MUON RINGS AND FREQUENCY

There is a great deal of experimental evidence to support Einstein's Special Theory of relativity. One of the more convincing experiments was carried out at CERN in 1977 and involved measuring the lifetimes of particles called muons in an apparatus called the muon storage ring[1]. The muon is an atomic particle which carries an electric charge, much like an electron, only it is more massive. It has a short lifetime of around 2.2 microseconds before it decays into an electron and two neutrinos. In the experiment muons are injected into a 14m diameter ring at a speed close to that of light and observations made on their lifetimes.

Einstein, in his Special Theory of Relativity predicted that time for an object that is moving at close to the speed of light slows down relative to that of a stationary observer, that distances for an object travelling at close to light speed are foreshortened relative to those same distances measured by a stationary observer and that the mass of an object moving at close to light speed appears larger to a stationary observer. The extent to which these changes take place is governed in all three cases by the same factor Gamma. Gamma is easily calculated as:

$$\gamma = \frac{c}{\sqrt{c^2 - v^2}} \qquad \text{Equation 1}$$

Where v is the velocity of the moving object and c is the speed of light.

The muons injected into the storage ring at CERN had a velocity of 99.94% of the speed of light c and so for the muons gamma had a value of 29.33.

The muons, which should normally live for 2.2 microseconds, were seen to have an average lifetime of 64.5 microseconds, which is 29.33 times longer than their normal lifetime. That is the lifetime of the muon was increased by a factor Gamma. This comes about because the processes which take place inside the muon and which eventually lead to its decay are taking place in an environment which is moving relative to us stationary observers at 99.94% of the speed of light and in which time relative to us is running 29.33 times slower. Hence the muon, in its own domain, still has a lifetime of 2.2 microseconds, it's just that to us, who are not moving, this appears as 64.5 microseconds.

Traveling at almost the speed of light a muon would normally be expected to cover a distance of 660 metres or roughly 15 times around the CERN ring during its 2.2 microsecond lifetime, but in fact the muons travelled almost 20,000 metres or 440 times around the ring. This is because distance in the domain of the muon is compressed so what we stationary observers see as being 20,000 metres the muon sees as being just 660 metres.

Both parties agree that during its lifetime the muon passes the point at which it entered the rings some 440 times. We stationary observers see this as having taken place in some 64.5 microseconds, while the muon sees these 440 events as having taken place in just 2.2 microseconds. Hence for the muon the orbital frequency is increased by this same factor Gamma. This really is quite a remarkable result, there is no other phenomenon which leads to a multiplication of frequency in this manner.

This increase frequency can provide us with a model for the hydrogen and other atoms which, unlike the currently held theories, provides an explanation as to exactly why the energy levels of electrons in orbit around atomic nuclei should be quantised. It does so because the frequencies experienced in the domain of the orbiting electron are multiplied by Gamma in this way and form a harmonic series, each member of which corresponds to a stable state of the hydrogen atom. This idea is explored much more fully in Sampling the Hydrogen Atom.

[1] Bailey, H.; Borer, K.; Combley F.; Drumm H.; Krienen F.; Lange F.; Picasso E.; Ruden W. von; Farley F. J. M. ; Field J. H.; Flegel W. & Hattersley P. M. (1977). *Measurements of relativistic time dilatation for positive and negative muons in a circular orbit*. Nature 268 (5618): 301–305