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Physical definition of time

The physical meaning of time is revealed, and its properties are determined.

Time is one of the things we probably ***cannot*** *define*
R. Feynman

Comparing two motions means determining the coordinates of one motion corresponding to the given coordinates of the other motion.

Suppose that such mutual correspondence of coordinates as a table or formula can be established experimentally for any pair of motions we are interested in.

We may be interested in many pairs and, in addition, in many combinations of different pairs.

In other words, we will need to identify many different matches by performing many different experiments.

However, no matter how many different motions we compare with each other, a random given pair of motions cannot be compared without using experience, unless each of these motions is compared with *the same* motion.

On the contrary, if all motions are compared each time with the same motion, any pair of motions under study can be compared with each other after such comparison *without using experience*.

Moreover, it is enough to study any motion we are interested in *only once* in an experimental way so that it can be compared with any other motion under study without using experience, if only to compare all motions each time with the same motion.

This is the necessity and reason for the selection of one *reference* motion among all kinds, which is called *time*.

So, *time is the* ***reference motion*** *(RM), with which all other motions are compared.*

RM itself is no longer compared to anything else (on the contrary, everything is compared to it), so the concept of uniformity or irregularity of motion is not applicable to it.

The so-called "time uniformity" means only that RM itself is divided into equal parts; other motions appear to be uniform or non-uniform, depending on whether they are proportional to the RM parts.

Properties of RM

Not every motion can be a reference, but only a motion with certain properties.

RM should be the same (identical) for all motions under study.

This means that the RM highlighted *should not depend* on the motions under investigation. In other words, any changes in the motions under study must not change RM itself, otherwise each new motion will have its own impact on RM. Therefore, comparing different motions with each other after comparing them with such RM *without using experience* will be impossible.

Consequently, not every motion can be an RM, but only one that does not depend on the motion under study (RM *independence condition*).

Although we call the function $S = f(t)$ a dependence, it should be understood as a mutual correspondence only.

Independence is achieved by the isolation of RM from the force of other motions.

The required property of RM is also its continuity or infinite duration, called *perpetual motion*. This ensures that it is always ready to be compared with any motion we are interested in.

Inertial motion has these properties.

The article [1] shows that inertial motion is *circular*, *perpetual* and *spatially limited*.

Selection of RM

This explains why *circular* motions are used as RM. The spatial scale of circular RM can vary from macro to micro world.

Natural circular Earth RMs are daily Earth rotation, monthly Moon motion and annual Earth motion. The use of these movements as RM is not only due to the fact that it solves the problem of the availability of such RMs (as this is the reference that everyone possesses at once), but also due to the fact that any motion of ourselves or of objects available to us does not affect the motion of such bodies in any way (RM independence condition).

Ultra-small intra-atomic motions under normal conditions also satisfy the independence conditions.

Circular motion can be considered as linear or angular, directed from the centre of motion to an external frame, not connected with this motion.

Angular motions are, for example, circular movements of the hands of a watch that have several external frames forming the dial.

The Sun, moon and stars can be used as external frames of daily earthly rotation.

Observation conditions of such natural frames are not ideal. It is performed not from the centre, but from a point on the Earth's surface shifted relative to it by the distance of the Earth's radius.

These frames are not equally accurate. The moon has its own angular motion by 1/29th of the daily cycle, which corresponds to 12.4° or 49.6 minutes. This will be the error of a single daily cycle measurement using a lunar frame, which is continuously accumulated. The use of solar or stellar frame is more accurate, as it also shifts during the daily cycle, but by a value not exceeding 1/365 of this cycle. This corresponds to about 1° or 1/15 hours or 4 minutes. This error, of course, also accumulates. The disadvantage of solar frame is its excessive brightness, which requires the use of attenuation filters. However, its simplest version, smoked glass, was already available in the Middle Ages.

The stellar frame is available for direct observation with point dimensions that increase the accuracy of guidance, but its daily shift is equal to the same of the solar frame, as it is caused by the same motion of the Earth relative to the Sun.

Therefore, the error of measuring the daily cycle by means of a stellar frame is also about 4 minutes and accumulates, requiring constant corrections.

