Uncovering the principle behind all methods for measuring time to recognise what dilates is not time but timer

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Abstract

Today, the scientific community comprehensively accepts the viewpoint of time dilation. Here, we argue that any method for measuring time relies on an equivalence between time and some phenomena for reference as a timer, e.g. swing of pendulum, fall of sands in sand clock or electron jumping between two states in atomic clock. We propose what really dilates is not time but timer because the equivalence in time measure only holds true within a limited phenomena range and the clock in either variant gravity or speed exceeds its application range, just like the equivalence in inertia mass that cannot apply to those phenomena that exceeds the application range of 'macro, low-speed, inertia-system'.

Keywords: time measure; application range; atomic clock; electron transition.

Contents

1 Introduction

Since special relativity, time dilation has become a common viewpoint. Although time seems to be directly measured(our eyes directly see the reading on the timer), there is a more general premise that needs to be satisfied: the equivalence between time and timer needs to hold true during the process of our direct observation. However, such an equivalence has some underlying artificial assumption because choosing what phenomenon as the timer is determined by observers rather than nature. Thus, we need to figure out the principle behind how we build such an equivalence in measuring time.

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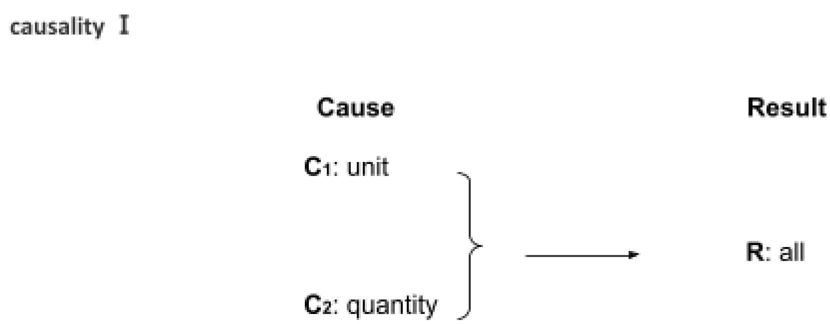
2 The general principle behind the equivalence of phenomena measure

First of all, we cannot directly perceive any abstract equivalence from reality but various phenomena, which are generated via the interaction between observers' sensors[2] and reality. Any phenomena, either perceived or non-perceived, can be taken as an intersection of several finite properties simultaneously fixed at a certain degree. In short, denote $A_i, i = 1, 2... k$ are all finite properties. For any phenomenon denoted as P, there are some fixed degrees of A_i, denoted as a_i, then

$$P \approx \bigcap_i \{A_i = a_i\} \tag{1}$$

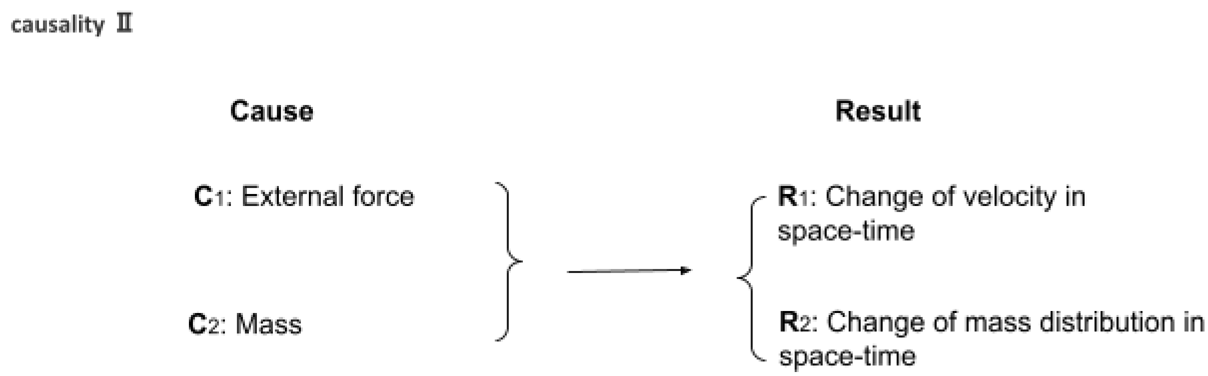
Further, we can also perceive one phenomenon occurring after another. If this occurrence always happens without exception, it constitutes a causal relation. For example, based on 'any big things is constituted by smaller things', a causality about quantity can be abstracted as below. To differentiate with other causal relations, we denote it as causality Ⅰ and A→B represents that B is the result of A.



