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Relativity and Time Dilation

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***Abstract:** In this article we are going to see what exactly is time dilation, different types of time dilations like gravitational time dilation and velocity time dilation and the most important thing that we need to see is why we can't travel at the speed of light. With this we will also see that even though we travel at speeds comparable to c still why our relative velocity won't cross the speed of light.*

I. INTRODUCTION

So first of all what is time dilation???? It is nothing but difference in time which occurs due to some circumstances. In general there are two types of time dilation which can occur, one which is due to velocity and the other one is due to high gravitational force which is been applied by nearby object eg- if we go on some other planet the rate of flow of time for us with respect to that of people on earth will be different We will also see the derivation of relative velocity and why even though if we consider that a person is moving at c/2 inside a train which is moving at c but still the velocity of man with respect to ground won't exceed c, we will also see what is the thing which will stop us from going into past.

II. TIME DILATION

This part is nothing but just a revision of the important concepts which we will require to understand why we can't go at c or in past. So as seen earlier generally there are two types of time dilation a) Gravitational time dilation and b) Velocity time dilation Let's try to understand what exactly gravitational time dilation is , no doubt it is the amount of time dilated due to gravitational force . So let's see how is this time dilation related with mass . To understand this let's consider a situation where we have a piece of cloth which is completely stretched and is tied from all four ends. After that we drop a marble on that cloth , as a result it provides some small amount of curvature on that cloth, now let's drop a golf ball on it , what we will see, it will again form some amount of curvature on that cloth but this time it will be more steep than that of previous one. So similar thing happens in this case when an heavy object is placed on space time curve, the object wraps the space time curve , as a result relative change in time changes.

The amount of gravitational time dilation can be easily found by

$T=T'[1-(2GM/ rc^2)]^{½}$ where T is the normal time, T' is the time which a person standing in high gravitational field will experience, G is the Gravitational constant , M is the mass of the body which creates gravitational field and r is the radial coordinate from the observer.

After that lets come to velocity time dilation. When we move at high velocities (comparable to c) time slows down for the person which is traveling at that velocity relative to the person who is in rest. With this even length contraction takes place in the picture. So what happens if we go on increasing our velocity, till we reach c, time moves comparatively slower than that of normal frame of reference which helps us to travel in future Once we reach at c, time is been stopped to the person traveling at c with respect to the one in rest and once we exceed the speed of light, we will go in past with respect to the person in rest. If we want to calculate the amount of time dilated we can easily calculate it by $T'=T/[1-(v/c)^2]^{½}$

Now let's see the most important thing

Why we can't travel at c **-** As we saw as we move with higher velocities, the amount of time which is been dilated goes on increasing, so ideally we should easily be able to travel at c, but what stops us from doing so. So the answer to it is, in this situation relativistic mass comes into the picture.

So let's see how exactly it is been derived As we know $dE/dt =Fv$ ------ 1

And energy of any particle at rest is mc^2 Now substitute $E=mc^2$ in 1 so we get $dmc^2/dt =Fv$

But $F=dmv/dt$ {Mass is variable} Therefore $c^2dm/dt =vdmv/dt$

Now by multiplying by 2m on both sides We get, $mc^2dm/dt =mvdmv/dt$

But as we know, $2m\, dm/dt = dm^2/dt$ and $2mv\, dmv/dt = d(mv)^2\, dt$ Therefore $(mc)^2 =(mv)^2 + k$

Now we know, at c=0 $m=m_0$ As a result $k=(m_0 c)^2$

Resubstituting value of k we get,

$(mc)^2 =(mv)^2 + (m_0 c)^2$

$m^2(c^2 - v^2) = (m_0 c)^2$ $m = m_0/[1-(v/c)^2]^{½}$

So as we now have equation for relativistic mass to, Now let's see what happens if one goes at c $m = m_0/1-1$ = infinite

But as we know first law of thermodynamics says that mass+energy in our universe is constant So one can never travel at c

Now as we know to go into the past with respect to normal frame of reference, one needs to travel at more than that of c. First of all its sure that nothing can travel at c , even though if we assume that an object moves with more than c, then what we can see is that relativistic mass of that object becomes imaginary and also is negative, which can't be true in at least our universe,as a result we can't ever travel at c

Now let's solve one of the popular question which is let's consider a person is moving with c/2 in a train which is moving at c. So as per simple formula of relative velocity one travels with c+c/2 =1.5c with respect to ground frame of referencebut this isnt true as this formula is only valid if we travel with velocity which are negligible in comparison with c and this is been derived by approximating $vu/c^2 = 0$

So let's see what actually happens Consider a person is moving at velocity u in a train which is moving at v with respect to ground. Let x' be the distance by the person who is inside the train in time t' Therefore x'=ut'

Now let's move to ground frame of reference, so the time and distance traveled can be easily calculated by Lorentz transformation