RM simulators

The discovery of the new time associated with Galileo is the possibility of using *oscillatory* motions instead of *rotational* ones as RM simulators. The scale of oscillatory motion can be comparable to that of a human being, i.e. it is an intermediate between large space and small atomic motions.

The oscillatory motions are not inertial. There is an unbalanced force interaction of moving parts that form the power system under vibrational energy exchange. The oscillating power system itself can be *isolated* from other bodies and motions, and its oscillating power exchange can be independent of external motions, i.e. completely *internal*, which means unlimited (*infinite*) preservation of the internal oscillatory power exchange between parts of the power system.

The isolation is not ideal, and the oscillatory motions are not continuous. However, it is possible to use the possibility of restoring the decreasing energy reserve.

Violation of the isolation can be controlled by reducing the amplitude of vibration (attenuation) and restoring its original value by means of compensating periodic external force. This compensation is not infinite but may be enough for practical purposes.

Other (not oscillatory) RM simulators, such as flowmeters (e.g. hourglass), are also possible, which are derivative of relatively oscillatory or rotational and can be graded with them.

Comparison of rotational and oscillatory motions

The possibility of using oscillatory motions as simulators of rotational motions is easily explained by the fact that the rotational motion is represented as a kind of oscillatory motion. Indeed, the rotational motion is mathematically expressed by two rectilinear mutually perpendicular oscillatory motions with a phase shift by a quarter of the period:

$$x = R\ sin\ \omega t,$$
$$y = R\ cos\ \omega t,$$

where x, y are Cartesian coordinates of oscillatory motion,

R is amplitude of oscillatory motion equal to the radius of rotational motion,

ω is oscillatory motion parameter equal to the angular frequency of rotational motion.

The rotational motion in this record corresponds to the oscillatory motion in two coordinate axes with internal oscillatory energy exchange.

Since:

$$f_x = ma_x = mR\omega^2 \sin \omega t = m\omega^2 x,$$
$$f_y = ma_y = mR\omega^2 \sin \omega t = m\omega^2 y,$$

where f_x, f_y are projections of the operating force on the coordinate axes OX, OY, it follows that the Newton's law of universal gravitation is the Hooke's law of elasticity. Newton's formulation determines only the magnitude of the amplitude of $mR\omega 2$ in this oscillatory motion.

This partly explains Newton's dislike even for Hooke's portraits.

RM isolation condition

The frequency of the circular motion under consideration n is determined by the number of its cycles corresponding to one cycle in the compared RM.

Frequency is determined by the ratio of the spatial scale of the motions being compared. The RM independence is determined by the difference from the frequency unit of all other motions compared to it. Proximity or equality to the unit of circular motion frequency compared to RM corresponds to the *resonance* condition.

This is accompanied by a breach of the RM isolation with the occurrence of interaction with the correlated motion.

The interaction can be reversible oscillatory energy exchange between two power systems forming circular motion, or irreversible, accompanied by energy transitions of both power systems from one initial state to another. Therewith, the internal energy reserve and the radius of circular motion increase in one power system, and the frequency of internal energy exchange decreases, while the internal energy reserve and the radius of circular motion decrease in the other one, and the frequency of internal energy exchange increases. Therefore, the initial equality of frequencies and spatial scales of both interacting power systems is broken and the interaction between them is terminated.

Due to the arising change of natural frequency, the resonance interaction with RM is inadmissible. However, no motion accepted as RM can be guaranteed from the possible existence of another motion of the same dimensions and frequency, which automatically means the possibility of resonance interaction between them. Therefore, the required isolation of any motion taken as a reference is always not absolute, but relative. As a result, it is natural to have not only one RM, but a set of RMs, varying in size and frequency. This makes it possible to use one of them, which is the best under the given conditions according to the isolation requirement. In addition, it is also possible to use independent, non-resonant motions, for example, a device based on the outflow of jets (hourglass). Of course, these devices must be pre-calibrated according to RM.

Another example is RM of atomic size.

Its isolation is determined by the incomparability of the atomic spatial scale with the human scale.

