

Time

I would write all of these quantum Mechanical subjects tonight if I just had the time. But I need time to work on the web and maybe write a chapter in my new book project, or maybe if I had enough time I could go shopping. Truth is, there never seems to be enough time to get everything we need to do, on a day to day basis. And while we commonly use the term "Time" all the time, do we really know what time is? If you ask ten different physicists, you will get ten different answers.

To me, Time... is what keeps everything from happening at once.

Aristotle may have come closest to understanding time when he speculated that time may be motion. But he was very specific about his speculative definition. He further added that motion could be slower or faster but *not time*. Unfortunately, to the great expanse of time between their lives, Aristotle did not have the privilege of knowing about Einstein's relativity in which time also becomes amenable to change. But this is a condition in the study of time that would be repeated. When Einstein was working to develop his theory of general relativity he proposed a revolutionary new concept that mass curves space. Unfortunately, *he* did not know that the universe was expanding. Astronomer Edwin Hubble made this discovery 13 years after Einstein had published his theory of General Relativity. Perhaps if Einstein knew of this great discovery he may have incorporated these ideas into his theories and General Relativity might look somewhat different today. Conceptually, it is much easier to derive space curvature in an expanding universe by defining it as an area of slower expansion being influenced by gravity. So while our universe is expanding, motion, the four fundamental forces and curved space-time are by products of the expanding space.

Some believe that time is an emergent concept. There is a foundational process of motion and forces from which time emerges, however what we perceive as time is mostly an illusion. Our memory creates the illusion of the past. Conscious perception of events gives the feeling of present. Future is a mental construct patterned on memory experience of the past. Concept of time emerges as our mind tries to make sense of the world around us which is filled with continuous change.

According to the Anderson Institute, "Time is a measured or measurable period, a continuum that lacks spatial dimensions. Time is of philosophical interest and is also the subject of mathematical and scientific investigation. It is a component of the measuring system used to sequence events, to compare the durations of events and the intervals between them, and to quantify the motions of objects. Time has been a major subject of religion, philosophy, and science, but defining it in a non-controversial manner applicable to all fields of study has consistently eluded the greatest scholars.

In physics as well as in other sciences, time is considered one of the few fundamental quantities. Time is used to define other quantities – such as velocity – so defining time in terms of such quantities would result in circularity of definition. An operational definition of time, wherein one says that observing a certain number of repetitions of one or another standard cyclical event (such as the passage of a free-swinging pendulum) constitutes one standard unit such as the second, is highly useful in the conduct of both advanced experiments and everyday affairs of life. The operational

definition leaves aside the question whether there is something called time, apart from the counting activity just mentioned, that flows and that can be measured. Investigations of a single continuum called spacetime brings the nature of time into association with related questions into the nature of space, questions that have their roots in the works of early students of natural philosophy. Among prominent philosophers, there are two distinct viewpoints on time. One view is that time is part of the fundamental structure of the universe, a dimension in which events occur in sequence. Time travel, in this view, becomes a possibility as other "times" persist like frames of a film strip, spread out across the time line. Sir Isaac Newton subscribed to this realist view, and hence it is sometimes referred to as Newtonian time. The opposing view is that time does not refer to any kind of "container" that events and objects "move through", nor to any entity that "flows", but that it is instead part of a fundamental intellectual structure (together with space and number) within which humans sequence and compare events. This second view, in the tradition of Gottfried Leibniz and Immanuel Kant, holds that time is neither an event nor a thing, and thus is not itself measurable nor can it be travelled."

But what do I know about time? Stand by for the quantum headache.

Time is a scalar quantity and, like length, mass, and charge, is usually described as a fundamental quantity. Time can be combined mathematically with other physical quantities to derive other concepts such as motion, kinetic energy and time-dependent fields. Einstein showed that if the speed of light is not changing between reference frames, space and time must be so that the moving observer will measure the same speed of light as the stationary one because velocity is *defined* by space and time:

$$\mathbf{v} = \frac{d\mathbf{r}}{dt}, \quad \text{where } \mathbf{r} \text{ is position and } t \text{ is time.}$$

Indeed, the Lorentz transformation (for two reference frames in relative motion, whose x axis is directed in the direction of the relative velocity)

