Geometric Model of Time

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Abstract: *The purpose of this article is to provide an alternative, strictly geometric, interpretation for the observed phenomenon of time. This Geometric Model of Time (GMT) is consistent with both Theories of Relativity but goes beyond current explanations for the nature of and the apparent one-directness of time - the so-called Arrow of Time.*
Key elements of the model are:

1. *Our physical space (not space-time) is a 4-dimensional phenomenon. The notion of a dimension of time that is distinct from space is not necessary for a complete description of our universe. All dimensions are identical and symmetrical. No one dimension can be singled out to be universally or uniquely labeled as "time" or be otherwise unique.*
2. *All physical objects in our universe are endowed with an axiomatic vectorial property we call velocity. The scalar value of this property (speed) is invariable and identical for all objects and is labeled as c (speed of light).*
3. *The experience of time as we know it is an illusion resulting from the observer's motion through space at c. "Time" is the term given by each observer to their own individual direction of travel in our physical four-space.*

This model is a better fit with observed phenomena than current ones as well as being simpler and more elegant, elegance being defined as having symmetry (in the sense that it treats no dimension as being singular).

1 Questions to be addressed

This model actually addresses two distinct, if related, questions:

1. What is time? (known as "the problem of time")
2. Why does time appear to only move in one direction? (known as "the question of the Arrow of Time")

2 Current problems with first question

The first question is often ignored in modern physics. It is simply accepted as just being there - another dimension by some interpretation, but one that is different from the three space dimensions. [1]
And even explanations such the entropy model (see section 3) mostly only address the second question.
The Geometric Model of Time (GMT) suggested here addresses the first question. And in the process effectively eliminates the second question because the answer is implied in it.

Even Einstein and Minkowski related to their own models of time as a 4th dimension as merely a mathematical tool, not literally as another physical dimension like space. The problem with that answer is it lacks the symmetry that physicists look for in identifying the laws of the universe. Why does one set of rules apply randomly to most dimensions and a different one to just single other dimension?
One of the well-established principles of physical sciences is that a rule with many exception is probably not the correct rule. Said another way the simplest explanation is usually the correct one. Essentially, this is a restatement of Ockham's razor.

3 Problems with current model of time as function of entropy

The most accepted current model for Time's Arrow, originally suggested by Eddington in 1928[1] and further developed by Boltzmann[2], involves entropy as an indicator of the forward direction of time. Second law of thermodynamics tells us that entropy of the entire universe, as an isolated system, will always increase over time, or remain constant upon reaching maximum entropy state. Entropy model of time relies on this law to define the Arrow of Time as that direction of time in which the entropy of the universe increases.

There are a few issues with this model:

1. The model only works if the universe and time are assumed to be infinite. (In any arbitrarily sized finite space, entropy can randomly increase for limited periods of time. Only in an infinite amount of space can the total entropy be assumed to unquestionably average out as remaining same or increasing).

[1] If M-theory is right, there may be more dimensions (10 or 11 depending on how they are expressed), but this does not in any way affect the ideas presented here. If anything, having 10 space-like dimensions and only one time-like one would make the asymmetry even more pronounced.

2. The total entropic state of this universe is assumed to be known (it actually cannot be), since the law is reached from noting that in all known cases entropy increased over sufficiently long time.

   There is, of course, also a simple statistical explanation for this; namely there are more ways for any group of constituents to be arranged uniformly (i.e. - in higher entropy) then in a more ordered (low entropy) way. But this statement of law still assumes we know the state of the whole universe and therefore know it increases in entropy over time. Not an unreasonable conclusion, but not a proven one.

3. As stated above, in any arbitrarily sized finite space entropy can randomly decrease for limited periods of time, yet there is no definitive indication that time either stops or reverses in those limited sections of space.

4. Increase in entropy based on 2nd law does not apply on microscopic levels, only macroscopic ones. Yet, one would be hard-pressed to argue that there is no time on the microscopic level, especially when noting the fact that when taken together en-mass all microscopic events add up consistently with their macroscopic sum totals. This idea is similar to what is known as Loschmidt's Paradox, which can easily found in any good encyclopedia and will not be restated here.
   One can indeed argue that since microscopic events, unlike macroscopic ones, are reversible, there is in fact no Arrow of Time on those levels. But saying that there is no definitive single direction of an Arrow of Time, is not same as saying time does not exist on those levels. After all, even if there is no one definitive direction of change, there is still a difference between the states of a particle in one moment and another.