This isolation is also not absolute. The presence of other motions of a scale comparable to that used by RM violates the isolation condition. It can be other space scale motions for Ptolemy's or Copernican motions. Similarly, atomic motions may be perturbed by the intraatomic isolation condition of the selected RM.

In general, isolation is ensured by the incomparability of the scale in question. The space scale is too large for a human being, the atomic scale is too small, therefore both are applicable as independent RM in the absence of interaction with other motions of a comparable scale.

Non-isolated RM

A strictly isolated power system corresponds to a continuous oscillating motion.

Not strictly isolated power systems represented by weakly attenuating motions are also practically applicable. The motions can be circular or oscillating with no strict isolation from other observable motions. Partial breach of isolation, accompanied by attenuation of internal oscillations, can be compensated by periodic maintenance of the oscillating system from outside.

But this is a technical issue, not a fundamental one.

Theoretically, internal oscillations are conceivable infinite, but practically they are only enough for the required observations.

So, we know what time is and what its properties are.

Necessary apologies

The epigraph quote by R. Feynman has the following appearance:

"Let us consider first what we mean by time. What is time? It would be nice if we could find a good definition of time. Webster defines "a time" as "a period," and the latter as "a time," which doesn't seem to be very useful. Perhaps we should say: "Time is what happens when nothing else happens." Which also doesn't get us very far. Maybe it is just as well if we face the fact that time is one of the things we probably cannot define (in the dictionary sense), and just say that it is what we already know it to be: it is how long we wait!
What really matters anyway is not how we define time, but how we measure it." [2]

A significant evidence simply means that physicists do not know what time is and, accordingly, what its possible or impossible properties are. Can it, for example, be lengthened, shortened or reversed (objectively, i.e., regardless of perception)? What are the mountains of pseudoscientific literature written about? It is worth evaluating the picture of a specialist leafing through the *definition dictionary* in search of a definition of the *basic* concept of his science. Look for it from philologists? And postulate the impossibility of definition, when not finding? – A bold statement.

Theoretically, it is clear that such definitions as "A, expressed through B, in turn expressed through C," etc., finally leads either to a bad infinity, or to the expression of the last element of such a chain through any previous one, corresponding to the logical circle, or finally to the forced break of the chain of definitions, the last element of which is deprived of a definition.

This *last* element, which is undefined, is considered to be "very simple", as it were, not requiring definitions, to avoid natural concern, and is therefore accepted as the *first* in the chain of definitions. There may be more than one inverted chain of definitions, but there may be many that relate to different fields of knowledge represented by different sciences.

All of them begin with "undefined" concepts, which are supposedly related to philosophy - language, time, number, mathematical operation, mass and strength.

But are they simple enough to be considered primary? And how can we reconcile this with the fact that time, which is just one of these concepts, is considered to be too *difficult* to understand and requires constant study?

These concepts either do not have definitions that are considered superfluous or, on the contrary, have an abundance that also indicates that clarity has not yet been achieved.

The absence of definitions can be replaced by an overabundance of comments (see, for example, [3]).

Which does not bring understanding closer at all.

And this is after a century of reasoning on the topic *"Einstein deeply analysed the nature of time"*. So, what are the results of such analysis?

All this means that this problem should be considered rather complicated. But the main difficulty is another one, determined by the perception (and acceptance) of its possible solution.

Who can be glad to hear that the problem, supposedly designed for generations, is being solved with almost two words?

But what can we do if the concepts under study really belong to the initial or primary ones? Even if they are not simple in content, they cannot be too complex or incomprehensible. After all, we invented them and introduced them, don't we have to explain the meaning of our own actions?

We hereby declare the closure of the time as a scientific or philosophical problem. It no longer exists.

References

1. A.I. Somsikov. Law of inertia. http://viXra.org/pdf/1909.0394v1.pdf.

2. R. Feynman, R. Leighton, M. Sands. The Feynman Lectures on Physics, ed. Mir, Moscow, 1965, issue 1, p. 86.

3. Institute for Time Nature Explorations. http://www.chronos.msu.ru/.