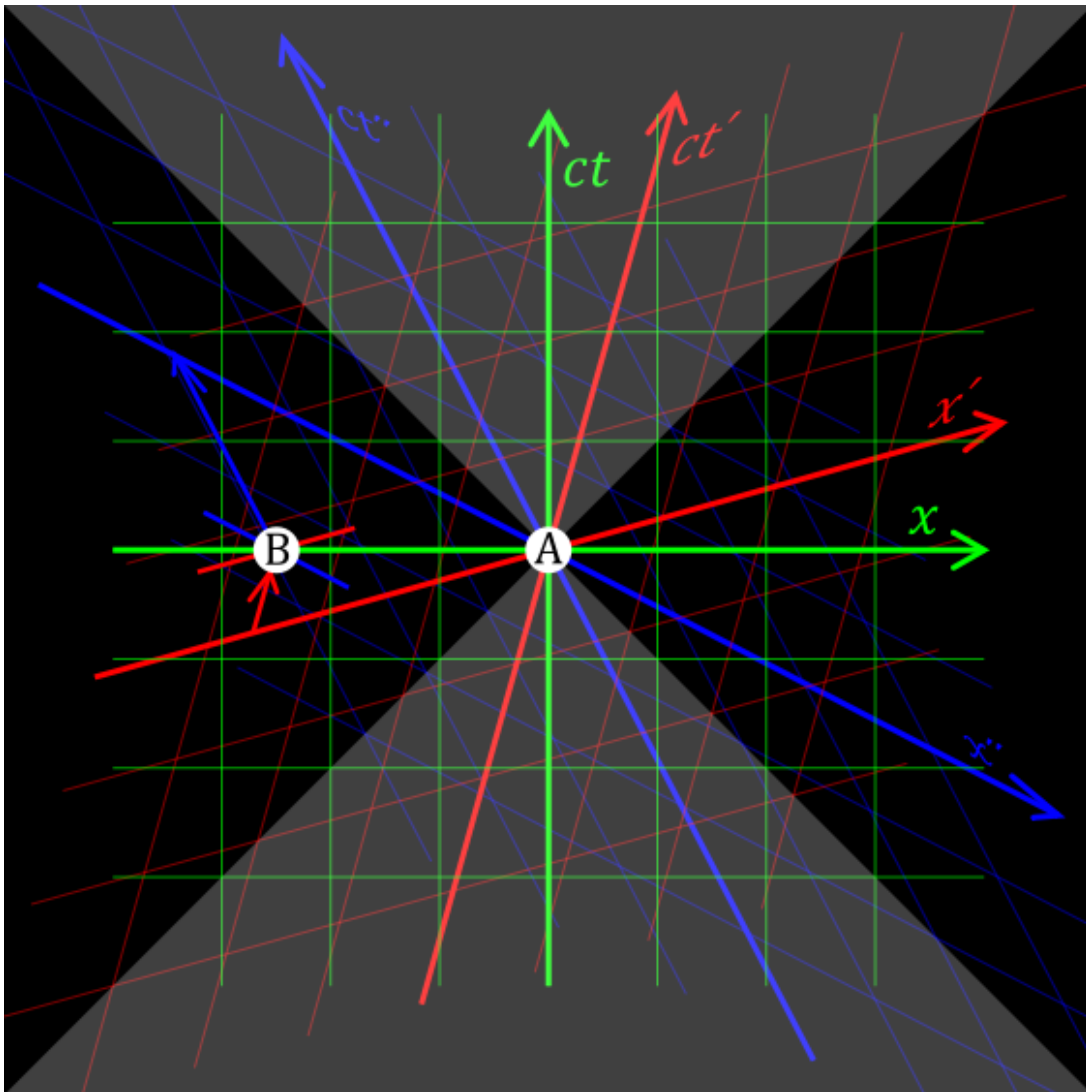
$$\begin{cases} t' &= \gamma(t - vx/c^2) \text{ where } \gamma = 1/\sqrt{1 - v^2/c^2} \\ x' &= \gamma(x - vt) \\ y' &= y \\ z' &= z \end{cases}$$

can be said to "mix" space and time in a way similar to the way a Euclidean rotation around the z axis mixes x and y coordinates. Consequences of this include relativity of simultaneity. More specifically, the Lorentz transformation is a hyperbolic rotation

$$\begin{pmatrix} ct' \\ x' \end{pmatrix} = \begin{pmatrix} \cosh \phi & -\sinh \phi \\ -\sinh \phi & \cosh \phi \end{pmatrix} \begin{pmatrix} ct \\ x \end{pmatrix} \text{ where } \phi = \operatorname{artanh} \frac{v}{c},$$

which is a change of coordinates in the four-dimensional Minkowski space, a dimension of which is ct . (In Euclidean space an ordinary rotation

