

Modern Physics

Notes on the Meaning of Time

We learn in modern physics that time for a moving frame of reference is “dilated”. A simple example to illustrate this phenomenon is the decay of a radioactive nucleus: let us say that the half-life of one such particle is T_0 , and it is moving in our laboratory with a speed v , then from the perspective of the laboratory, the half-life will be

$$T = \frac{T_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Where c is the speed of light. In this equation T is always greater than T_0 , and that this why this is called time “dilation”.

This correction to the half-life and other experiments have confirmed the reality of this phenomenon many times, but we normally do not experience large velocities (compared to the speed of light) in everyday life, so it is natural that we feel uneasy about this. For our normal comprehension, time is just one variable and moves forward everywhere. We even assign a “Universal Time” to the time in a particular slice of Earth.

So, how can we reconcile these ideas? Can we make sense of relativistic time? Here is an approach: Instead of thinking in terms of time as a variable by itself, we can think of events separated by time *and* space. Events that contain all these four variables (three space coordinates and one time) with respect to a frame of reference are truly universal. That is, the event is the same in any other frame of reference, here are some examples:

Event1: Certain human-made spacecraft touches down on tranquility base, July 20th, 1969.

Event2: A paramecium dies in a Petri dish on the first-floor lab of the Science Complex building.
May it rest in peace.

Event3: One CO₂ molecule floating 10m above your grill absorbs an infrared photon.
Contributing to global warming and some delicious ribs.

Event4: A train passing through Lawton, OK whistles and awakes everybody on 27th street!

Event5: A nucleus of a ¹⁴C in a wooden chair decays into ¹⁴N emitting an electron and a neutrino, this during the taping of The Antiques Road Show... by the way, the chair was fake.

Event6: A baby is born in Lawton, Oklahoma who someday will become Principal.

All these events are referred to a frame of reference, which is our own planet. Technically, the surface of the Earth is not really an inertial frame because we are rotating, so we always experience a small acceleration towards the axis of the planet, but that correction is very small, so we don't need to worry about it. We can safely use our planet as a reference frame.

For events that happen in one frame of reference, we can define time, measured with clocks at rest, and that time will be “universal” for that frame of reference. Our bodies age and decay according to the time of the frame of reference of our own bones, so our “physio-time”, like Isaac Asimov used to say, doesn’t really dilate or contract with respect to our own.

Now, the events described above are all well-defined with respect to our frame of reference and with our own clocks but seen from a moving frame of reference they would have to be corrected. In those frames of reference, their separation in time and space might be different.