5. Second Law of Thermodynamics does allow for entropy of even large system to decrease for short periods or remain constant even over long stretches of time if said system is it at its highest state of disorder. However, it would be highly questionable to claim that this means that time would actually no longer exists or stands still in said region (although, granted, it may be difficult to measure, or even quantify).

As a demonstration let us have a thought experiment.
Most familiar clock mechanisms rely on increase in entropy, such as the unwinding of a previously wound spring and such, or even the internal chemical processes within our body. However, this is not strictly a requirement. This alone should tell you of entropy's shortcoming as a model, but let us look in more detail.
An example of such a clock is a perfect pendulum clock (one with zero efficiency losses).

One such clock could be formed by any object in space, sufficiently far from gravitational effects, spinning at a steady rate in relation to an observer.
Let us design such a clock by spinning a wheel with markings on it in deep space and at a steady rate in relation to us.
Let us now put the whole contraption inside a large box.
The entropy inside said box may decrease, remain the same, or increase at random over any finite period of time. The very thinly populated particles of matter floating in space caught in the box during its construction may, purely by chance, all drift to be more densely concentrated in one area of the box than before. Yet, we'd still be able to observe and measure time as moving forward by counting the steady turns of our spinning wheel.
For simplicity, let us assume complete vacuum.
Of course if the observer is inside the box watching the wheel turn, then it is the observer's own internal clock that is adding to the entropy. Else they would not be able to know one moment of the wheel's position from another. This is reminiscent of the so-called Maxwell's Demon scenario.
However, if we place the observer outside the box (and therefore outside the isolated system), the system's total entropy will remain on average unchanged while it is sealed.
While the system remains closed and the observer outside, there is nothing we can say about the state of entropy inside the box, nor about the flow of time in it. That is part of the definition of the system being isolated. We may even call it a "Schrödinger's Wheel".
However, when the box is finally opened and we observe that the angle of the wheel has changed, we can say that time has continued flowing inside the box even while it was isolated despite the fact that there was no sum change in entropy. One can debate definitions and whether a tree really falls in a forest when no one is there to hear it, but this gedanken certainly meets all the criteria of what we experience as time.
Therefore time and entropy are only loosely connected at best.
It is as much an indicator for time as smoke from a train's chimney is an indicator of the direction of the train's movement. Useful one, to be sure, but not a fool-proof one.
Sure, in general and disregarding wind gusts one can use it to make good educated guesses of which way the train is going, but that is not to say that the smoke explains why the train goes one way and not the other, or how it came to leave the station in the first place.

In short, as Dr. Dave Goldberg, Associate Professor of Physics at Drexel University, puts it: Most would say that time makes entropy increase, not that entropy creates time.[3]

The Geometric Model of Time presented here eliminates the need to use entropy as part of the explanation.
The author, as some others have expressed, feels the entropy explanation gives us a mathematical general, though incomplete, way of breaking up time's symmetry, but it comes up somewhat short of explaining the mechanism by which time has "chosen" the direction it did for entropy to increase, nor why time has to always move at all. Entropy increases forward in time because the higher number of ways a system can be arranged more uniformly, but that leaves something very lacking in explaining why time moves in the first place. Furthermore, the entropy model can only explain the Arrow of Time when averaged over arbitrarily minimal spans of time and volumes of space, but not below those (i.e. not within smaller regions of space over shorter stretches of time).

4 An Alternative Model of Time

To avoid getting caught in everyday preconceptions of space and time as we are used to thinking of them let us dispense with the terms "space" and "time" and instead only use the terms "dimensions x, y, z, and t", and momentarily let go of all our preconceived intuitive notions of time and think of it as simply another dimensional axis.
Likewise, instead of "speed of light" let us use only c to help let go of our everyday concept of speed as a function of distance traveled over time. Instead let us think of it as simply a universal, unchanging, inherent, axiomatic property of any object within space (i.e. - our universe). Let us refer to this property as C, instead of "velocity" and to its numeric value as c.
It is similar to the way an electron's "spin" isn't literally a spin as such, but rather just a designation for a property which is somewhat akin of our everyday experience of a spinning object.
You are being asked to let go of these notions not so much because they are less correct, but because it will make the visualizations easier.

