# An Overview of the Nature of Time



## Introduction

Time is very important. If time stopped progressing, the Universe would cease to function! But despite its obvious importance, a simple definition of time is elusive, if not impossible. All we seem to know is one of its properties: time progresses in one direction and therefore allows us to assign a chronological order to events. This statement works adequately for us in everyday life, but it falls far short when we try to do foundational physics.

And so for the purposes of this paper I have to give a more specific definition of time: Time is the human *perception* of temporal motion. Time is also a *physical* component of temporal motion. Motion is defined, for our purposes here, as a ratio between space and time or as a ratio between time and space. The presentation that follows will examine these concepts in more detail.

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## Temporal Motion

Time and space in the human experience always occur together. We experience time at a particular place in space, and likewise we experience a place at a particular time. The same is true in physics. The speed of light is the most prominent example of a universal space/time association. It also enters into fundamental and well known physics equations like $E = mc^2$ and $E = cB$. This intimate association between space and time suggests that we can compare the properties of spatial motion with those expected for temporal motion and gain some insights.

Spatial motion is very familiar to us. During the interval of observation an object with spatial motion has a beginning location in space, and ending location in space, and a trajectory or path in space that connects the two. Formally, we say that this is spatial *displacement* with respect to a time *progression*. Now, we might think that we could just swap the words “space” and “time” and end up with a description of temporal motion. But it is not that simple. Our reference system is inherently spatial and probably won’t portray temporal motion in such a simple way. In fact the concept of temporal motion seems so weird that we have to think hard to come up with clues about how to recognize this kind of motion. Here are a few properties we could reasonably expect:

1. Temporal motion is not motion in space. A recognizable object with temporal motion will have a starting point (so to speak), but cannot have a spatial path or a spatial trajectory. From the standpoint of a spatial reference system we will be looking for some sort of "motionless motion."

2. Temporal motions can have no directional preference in a spatial reference system. Temporal motions are in a world of "when" instead of "where." This means that however temporal motion may manifest itself, it must have a spherical distribution in space that centers on the object which possess it. This implies that the motional intensity will decrease inversely in proportion to the square of the distance from the object (just like the

intensity of light from a light bulb rapidly weakens with distance). This non-directional character also implies that the motion must be multidimensional, as all directions in space must be treated equally. This implies something like an expansion, or a contraction, *not* the familiar vectorial motion we see on a car or a rocket.

3. Temporal motions are "non-local" (a consequence of #2). Hence, temporal motion must be infinite in (spatial) extent. It is not limited by space. It is anywhere/everywhere simply because it is incapable of participating in a spatial location scheme. This also implies, strangely, that it has no propagation velocity; its effects must be instantaneous in a spatial reference system.

4. If temporal motion is actual motion then it must express the theme of "motion" somehow, even though it is still "motionless motion." In other words, we would expect that temporal motion would still manifest traits of momentum, energy, work, power, etc., although these manifestations could be very different from the more familiar spatial traits we see with ordinary motion.

What we seem to have in this list of characteristics is a description of a *force field* (although perhaps with some reservations, which we will get to shortly). Let's use a gravitational field as a test case. We will go down the list and see how well it matches the known properties of gravitation. For the sake of conceptual definiteness, let's imagine we have two gravitating lead balls, each suspended from a wire, in our laboratory. Then we ask some questions:

1. Is gravitation "motionless motion"? Yes! In fact, we usually think of gravitation as a force that causes motion, not the actual motion itself. We could replace the concept of "force" here with the concept of motion, or at least motional potentials, and so we seem to be okay on this point. The motion clearly has a "starting point" so to speak, but it also has no spatial path or trajectory.

2. Does gravitation have a vectorial directional preference? No! The balls can have any relative orientation and the motion is still simply "towards." It is indifferent to north, or south, or east, or west, or above, or below (as is time). It only has a signed magnitude. Any "direction" we assign to the motion, is actually a property of the reference system, not a property of the motion itself.

   Does it have an inverse square intensity distribution? Yes! Newton's law of gravitation is $F=G\, m_1 m_2/r^2$. The inverse square relation is obvious.