$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$ is the corresponding change of coordinates.) The speed of light c can be seen as just a conversion factor needed because we measure the dimensions of spacetime in different units; since the metre is currently defined in terms of the second, it has the exact value of 299 792 458 m/s. We would need a similar factor in Euclidean space if, for example, we measured width in nautical miles and depth in feet. In physics, sometimes units of measurement in which $c = 1$ are used to simplify equations.



This picture illustrates the relativity of simultaneity in Lorentz transformations. The three colored reference frames are associated to three different observers in relative motion along the x axis. Relative to the green observer, the red one is traveling at $+0.28c$ and the blue one at $-0.52c$. Event B is simultaneous with A in the green reference frame, but it occurred before in the blue frame, and will occur later in the red frame. The upper highlighted area is A's future cone, consisting of the events which will occur after A in any reference frame. The lower highlighted area is A's past cone, consisting of the events which occurred before A in any frame. The

interior consists of the events from which a massive particle could have reached A, or which can be reached by a massive particle starting at A. The surface of the light cone: the events which can be reached by a light ray starting at A, or from which a light ray reaching A could have originated. The black areas outside the double cone consist of the events whose temporal ordering with respect to A depends on the frame of reference.

Time in a "moving" reference frame is shown to run more slowly than in a "stationary" one by the following relation (which can be derived by the Lorentz transformation by putting $\Delta x' = 0$, $\Delta t' = \Delta \tau$):

$$\Delta t = \frac{\Delta \tau}{\sqrt{1 - v^2/c^2}}$$

where:

$\Delta \tau$ is the time between two events as measured in the moving reference frame in which they occur at the same place (e.g. two ticks on a moving clock); it is called the proper time between the two events;

Δt is the time between these same two events, but as measured in the stationary reference frame;

v is the speed of the moving reference frame relative to the stationary one;

c is the speed of light.

Moving objects therefore are said to *show a slower passage of time*. This is known as time dilation.

These transformations are only valid for two frames at *constant* relative velocity. Naively applying them to other situations gives rise to such paradoxes as the twin paradox.

That paradox can be resolved using for instance Einstein's General theory of relativity, which uses Riemannian geometry, geometry in accelerated, noninertial reference frames. Employing the metric tensor which describes Minkowski space:

$$\left[(dx^1)^2 + (dx^2)^2 + (dx^3)^2 - c(dt)^2 \right],$$

Einstein developed a geometric solution to Lorentz's transformation that preserves Maxwell's equations. His field equations give an exact relationship between the measurements of space and time in a given region of spacetime and the energy density of that region.

Einstein's equations predict that time should be altered by the presence of gravitational fields (see the Schwarzschild metric):

$$T = \frac{dt}{\sqrt{\left(1 - \frac{2GM}{rc^2}\right) dt^2 - \frac{1}{c^2} \left(1 - \frac{2GM}{rc^2}\right)^{-1} dr^2 - \frac{r^2}{c^2} d\theta^2 - \frac{r^2}{c^2} \sin^2 \theta d\phi^2}}$$

Where:

T is the gravitational time dilation of an object at a distance of r .
 dt is the change in coordinate time, or the interval of coordinate time.
 G is the gravitational constant
 M is the mass generating the field

$$\sqrt{\left(1 - \frac{2GM}{rc^2}\right) dt^2 - \frac{1}{c^2} \left(1 - \frac{2GM}{rc^2}\right)^{-1} dr^2 - \frac{r^2}{c^2} d\theta^2 - \frac{r^2}{c^2} \sin^2 \theta d\phi^2}$$

is the change in proper time $d\tau$, or the interval of proper time.