Similarly, when we push something in daily life, some change can be observed in either the object's speed or its motion direction, which can be unifiedly described as 'change of velocity in space-time'. However, this is an unrigorous causality because it does not describe all the possible situations. If we increase the strength of the force to a certain degree, the object may be either deformed but still as an integrity or shattered into pieces, which can be unifiedly described as 'the change of mass distribution in space-time'. Thus, two causes of 'force', 'mass' and two results of 'change of velocity in space-time' and 'change of mass distribution in space time' constitute a rigorous causality that completely reflects

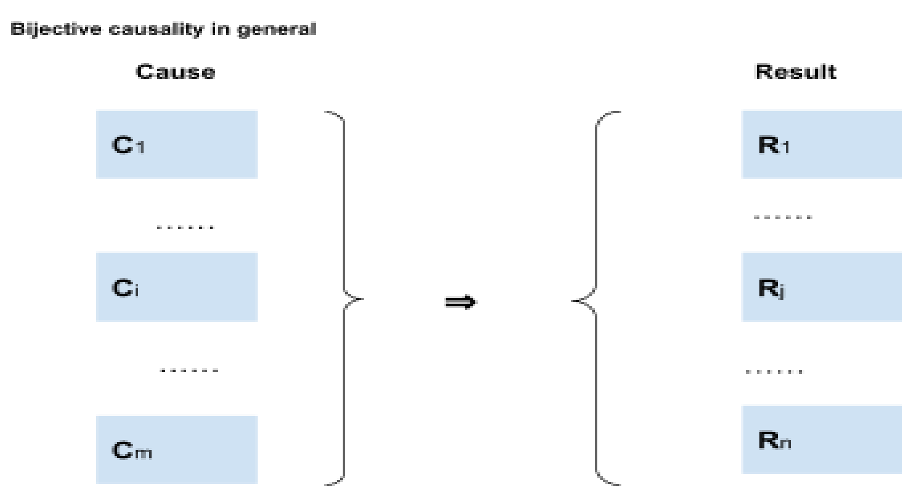
[2] Sensors here refers to not only the natural sensor, e.g. eyes, ear, but also the technique aids or tools that extend the perception scope of observers, e.g. telescope, microscope, etc.

all relevant situations that could possibly occur in reality, denoted as causality Ⅱ.



No matter for causality Ⅰ or Ⅱ, It is noted that there is a sufficient and necessary relationship between all causes and all results. For example, in causality Ⅱ, R_1, R_2 covers all the possible results for C_1, C_2 while C_1, C_2 constitutes all the possible causes for R_1, R_2. If viewing a property as a set and any degree of the property as an element of the set, a bijective mapping can be regarded to exist from C_1, C_2 to R_1, R_2. To be specific, any given degree of C_1, C_2 would result in a unique degree of R_1, R_2 while for any degree of R_1, R_2, we can always find a certain degree of C_1, C_2 as the corresponding cause. For convenience, we call such a causality as 'bijective causality'. For differentiation, we use '⇒' to represent a bijective causality. Especially, a causality and a bijective causality involving m causes and n results can be simply denoted as m→n and m⇒n.

Now Let us consider how a mathematical equivalence between different physical properties derives from such a bijective causality. For a general bijective causality $C_1, C_2 \ldots C_m \Rightarrow R_1, R_2 \ldots R_n$, lowercase c_i, r_j are denoted as the degree of the cause C_i and result R_j.