4.1 Recap of some established facts

Special Theory of Relativity tells us that nothing can travel though space (x, y, and z dimensions) faster then c.
But in the four-space x, y, z, t no object can travel faster OR slower than c. There is no other speed. As one speeds up along x, y, or z, one slows down in t. It is not a constant limit - it is a constant, period.
This statement is already mathematically sufficiently well-established to not warrant repetition here. Anyone not already convinced of this fact can find proof via simple math or by way of a rudimentary on-line search (e.g. - [4], [5]). Likewise, in order to not detract from the subject, discussion of the physical (as opposed to mathematical)

explanation of this is left to Section 13 below.

Now, a frame transformation is equivalent to simply tilting the axes in a 4-dimensional graph[6].
In other words, mathematically speaking, space and time are completely equivalent and fully interchangeable (which should have already been intuitively obvious from the similarity of the two Lorentz-FitzGerald transformations).

Of course, the naturally occurring question is - What, then, accounts for our distinctly different experience of what we call time as compared to what we refer to as space?

The answer proposed here is - nothing. Not fundamentally, anyway.
Mathematically speaking, the only difference is the velocity at which we are traveling along each of these axes.
The proposal of GMT is that the numbers tell us the reality. The rest is perceptual bias resulting from nothing more than our own tremendous speed at which we are traveling through t. Furthermore, traveling along any "space" dimension at c makes THAT dimension indistinguishable from our concept of time. i.e. it becomes the traveling object's "time".
Likewise the former t dimension simply becomes one of the object's "space" dimensions.

All massive objects appear to be traveling in the same direction of time because they are at least partially co-moving in the four-dimensional space. That is, their t directions are at least partially lined up.

This may be somewhat hard to grasp intuitively at first. After all, you can see space, but you can't see time. And you can go back and forth in space, but time only flows one way, or so it seems.
To help get over that hump, consider for a moment looking at a passing car as it goes by you on a freeway at 100 miles per hour and the way your vision of it seems to smear. Now try to imagine doing it at over five and a half million times that speed, while the space between you also stretches to infinity and your mutual notions of time or even simultaneity no longer match.
Chances are, your imagination fails. Our brains and senses are simply not wired to think that way and there is no comparable experience.
Which demonstrates how our intuitive sense of those things is simply not enough to make such determinations.

So let us examine these perceptions and reconsider them.

As suggested before, one must stop thinking of speed in the terms we are used to as distance of space traveled in certain time.
That is a useful convention in everyday life where most familiar objects speed through time remains nearly constant relative to us, but it loses all meaning when discussed in relativistic terms.

Now let us examine the differences more methodically and address them individually.

5 Geometric Model of Time

Gödel demonstrated that there are theoretically possible solutions to the General Relativity equations - such as his rotating universe solution - in which time does not exist. He then further concluded that time, therefore, does not exist in any universe describe by General Relativity. Einstein himself admitted to failing to find any error in these deductions. Nor has anyone else since then had success in this endeavor.
Likewise the renowned John Wheeler and some of his colleagues have argued that since dimensions are selected arbitrarily, no specific dimension of time can exist. In fact, time appears to disappear, so to speak, in the Wheeler-DeWitt equation.

Let us consider a hypothetical rotationally-symmetrical 4-dimensional space. All properties of each of all four dimensions are identical in all aspects and their designations are chosen at random save that they are always perpendicular to each other. Let us also imagine that it is a requirement of this space for any object in it to have a vectorial property of constant value and varying direction which we shall refer to as C as stated in the beginning of this article (or "four-space velocity", if you prefer). We shall call its non-varying scalar component speed and call its constant value c and select its units to be c=100%, or 1 (A.K.A. - natural units).
We may further call the direction of any object's velocity its "t".
Of course regardless of t's direction, one can always take vectorial component onto any non-perpendicular axis.

The Geometric Model of Time proposes that it is indeed thus in our universe and all other phenomena we perceive as time or as distinct space are in fact manifestations of the above described system.