Or one could use the following simpler approximation:

$$\frac{dt}{d\tau} = \frac{1}{\sqrt{1 - \left(\frac{2GM}{rc^2}\right)}}$$

Time runs slower the stronger the gravitational field, and hence acceleration, is. The predictions of time dilation are confirmed by particle acceleration experiments and cosmic ray evidence, where moving particles decay slower than their less energetic counterparts. Gravitational time dilation gives rise to the phenomenon of gravitational redshift and delays in signal travel time near massive objects such as the sun. The Global Positioning System must also adjust signals to account for this effect. According to Einstein's general theory of relativity, a freely moving particle traces a history in spacetime that maximises its proper time. This phenomenon is also referred to as the principle of maximal aging, and was described by Taylor and Wheeler as:

"Principle of Extremal Aging: The path a free object takes between two events in spacetime is the path for which the time lapse between these events, recorded on the object's wristwatch, is an extremum."

Einstein's theory was motivated by the assumption that every point in the universe can be treated as a 'center', and that correspondingly, physics must act the same in all reference frames. His simple and elegant theory shows that time is relative to an inertial frame. In an inertial frame, Newton's first law holds; it has its own local geometry, and therefore its own measurements of space and time; there is no 'universal clock'. An act of synchronization must be performed between two systems, at the least.

Time in quantum mechanics

There is a time parameter in the equations of quantum mechanics. The Schrödinger

equation is $H(t)|\psi(t)\rangle = i\hbar \frac{\partial}{\partial t} |\psi(t)\rangle$

One solution can be $|\psi_e(t)\rangle = e^{-iHt/\hbar} |\psi_e(0)\rangle$.

where $e^{-iHt/\hbar}$ is called the time evolution operator, and H is the Hamiltonian. But the Schrödinger picture shown above is equivalent to the Heisenberg picture, which enjoys a similarity to the Poisson brackets of classical mechanics. The Poisson brackets are superseded by a nonzero commutator, say $[H,A]$ for observable A , and Hamiltonian H :

$$\frac{d}{dt}A = (i\hbar)^{-1}[A, H] + \left(\frac{\partial A}{\partial t}\right)_{\text{classical}} .$$

This equation denotes an uncertainty relation in quantum physics. For example, with *time* (the observable A), the *energy* E (from the Hamiltonian H) gives:

$$\Delta E \Delta T \geq \frac{\hbar}{2}$$

where

ΔE is the uncertainty in energy

ΔT is the uncertainty in time

\hbar is Planck's constant

The more precisely one measures the duration of a sequence of events the less precisely one can measure the energy associated with that sequence and vice versa. This equation is different from the standard uncertainty principle because time is not an operator in quantum mechanics.

Corresponding commutator relations also hold for momentum p and position q , which are conjugate variables of each other, along with a corresponding uncertainty principle in momentum and position, similar to the energy and time relation above.

Quantum mechanics explains the properties of the periodic table of the elements.

Starting with Otto Stern's and Walter Gerlach's experiment with molecular beams in a magnetic field, Isidor Rabi (1898–1988), was able to modulate the magnetic resonance of the beam. In 1945 Rabi then suggested that this technique be the basis of a clock using the resonant frequency of an atomic beam.