In this m⇒n bijective causality, suppose the property C_{i_0} is the measure target property that we want to measure. Given the causality is bijective, any degree of C_{i_0} could be uniquely determined as long as all other m+n-1 properties in the causality are fixed at a certain degree. In other words, any degree c_{i_0} of the measure target property C_{i_0} is uniquely determined by the array $(..., c_i, ..., r_j, ...), i \neq i_0, i = 1, 2, ... m, j = 1, 2, ... n$. But, considering c_{i_0} does not determine an unique array $(..., c_i, ..., r_j, ...)$, we cannot assume a rigorous equivalence between them, which means

$$c_{i_0} \neq \{(..., c_i, ..., r_j, ...), i \neq i_0, i = 1, 2, ... m, j = 1, 2, ... n\}$$

However, if we introduce some mathematical operator(s) to calculate m+n-1 components of $(..., c_i, ..., r_j, ...)$ to a single mathematical result according to the positive or negative relation between c_{i_0} and each component, then c_{i_0} would determine a unique mathematical result. Hence, we can assume a rigorous equivalence below

$$c_{i_0} = \{\otimes\ (..., c_i, ..., r_j, ...), i \neq i_0, i = 1, 2, ... m, j = 1, 2, ... n\} \quad (2)$$

In above, $\otimes\ (x_1, x_2, ... x_s)$ is denoted as the single mathematical result after implementing the mathematical operator(s) $\otimes$ on the array's components $x_1, x_2, ... x_s$.

Due to the arbitrary of c_{i_0}, by going through all degrees of C_{i_0}, we have

$$C_{i_0} = \{\otimes\ (..., C_i, ..., R_j, ...), i \neq i_0, i = 1, 2, ... m, j = 1, 2, ... n \quad (3)$$

Obviously, (3) is the consequence of viewing all m+n-1 causes and results other than C_{i_0} as variables. Here, if, at the start, we select part but not all m+n-1 properties, denoted as $...C_k ... R_s ...$, and make some constant assumption by fixing each of them to any constant degree $c_k, ... r_s$, then by repeating the above process, we have

$$C_{i_0} = \{\otimes\ (... c_k, ... C_p, ..., R_q, ... r_s ...)\} \quad (4)$$

For (4), by splitting the variable properties and constant properties, we have

$$C_{i_0} = \{\otimes\ (... C_p, ..., R_q, ...) \cup (... c_k, .. r_s ...)\} \quad (5)$$

For a specific array of constant degrees $c_k, ... r_s$, according to (1), suppose we can find some phenomenon that satisfies:

$$P \approx \bigcap_{k,s} \{C_k = c_k, ..., R_s = r_s, ...\} \quad (6)$$

and each variable property $C_p, ..., R_q$ of this phenomena P have been previously measured, by putting (6) into (5), then

$$C_{i_0} = \{\otimes\ (...\ C_p, ..., R_q, ...) of\ P\ \} \quad (7)$$

In above, $P \approx \bigcap_{k,s} \{C_k = c_k, ..., R_s = r_s, ...\}$

In fact, '$\otimes\ (...\ C_p, ..., R_q, ...) of\ P$ ' can serve as the reference for measuring C_{i_0}. Firstly, for the phenomenon P , $C_p, ..., R_q$ can be viewed to be previously measured, which means we can reach a consensus on the degree for each of them. Also, the definition of any mathematical operator is comprehensively accepted and agreed by us, so the mathematical result of several previously-measured properties $\otimes\ (...\ C_p, ..., R_q, ...)$ can also make different observers reach a consensus. Besides, any specific phenomena P does not generate any disagreement among different observers because it is impossible for all normal observers to perceive different results on a phenomenon. Therefore, $\otimes\ (...\ C_p, ..., R_q, ...) of\ P$ as a whole reaches a consensus for different observers and hence can serve as the reference for measuring C_{i_0}.

In history, all physical properties can be viewed to be indirectly measured under the frame of (7). Especially, if we view an indirect measure method as a physical law or a physical equation, C_{i_0} and $C_p, ..., R_q$ are equation's variables and $\bigcap_{k,s} \{C_k = c_k, ..., R_s = r_s, ...\}$ appears to be some physical constant.