Again, all objects have constant speed equal to c, only their C direction varies (and this gives their designated t).
Special Relativity shattered two previously held misconceptions about time - it showed that the center of time's coordinates, the "now", is not universal, and that the rate of time's flow is not universal. GMT goes further to state that nor is time's direction universal. And upon taking that view the non-universality of the apparent rate of flow becomes implied.

Let us look at two objects A and B on such a system whose expressions of C (four-space velocity vector) are precisely lined up with each other. i.e. - they are precisely co-moving in direction.
Since their speeds are already identical, they will appear to be stationary relative to each other. Before GMT we would describe this as the two of them moving at same rate though time and being stationary in space relative to each other.
In other words, both have their vector C expressed exclusively in each other's t direction.

Now let us consider A the observer and B changing its direction (while still maintaining constant speed c) slightly at an angle compared to A (Figure 1).

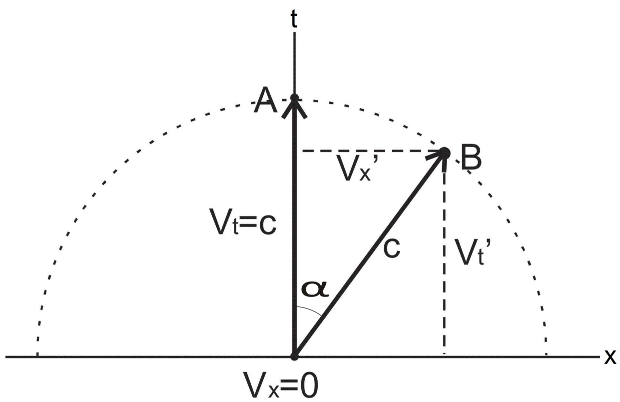

Figure 1

To the observer such object would appear to:

1. Be moving along x, y, or z (let us randomly designate the direction as x)

2. Slowing down along the observer's t.

Note that the axes show the objects' velocities (using natural units, where c=1 and v_t and v_x are fractions of 1) and not their positions as one may be used to from Minkowski's formalism. Here v_x' is the object's speed through space (in observer's frame of reference) and v_t' is their rate of movement through time (i.e.- the speed at which their time moves from the stationary observer's perspective), defined as the ratio between the moving object's time lapsed and observer's time lapsed. [2]

[2] If the reader prefers, we could easily formulate the same graph using "time" and distance traveled instead. If we use equivalent units (e.g.- seconds for time and light-seconds for space) or simply use Mankowski's convention of using "ct" instead of "t", then the velocity vector marked "c" in Figure 1 simply becomes always equal to t instead.

Notice that as B changes direction while its vector size remains the same and its angle relative to the A's vector changes, its tip traces out a circle of radius c around its base.
Of course, for practical reasons shown by Special Relativity (namely an objects relative mass increasing toward infinity as it speeds up in x and putting a cap on the vector veering more than 90°) the shape is actually capped off at a semi-circle on the positive side of t .
As the vector angles away from the observer, its component onto the original t and x shrink and expand accordingly and can be given as follows:

$$v'_t = c * \cos \alpha \tag{1}$$

and

$$v'_x = c * \sin \alpha \tag{2}$$

where α - the angle between the two objects' direction of motion in four-space - is the true measure of their relative emotion.[3]

Inversely, the angle α can be calculated from the relative motion of the object by:

$$\alpha = \sin^{-1} \frac{v'_x}{c} \tag{3}$$

Provided that if we go above 90°, the -/+ sign flips every 180°: for v'_t starting at 90° and v'_x starting at 180° (i.e. - for "time" after we pass the speed of light in relative motion and for "space" after we go back in time at full speed).

Or, combined:

$$v'_t = c * \cos(\sin^{-1} \frac{v'_x}{c}) \tag{4}$$

or, since $c = 1$:

$$v'_t = \cos(\sin^{-1} v'_x) \tag{5}$$

This demonstrates that the notions of a universal time which always flows in one direction, a fourth dimension that is somehow different from the other three, or even the concept of "time" in general, are all concepts completely unnecessary for the proper description of the universe. In other words, there is no evidence for the existence of any of any of these.
Of course, there is no evidence that any of these do not exist, either. But physical

[3]Note that (2) is effectively telling us that once an object passes the speed of light it is slowing down again and (1) tells us that at same time is starts moving backwards in time. And once it passes 2 x speed of light, it starts moving backwards in space, but forwards again in time, etc. This is also obvious from Figure 1. However, it was not previously so obvious from the Lorentz transformations.

sciences only deal with things that have physical manifestation. Theretofore the question is irrelevant.