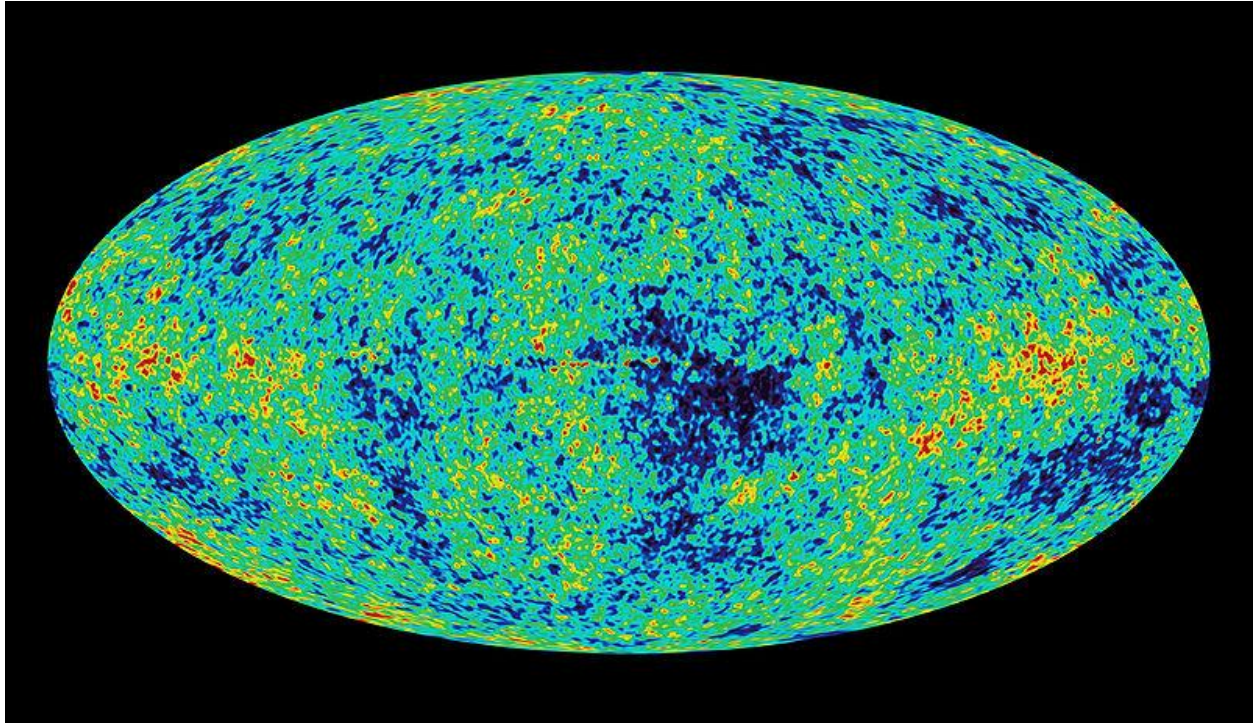
John Cramer is preparing an experiment to determine whether quantum entanglement is also nonlocal in time as it is in space. This can also be stated as 'sending a signal back in time'. Cramer has recently published an update indicating that the final experiment will take more time to prepare.

Time in Cosmology

The equations of general relativity predict a non-static universe. However, Einstein accepted only a static universe, and modified the Einstein field equation to reflect this by adding the cosmological constant, which he later described as the biggest mistake of his life. But in 1927, Georges LeMaître (1894–1966) argued, on the basis of general relativity, that the universe originated in a primordial explosion. At the fifth Solvay conference, that year, Einstein brushed him off with "Vos calculs sont corrects, mais votre physique est abominable." In 1929, Edwin Hubble (1889–1953) announced his discovery of the expanding universe. The current generally accepted cosmological

model, the Lambda-CDM model, has a positive cosmological constant and thus not only an expanding universe but an accelerating expanding universe.

If the universe were expanding, then it must have been much smaller and therefore hotter and denser in the past. George Gamow (1904–1968) hypothesized that the abundance of the elements in the Periodic Table of the Elements, might be accounted for by nuclear reactions in a hot dense universe. He was disputed by Fred Hoyle (1915–2001), who invented the term 'Big Bang' to disparage it. Fermi and others noted that this process would have stopped after only the light elements were created, and thus did not account for the abundance of heavier elements.



(WMAP map of CMB anisotropy, from http://www.gsfc.nasa.gov/gsfsc/spacesci/pictures/2003/0206mapresults/Full_m.jpg NASA.gov)

WMAP fluctuations of the cosmic microwave background radiation. Gamow's prediction was a 5–10 kelvin black body radiation temperature for the universe, after it cooled during the expansion. This was corroborated by Penzias and Wilson in 1965. Subsequent experiments arrived at a 2.7 kelvin temperature, corresponding to an age of the universe of 13.7 billion years after the Big Bang.

This dramatic result has raised issues: what happened between the singularity of the Big Bang and the Planck time, which, after all, is the smallest observable time. When might have time separated out from the spacetime foam; there are only hints based on broken symmetries.