   Is the motion multidimensional? Yes! But what this means needs some clarification. Let's say John falls out of a tree. According to Einstein, while he is falling there are no forces acting on him. He is in a "free float" or in an "inertial" condition. The earth however is rushing up to meet him. When he lands on his feet, the earth is still pushing up against him with an acceleration of $9.8\ m/sec^2$ and John sticks to the earth. Meanwhile, Jack, who is on the other side of the earth, diametrically opposite to John, also falls out of a tree. The earth rushes out to meet him too, and with the same result as for John. This cannot be an example of ordinary vectorial motion, because that would be *towards* John and *away* from Jack (or vice versa). In actual fact the motion is *towards both*, even though this would ordinarily require opposite motions. The motion here must be *one* motion that is multidimensional. It is simply "towards" in all three dimensions of its spatial manifestation.

3. Is gravity infinite in spatial extent? According to Newton it is. His law does not place any limit on the "reach" of gravitation.

   Is the propagation velocity of the gravitational effect instantaneous? According to Newton it is. His law does not include a time factor for propagation velocity. However, the current thinking in this field is that gravity propagates at the speed of light. But a little investigation of this point reveals some things that have apparently been overlooked by the scientific community. Says astronomer Dr. Tom Van Flandern:

   > "The most amazing thing I was taught as a graduate student of celestial mechanics at Yale in the 1960s was that all gravitational interactions between bodies in all dynamical systems had to be taken as instantaneous. . . .Indeed, as astronomers we were taught to calculate orbits using instantaneous forces; then extract the position of some body along its orbit at a time of interest, and calculate where that position would appear as seen from Earth by allowing for the finite propagation speed of light from there to here. . . . That was the required procedure to get the correct answers" ("The Speed of Gravity - What the Experiments Say" , Tom Van Flandern, *Physics Letters A*, 250 (1-3) (1998) pp. 1-11 ).

   The most obvious and incontrovertible experimental evidence for an extremely high propagation speed of gravity is that, unlike light from the sun, *gravity has no aberration*. Light from the sun takes 8.3 minutes to get to Earth, and during that time the Earth has moved forward in its orbit. The image of the Sun in the sky is therefore slightly retarded from where it would be if there were no aberration. But gravity is different. It always points directly (radially) to the Earth. The effect of gravity is attractive, and so if there were an aberration effect, it would tend to speed the Earth up in its orbit rather than slow it down. Says Van Flandern: "The net effect of such a force would be to double the Earth's distance from the Sun in 1200 years. There can be no doubt from astronomical observations that no such force is acting" and "From the absence of such an effect, Laplace set a lower limit to the speed of propagation of classical gravity of about $10^8 c$, where $c$ is the speed of light." (Laplace, P. 1966 *Mechanique Celeste*, volumes published from 1799-1825).

   Hence, there is physical evidence that the speed of gravity is enormously faster than the speed of light. Only a lower limit can be set, and it is about 20 billion times the speed of light. The propagation velocity of gravity could in fact be infinite (instantaneous).

4. Does gravity have a connection with the themes of motion? Yes! Energy can be stored in a gravitational field. We can do work against the field, and so forth.

This exercise should convince you that there is such a thing as temporal motion. But you probably don't feel very comfortable with it yet. So let's see if we can find some other manifestations of its properties.

## The EPR Paradox

Spatial motion moves an object from one *place* to another *place*. So we should ask this question about time. Can an object also have a *temporal place*, and can it move from one *temporal place* to another? Remember, these temporal places cannot be seen in a spatial reference system because they are non-local. Still, there might be some effect we can detect.

Let's imagine that we have a point light source and that it emits two photons in opposite directions. After an instant they are clearly in separate spatial locations. And presumably they are also in separate time locations, even though the latter cannot be seen. But nothing really seems to *require* this latter condition. Suppose the photons separate spatially, but, because of some experimental condition, they do not separate temporally. We end up with two photons that are in *two* different spatial locations, but in only *one* temporal location. They are separate in one sense (space) but are still together in another sense (time). If we then flip the polarization of one photon, what will happen to the polarization of the other? If it changes, and if the effect has to do with temporal location, then it must happen instantly, even though the photons could be separated by a large spatial distance across the laboratory. This will be seen as some kind of action-at-a-distance paradox because the effect would seem to be conceptually impossible.