What, then are the advantages of this new description and what new answers or perspectives it can provide?
Let us look.

6 Why we appear to be able to move in time only in one direction

GMT shows one can actually freely travel in either direction along any of the dimensions, including t.

Reversing direction in space, by definition, requires first decelerating and passing the zero speed point, even if for an instant, and then continuing accelerating in same direction, opposite from the original direction. Since all objects with mass with which we are familiar with are already traveling in what we usually consider the forward direction of t, in order to reverse direction they must first slow down in t to a stop and then pass it.

Since one cannot travel at any speed other then c, slowing down to zero in t requires speeding up in one of the other dimension to c. However, this is not possible since it would require an object with mass an infinite amount of energy.[7] That is to say reversing direction in time is possible, but according to Special Theory of Relativity is simply not achievable without infinite supply of energy.

7 Why one particular direction and not the other

The reason all observable physical objects appear to move in the same direction in time is that any object that happened to travel in the opposite direction at the moment of the Big Bang continues to get further from us in t with same difficulty in changing direction and therefore never intersects our path.
An experiment by Julian Barbour of the University of Oxford, Tim Koslowski of the University of New Brunswick and Flavio Mercati of the Perimeter Institute for Theoretical Physics involving a miniature simulated universe showed the spontaneous creation of two universes moving apart in different directions away from the experimental Big Bang moment[8].
Sean Carroll (ironically, a popular proponent of the entropy model of the Arrow of Time) and Jennifer Chen of Caltech suggested similar scenario in 2004[9]. Carroll and Alan Guth, father of the Inflationary Theory, have also announced they are currently working on such a model[10].

8 Why we can see space but not time

For a start, we cannot see space either. What we see are objects IN space.
The problem is one can never observe anything directly. We can only receive particles arriving to us from an event. And the particles can not arrive at us faster then at c.

According to GMT, time is actually no more than our word for whatever direction we are traveling in at the speed of light in relation to local space (defined later herein).
Let's look at what happens when you try to look at an event while moving away from it at the speed of light - c. The light arriving to you will experience the typical redshift due to the Doppler Effect in the same manner as observed with remote galaxies subject to Hubble's law.
The equations for radial redshift are given as:

$$f_{observed} = f_{emitted} / \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}} \tag{6}$$

and

$$\lambda_{emitted} = \lambda_{observed} / \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}} \tag{7}$$

As one can easily see, this means that as the velocity v gets closer to c, the observed wavelength tends toward infinity and the solution becomes completely meaningless (due to division by zero) as v becomes c.

As wavelength moves toward infinity, frequency tends toward zero. A wave of infinite length and zero frequency is not a wave at all. It is a static field. In other words - it can deliver no ongoing information about the emitting object.

The situation with looking forward is reversed, but essentially the same, with infinite blueshift. The wavelength becomes zero and the frequency infinite, making it as impossible to use the light to see the emitting event.

Of course "seeing" need not be literal. Any means of observation will do. So what about observing the future or past by use of other, slower than light, particles or objects?
I quick look demonstrates it is not much different.
When looking forward we are already subject to the universal speed limit c, thus using slower particles changes nothing. Looking backwards at an event from which we are receding at c using slower than c particles emitting or bouncing from it

means said particles simply never catch up with us. We are moving away from the information faster than the information is coming to us.

Thus, the only way to see either backwards or forwards in a direction one is traveling along at c (i.e.- in time) is via faster-the-light communications, forbidden by relativity.

So much for seeing the past or future.

That having been said, the word is still out on tachyons. If, however, they do exist, one could indeed use them to get information - that is, to see - across time.

9 Why we can remember the past, but not the future

The answer to this question seems to escape us specifically because it is so exceedingly simple.
Best way one can put it is: For the same reason you can see your footprints in the sand behind you but not in front of you.
In other words, within GMT causality still applies.