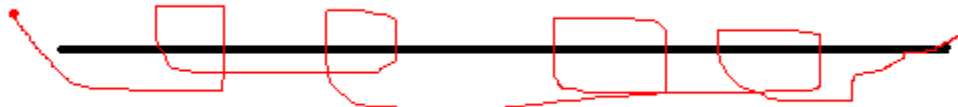
General relativity gave us our modern notion of the expanding universe that started in the big bang. Using relativity and quantum theory we have been able to roughly reconstruct the history of the universe. In our epoch, during which electromagnetic waves can propagate without being disturbed by conductors or charges, we can see the stars, at great distances from us, in the night sky. (Before this epoch, there was a time, 300,000 years after the big bang, during which starlight would not have been visible.)

So what is time?

Time is a mystery, perhaps the ultimate mystery. It is deeply entangled with the enigma of consciousness. Yet only rarely do we take time to reflect upon the nature of time. Time, is assumed to flow in one direction, leading to a series of events that occur one after the other in sequence. This is the conventional view, in both science and philosophy. But this view of time is entirely inaccurate. These are assumptions based on time as being linear. I and many other researchers believe that time is helical rather than linear.

Ben Goertzel has proposed a Helical Model of Time. Helical time is time which moves around and around in circles, occasionally, however, moving somewhere that it has not gone before, going off in a new direction. It is backwards- forward- moving time, without the backwards and forwards necessarily being in equal balance. The concept of helical time gives us a vision of a time that is moving linearly in one direction -- but only probabilistically so. Instead of moving forwards 100% of the "time," it is moving forwards perhaps 60% of the time, and backwards 40%. Or maybe it is moving forwards 80% of the time, and backwards 20%.

The word "helical" is used here metaphorically; it is not a precise mathematical helix structure. If one wishes to visualize time as a helix, however, some care should be taken. One should not envision a helix wrapped neatly around an emergent linear time axis, like a vine around a pole. A better image is a helix that is angled with respect to the emergent linear time axis -- sometimes going forwards with respect to this axis, sometimes going back. And it should be remembered that the helix of time does not grow around the emergent axis of time like a vine around a pole, either. Rather, the emergent axis of time is a kind of coarse-grained, averaged view of the motion of the helix of time. The linear flow of time is obtained from the underlying helical flow by the imposition of subjective ignorance.



A graphical depiction of the forwards and backwards movement of time. Space is collapsed onto a single vertical axis, for illustrative purposes. From <http://www.goertzel.org/papers/timepap.html>

But there are other ideas concerning the dynamics of time.

Imagine standing under a vast, scintillating aurora borealis, and seeing it change colors as you changed your thoughts. This exact situation led Russian medical doctor Alexander V. Trofimov into his groundbreaking research on human consciousness, in collaboration with Vlail P. Kaznacheev, and following in the footsteps of the great 20th century physicist Nikolai Kozyrev.

Essentially, Kozyrev devised reproducible experiments that prove the existence of a "torsional energy field" beyond electromagnetism and gravity, which travels much faster than light. He called it the "flow of time." Others, Einstein among them, have called it "ether." Others call it "zero point energy."

Within this “flow of time,” the past, present, and future all exist at the same time, and in every place. This discovery sets the stage for all psychic phenomena to be scientifically explainable. Trofimov and Kaznacheev have, for the past thirty years, been experimentally developing the practical explanations, and have made some surprising discoveries.

Among Trofimov and Kaznacheev’s conclusions are:

- 1) our planet’s electromagnetic field is actually the “veil” which filters time and place down to our everyday Newtonian reality — enabling us to have the human experience of linear time,
- 2) in the absence of an electromagnetic field, we have access to an energy field of “instantaneous locality” that underlies our reality,
- 3) that the limiting effect of the electromagnetic field on an individual is moderated by the amount of solar electromagnetic activity occurring while that person was in utero, and
- 4) that once a person has accessed these states, his or her consciousness remains so enhanced.

I have done a search for the plans on the internet and come up empty handed. It is reported that construction specifications for these apparati are published in Russian scientific literature. So here is where I will leave it. If someone can find and send me these specifications in English, I will assemble the devices and attempt to duplicate the findings.

Maybe we could find more time if we traveled in search of it....