Therefore $x = (x' + vt') / [1-(v/c)^2]^{½}$

And $t = [t' + (vx'/c^2)] / [1-(v/c)^2]^{½}$

Now substitute x' = ut' in both equations Therefore

$x = (ut' + vt') / [1-(v/c)^2]^{½}$

And $t = [t' + (v(ut') /c^2)] / [1-(v/c)^2]^{½}$ As we know velocity=x/t

Therefore after dividing both we get

Relative velocity= $(u+v) / [1+(uv/c^2)]$

Now let's see what will be relative velocity with respect to ground of a person traveling with c/2 in a train with c

Relative velocity= 1.5c/[1+0.5] = c

As in Newtonian mechanics uv is quite small compare to c Therefore $1+(uv/c^2)$ is appropriately equal to 1

But at speeds which are comparable to c, we can't approximate $1+(uv/c^2) =1$

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REFERENCE

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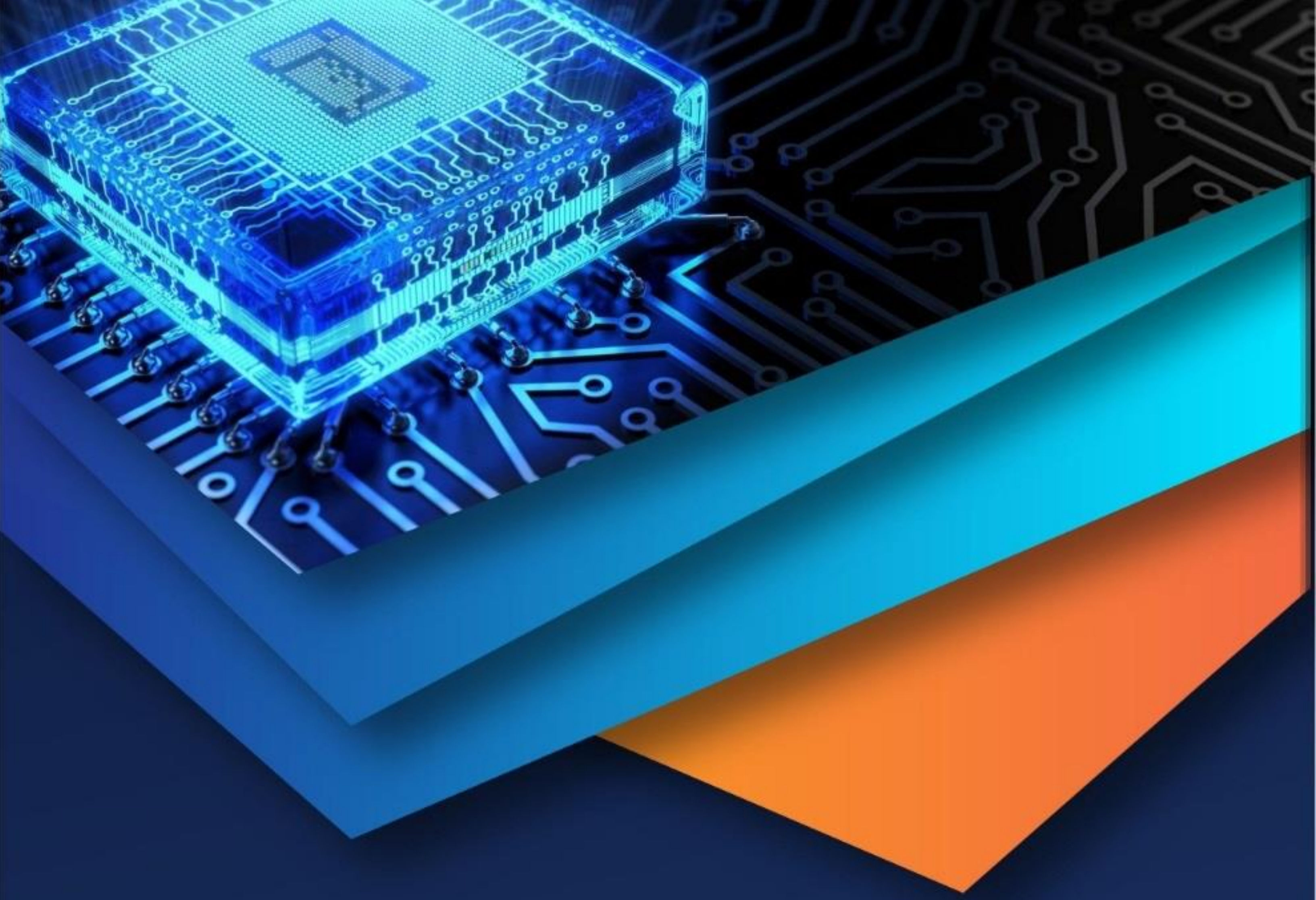

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