Let us consider a line. We can name its end points A and C and any third point somewhere between them B.
We can say that A is the beginning of the line and C as the end, or the other way around. But what we cannot argue against is that B will still remain sequentially between them.
So if we have a vector pointing from A to C, the sequence will always be A-B-C and no other.

This will be true whether we are talking about time or space.

Thus if an observer is moving from A to C, at any given B between them all points between A and B will "precede" B and therefore can have causal affect with B and all points between B and C cannot.

This appears to be what Amrit Sorli, Davide Fiscaletti, and Dusan Klinar at the Scientific Research Centre Bistra in Ptuj, Slovenia are talking about when they say that time is: "the numerical order of material change"[11]. Oddly, however, they derive the exact opposite conclusion, namely that Mankowski/Einstein description of time as a possible, or even symbolic, 4th dimension was simply a mistake and time must be a completely separate from and unlike space. However, especially judging from Fiscaletti's individually-authored *The Timeless Approach: Frontier*

Perspectives in 21st Century Physics[12], the apparent disagreement may only be semantic and due to their choice of formalism. The authors do distinctly agree that Minowski's formalisms indicated a four-dimensional space, and not space-time. The discrepancy appears to be in their choosing to consequently define time differently from GMT.

10 GMT and Gravitational Time Dilation

But time dilation and length contraction also happen due to gravity and not only motion. So we must examine if GMT still holds in such circumstance.

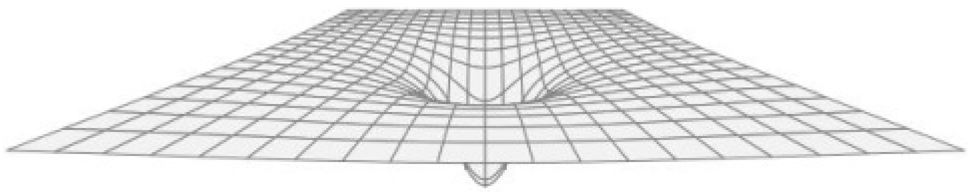

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Figure 2

Einstein's General Theory of Relativity tells us that mass warps space.
In the common 2-dimensional attempt to visualize this effect shown in Figure 2, we see the grid-lines bend, but more importantly to our case, they also stretch out and move further and further apart from each other inside the gravity well.
If we were to now recreate Figure 1 to demonstrate GMT in conditions inside a gravity well, this would have the effect of stretching out the scales on all axes.
This would have the same effect as the elongation of distances (or, alternatively, as the shortening of the moving object by comparison, as more commonly expressed in relativistic length contraction equations) and of an object seeming to move through time slower. This is completely consistent with General Relativity (see Figure 3).