Experiments of this sort have been done during the last few decades and with several different experimental designs. They started out originally as a "thought experiment" which was proposed by Einstein, Podolsky, and Rosen in 1935. Later, John S. Bell, proposed a theorem ("Bell's inequality") that facilitated experimental tests of this "EPR paradox" as it is now known. The action-at-a-distance effect turns out to be real and verifiable under specific experimental conditions. It is evidence, I believe, for the idea that time not only progresses, but also has dimensions of "location" just like space.

## Speed of Light Invariance

Let's take another look at the location aspect of temporal motion. Suppose again that we have two photons being emitted in opposite directions. One photon traverses one unit of spatial displacement to the left, and the other, one unit of spatial displacement to the right. This happens in one unit of time progression. But what if time itself is progressing *locationally*? That would mean that the characteristics that were applied to space should also be applied to time. The total spatial separation between the photons is two units, but the total time separation is therefore also *two* units rather than one. This means that the photons actually separate at the speed of light, instead of twice the speed of light.

As mentioned above, space and time are never really separate. But apparently at low speeds, the motion is locational in mostly a spatial sense. At higher speeds it also starts to become locational in the temporal sense. At the speed of light the two are exactly balanced. This seems to have two consequences. One is "Lorentz invariance" (which will not be discussed here). The other is the appearance of a universal speed limit.

## A Limit for Spatial Speeds

Let's look at some electrons being accelerated in a large particle accelerator. Electrons leave the injector section at 15 MeV, which corresponds to v/c= 0.9995. In the main section they are boosted to 5GeV, which corresponds to v/c= 0.99999995. The energy increases by a factor of 300, but the speed increases by a factor of only 1.0005. How can there be such a huge increase in energy with only a tiny (5 parts in ten thousand) speed increase? Physicists say that the mass of the particle increases. The mathematics of this claim is consistent with the behavior, and so this is one possible interpretation.

But a more fundamental measure of the motion is energy, not mass. Is energy temporal motion? Remember temporal motion itself cannot be seen in a spatial reference system. And remember, it is supposed to express the theme of motion (work, energy, etc.) somehow. It also has to manifest itself in a non-vectorial manner. Energy is indeed a non-vectorial (scalar) quantity. If we say spatial motion is denoted by s/t, then temporal motion would be t/s. We can play with this mathematically by plugging these units into various equations and looking for dimensional consistency (or inconsistency). If energy is t/s and $E = mc^2$ , then mass must have the dimensions of $t^3/s^3$ for instance. By repeating this with other well known equations, we could eventually work out the dimensions of say, Planck’s constant, from various equations that use it. Are the dimensions consistent? (I leave this as an exercise for the reader).

If they are, this is another piece of evidence for the temporal motion concept. And interestingly, it implies that speeds greater than light are possible, but they have a locational temporal component that is larger that the locational spatial component. Said differently, speeds much less than light are mostly spatial; speeds much greater than light, would be mostly temporal. Speeds equal to that of light, have a balance of both.

## Quantum Mechanical Behavior

Quantum mechanics makes use of an expression for total energy as the sum of potential and kinetic energy. It is called the "Hamiltonian". These terms are not used directly but are converted into "operators" as seen in the well-known Schrodinger equation. Remember that energy is non-directional (scalar) and expresses the theme of motion. Its use in quantum mechanics makes us wonder if quantum mechanics has something to do with temporal motion. The equations have an infinite number of solutions, and must be limited by "boundary conditions", say on energy. Without this, there is no quantum mechanical behavior. This is a strong clue that it involves the non-local nature of time and temporal motion. And in fact the term "non-local" appears frequently in the literature of quantum mechanics. The "matter waves" of quantum mechanics also have an infinite propagation velocity and so there continues to be vigorous debates about whether the waves are real, or just mathematical abstractions.

Again, spatial and temporal motion always occur together, although the experimental situation may favor the manifestation of one more than the other. A good example of this is diffraction. Let' s suppose we have a monochromatic light source, an opaque screen with a circular hole in it, and a photographic plate beyond the screen to capture an image. Light goes from the source, through the hole in the screen, and onto the photographic plate. If we use a screen that has a hole that is much larger than the wavelength of light, the light just seems to go straight on through to the plate, and leaves an image of a circular disk of light. There is no obvious diffraction pattern.