3 The particular principle behind the equivalence of time measure

Here, by applying bijective causality Ⅰ to time, we obtain a specific case of causality Ⅰ, denoted as Ⅰ(a)

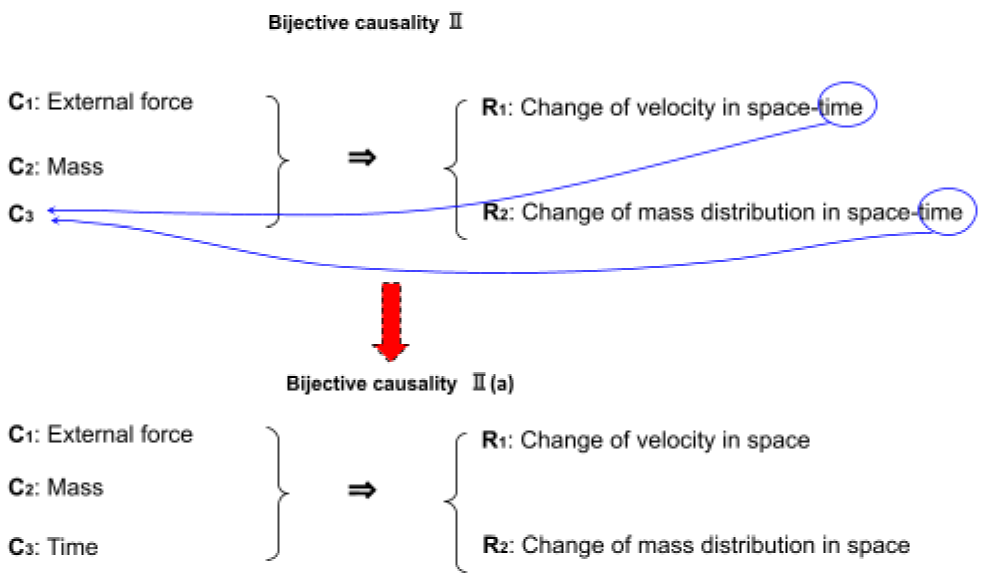
Unit time[C_1],Quantity[C_2]⇒ Time[R].

According to (7), time can be measured through the below equivalence derived from Ⅰ(a) :

$$\text{Time[R]}=\otimes(\text{Unit time}[C_1],\text{Quantity}[C_2]) \quad (8)$$

Given quantity can be directly measured by our eyes, there is no need to design some indirect method to measure it. Hence, as long as we could measure the unit time, time can be measured by (8). In the following, we will concentrate on how to measure the unit time.

In bijective causality Ⅱ, by separating 'space-time' into space and time and viewing time as a third cause, we could obtain an equivalent form of causality Ⅱ, denoted as causality Ⅱ(a).



According to (7), in order to design a measuring reference that is equivalent to C_3 of time, we need to select some properties from C_1, C_2, R_1, R_2 in bijective causality Ⅱ(a) as the variable properties and the remaining ones as the constant properties to constitute the constant assumption. According to how many properties that can be selected as variable properties, there are totally $C_4^1 + C_4^2 + C_4^3 + C_4^4 = 15$ possible permutation and combinations of equivalences. Among these equivalences, only one equivalence is adopted by us to indirectly measure time in history, which is

$$\text{Time}[C_3] = \otimes R_2 \text{ of } P \tag{9}$$

In above, $P \approx \{$ constant $C_1 \cap$ constant $C_2 \cap$ constant $R_1\}$, all $C_i, R_j \in$ causality Ⅱ(a)

More generally, the equivalence in (9) means that as long as some phenomenon satisfies the constant assumption: $\{$ constant $C_1 \cap$ constant $C_2 \cap$ constant $R_1\}$, we can simply equal time with the change of this phenomenon's mass distribution in space-time. Further, all such qualified phenomena can be divided into three types according to different kinds of external force that mainly dominates C_1.

