ancient China, due to the need of measuring land, building houses, and building bridges, there were not only length measuring tools (rulers), but also length measuring standard. The latter takes its law tube resonant frequency (equivalent to wavelength) as the ruler reference.[24] The ancient Egyptians built great structures -- pyramids and temples -- that could not be carried out without geometrical measurements of length and angles. In modern times, early weights and measures have MKS system, CGS system, the first letter of the former stands for meters (m), the first letter of the latter stands for centimeters (cm); This is all proof that the length measure is the head....Modern industrial production and science and technology advance rapidly, Planck length in micro aspect, light year (ly) in macro aspect, both reflect the importance of length measurement.

In 1960, the meter was defined in terms of atomic radiative transitions; and in 1983, the fundamental physical constant (the speed of light in vacuum) was used to define the meter. These are all valuable efforts and have yielded considerable achievements. But science is constantly evolving, and definitions are not permanent. What new, advanced and rational definitions are likely to emerge? This article does not provide a credible solution. We only discuss the problems existing in the current definition of meter, hoping to attract the attention of the physical and metrological circles and find new solutions in extensive and in-depth exploration. Future methods must be logically consistent, experimentally feasible and reproducible. To this end, the primary task is to develop basic science.

If we dig into the basic theory of physics, we find a strange phenomenon. For example, the invariable principle of the speed of light, which Einstein solemnly proposed in 1905 when he proposed SR, was refuted by Einstein himself from 1907 to 1911.For example, in Einstein's 1911 paper[25], the core idea was that the gravitational potential slows down the speed of light. This view was carried on even 103 years later (in 1914) by the physicist J.Franson.[23]Franson was a proponent of general relativity (GR), so where did he leave SR? Such a situation, so that we have to suspect that the principle of the invariance of the speed of light is fundamentally wrong, with it as the theoretical basis of the current definition of the meter has collapsed!

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