If we make the hole much smaller, then the familiar "bulls-eye" diffraction pattern of light and dark concentric rings appears. The overall pattern is very definite, but it turns out that there is no way to predict where each individual photon will strike the photographic plate. In fact the light source can be dimmed down so severely that only one photon at a time will be traversing the apparatus. The photographic result starts out with a very grainy appearance.

Eventually a grainy diffraction pattern will begin to appear. Still later, the pattern becomes fully distinct and is every bit as sharp and definite as it is with a bright light source and a short time exposure.

If we use smaller and smaller holes, the bands get thicker and coarser. Ultimately they disappear altogether and the photo, which requires a long time exposure under these conditions, is completely uniform. The light path has become completely non-directional and has a hemispherical distribution. This is why physicists can use the scheme of "Hyguens wavelets" to predict diffraction patterns.

## Which temporal motion is the one that humans perceive as time?

As you have seen, there are various kinds of temporal motion. The gravitational field, and probably also magnetic and electric fields, are manifestations of temporal motion. Motion at high speeds is too. Which temporal motion is the one that humans perceive as time? We all seem to be on the same clock, and so whatever embodiment we are looking for must be grand in scope, probably Universal. It must be a physical non-thing, kind of like a zero for Roman numerals ("Why would you need a number to represent nothing?"). The locational aspect of time seems to help here. Time must not merely progress, it must *expand* (increasing the time separation between locations). The expansion must be centerless spatially so that there is no locatable master source or inverse square effect. But since time is non-local in a spatial reference system, this requirement is met naturally.

So what your watch is measuring is actually the expansive time component of the "nothing fabric" of the physical universe. (Space is involved in this too, but that is another topic. )

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## Temporal motion concept is for people with "the right stuff"

I am confident most people will eventually become comfortable with the concepts explained above. Superior intelligence is not need to understand them. There are no eleven-dimensional strings. Tensors were not needed. Both the math and concepts of foundational, fundamental physics are simple. But while reading through this, you may have gotten a sense of what mental skills are required to handle temporal motion. My own list includes the following:

- **Accurate perception of facts and deep respect for facts.** A respect for the facts will keep you from wandering off into the weeds.

- **An ability to tolerate mental chaos.** Finding out that half of what you know is probably wrong can be very unsettling. Just take a break. Sleep on it. Don' t panic. It will sort itself out somehow.

- **Creativity to see facts in a new way.** This means breaking loose from the so-called "reigning paradigm." It is extremely difficult to do. Searching for an underlying theme of simplicity and elegance, even a kind of perverse cleverness, is helpful and inspiring.

- **Courage and persistence.** You will be discouraged by the utter apathy of your colleagues. They may also assert that you are wasting your time, spending taxpayer money on "junk science" . What will the public think? What if the dean of the college finds out? You could lose you job because of your silly ideas. You have probably had doubts like this yourself. In all this, you can' t just be stubborn and wait it out. You still have to *do something* productive.

If you think you have "the right stuff", give yourself a little test. What is your attitude towards topics that have not been covered? If there is such a thing as "motion without a direction," for instance, can there be such a thing as "a direction without motion"? Does that sound like a silly question? Would you be willing to spend your time and your money investigating it? Or would you write it off as "junk science"?

I am not being hypothetical here. This is a serious question. Physicists make use of a concept called "intrinsic spin". It has a value of +1 or -1 (no zero). A more general term would be "intrinsic rotation" which could take on a range of quantized values (…-3,-2,-1, 0, +1, +2, +3 …). Spin clearly has a direction (or "axis") but it does not change position nor move translationally. Assuming it is truly intrinsic, and not something *with* a spin, you could actually call it "a direction with no motion". One of its manifestations is angular momentum, and angular momentum is extremely important in quantum mechanics and in atomic theory. Understanding this from a new perspective could lead to startling new technological advances .

Another example is antigravity. It is still treated as a joke nowadays. It is only stuff of science fiction, not reality; physicists cannot imagine actually doing it in a laboratory, or designing a demonstration unit. But a knowledge of how gravity actually operates could lead to significant advances in propulsion systems. An understanding of gravity and the non-local effects of temporal motion could lead to development of faster-than-light-propulsion.

Perhaps you can see these possibilities, and the need for further investigation and exposition. Please give your attention and support to people who are investigating these things. They need to know that it all matters to you as well as to them!