- External force $[C_1]$ is dominated by gravity. Obviously, the motion of any celestial body is mainly under gravity. For example, the moon can be viewed as the phenomena that approximately satisfies a constant degree of C_1,C_2 and R_1 in (9). So we can assume an equivalence between time and the mass distribution of the moon along its orbit surrounding earth, which can be approximately treated as the rotational angle of the moon. Besides, a sand clock that locates in a constant gravitational field and keeps a constant velocity can be taken as a qualified phenomena in (9). When a fixed quantity of sands move from the container's top part to the bottom part, the mass distribution for all sands changing inside the space of the container constitutes R_2 of P in this case. Also, the phenomenon of a pendulum that keeps the same velocity relative to the observer in a constant gravitational field meets the constant assumption in (9). When it swings back and forth, the change of the pendulum's mass distribution in its maximum swinging space, which is R_2 of P in this case, can be taken as the reference for measuring time.

- External force $[C_1]$ is dominated by electromagnetic force. Either mechanical watch, electronic watch or atomic clock belong to such time measuring methods. Take the atomic clock for example. If we make the phenomena of the cesium-133 atom satisfy the constant conditions of (9), an equivalence can be assumed between time and the electron inside the cesium-133 atom jumping between two states, which can be viewed as the change of the atom's inside mass distribution.
- External force $[C_1]$ is dominated by both gravity and electromagnetic force. The whole universe, if regarded as an isolated system, can be viewed to satisfy the constant assumption in (9) . Hence, we can assume an equivalence between time and the change of the whole universe's mass distribution in space, which is R_2 of P in this case. Further, if we reduce the scale of mass distribution to the micro size, it can be viewed as the object's composed particles' motion, either randomly or consistently. For random motion, it represents the degree of disorder inside the object. According to the current physical system, disorder in a system can be described by another physical property of 'entropy'. Thus, entropy is actually nothing but an abbreviation for 'change of an object's mass distribution over space'. In this view, time can be measured by the entropy of the whole universe.

In (9), $\otimes$ can be taken as a different mathematical operation according to a different measure method. For example, $\otimes$ for the method of atomic clock is to multiply by 9192631770[1].

4 What dilates is not time but timer

From above, all measure methods for time in history follow the equivalence in (9) and the application range restricted by the constant assumption is {constant $C_1 \cap$constant $C_2 \cap$ constant R_1}, all $C_i, R_j \in$ causality Ⅱ(a). Hence, any time measure method can only apply to those phenomena that meet constant $C_1 \cap$constant $C_2 \cap$ constant R_1. In other words, if any of these three properties do not keep a constant degree, we cannot assume an equivalence between time and timer. In particular, if C_1 in Ⅱ(a) is dominated by gravity and does not keep a constant, insisting on measuring the time flow by the reading on the timer would be not accurate. For example, what influences the fall of sand in a sand clock is not only how fast the time flows but also gravity. Obviously, the stronger the gravity is, the more quickly the sands flow down. If the sand clock is viewed as the most accurate time measure method, by comparing two sand clocks in a higher and a lower gravity field, we would be misled that time could be affected by gravity. But in fact, gravity only affects the falling speed of sand. Similarly, although the transition cycle of the cesium-133 atom is much more precise than a sand clock, its measure principle also follows (9). In nature, no matter for a sand clock or an atom clock, both of them are nothing but some sort of reference phenomenon that can be affected by some factors other than how fast the time flows. Different speed or gravity would provide different kinetic or potential energy for the electrons in a cesium-133 atom to jump off between different states, which would influence the frequency of its transition. Hence, if the atomic clock is viewed as the most accurate time measure method, we would be misled that time is affected by gravity or speed. Undoubtedly, 'timer is affected' does not mean 'time is affected'. For another classical instance that a traveling-back spaceman is younger than the person on the earth, timer here is actually the metabolism rate of the human body. In fact, the time flowing rate is no different for either spacemen or the man on earth, but the spaceman's metabolism rate is affected by the spaceship's faster speed than the man on earth, which makes their ages different.

Therefore, the time dilation effect proposed in special relativity actually confuses the change of the reference phenomena for indirectly measuring time with the change of time itself. What is really dilation is not time but timer. If we insist on measuring time by some phenomena in dilation served as a timer, time flow would be counterintuitively affected. Strictly speaking, the time dilation effect should be called the timer Dilation Effect.

REFERENCES

[1] 9th edition of the SI Brochure. **9**,130-131 (2019).