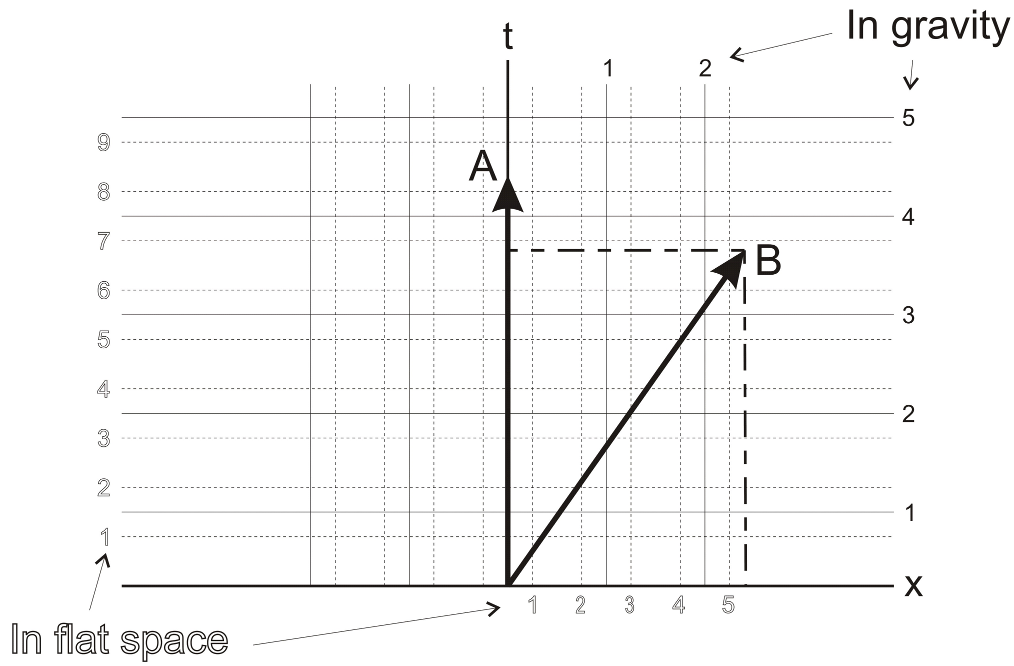

Figure 3

As in Figure 1, object A in Figure 3 is stationary relative to an observer, and object B is in motion. Both are inside a gravity well. Both appear to experience time dilation and length contraction relative to a hypothetical observer outside the gravity well in flat space. B also shows space expansion (i.e. - length contraction) and time dilation relative to A.
In other words, GMT still holds in full consistence with Theory of Relativity in warped space as well as it does in flat.

11 Time motion relative to what?

Since we are speaking of V_t for the observer themselves, an immediate questions that should come up is: "motion relative to what"?
The answer is - relative to local space.
The debate about the existence or non-existence of Absolute Space goes back to at least the time of Newton and Leibniz, but we need not necessarily stipulate Absolute Space as such. There need not necessarily be a universal frame of reference. One need only move relative to LOCAL space in order for this concept to make sense. By "local space" is meant the space in the immediate vicinity of the object's motion.

According to Newton: "Absolute Space in its own nature, without regard to anything external, remains always similar and immovable." But, of course, we now know it to be far from uniformly similar and immovable. Hubble's law and gravity

wells are some examples.
In other words, Absolute Space is commonly thought of an a uniform, universal frame of reference. This cannot actually be the case when space itself constantly changes in one location relative to another.
Space does, however, exist. We know space to have properties such as vacuum energy and positive or negative pressure. It can warp, shrink, and expand. It is not a nothingness.
Therefore is it quite conceivable that an object may be able to move relative to the space in its immediate vicinity at any given instance.
And that is exactly what is meant here by "local space".

Indeed, this is very reminiscent of the old aether concept, the existence of which was presumably disproved by the Michelson-Morley and subsequent experiments. But that is because the experiment was attempting to determine the direction of the earth's movement relative to this imaginary aether by comparing the difference in the velocities on one side of earth with that on the other, the assumption being that if the earth is flying through the aether, then one side is spinning with motion and one against it.
But we already know from GMT the velocity of ALL objects in the universe (such as measuring apparatuses on different sides of the earth) is ALWAYS c. So no such difference could ever be measured.
The experiment doesn't even factor in time, naturally assuming that space is 3D and all objects move though "time" in one direction. But if we take the model proposed by GMT, the experiment becomes pointless.
This point is so crucial, it must be restated: The reason experiments cannot measure the motion of an object relative to space is that this motion is always c, regardless of the object in question or the frame of reference.
Likewise, the motion of massless particles, such as EM radiation, can be though of as always being perpendicular to that of mass particles, and therefore will always measure at c relation to a massive observer.

Some will feel that is the same as the argument for Absolute Space or a Preferred Frame. And indeed GMT implies space to be a Preferred Frame. However, in GMT no object can be stationary in this Preferred Frame, only space itself. In fact, no object can move in reference to it at any speed other then c.
No doubt, many will feel reluctance to bring back such seemingly archaic notions. Yet if one models time as a 4th dimension, whether as merely a mathematical tool such as in General Relativity, or otherwise, one fact remains undeniable and must be contended with - in such four-space the speed of any object relative to the coordinates always equals to c. Not zero. Not even unknown. Therefore such Preferred Frame MUST exist.

An alternative way to think about this is the one hinted at at the beginning of this paper. Since velocity is an axiom, one can think of it as simply an inherent, unchanging property of all physical objects in our universe.
It is a property that is an absolute requirement for any physical object in our universe. Moving at c through our four-space is simply synonymous with existing in it. If there is something that does not meet this requirement, it simply does not meet the current definition of physical existence.

Undoubtedly, this will be the most difficult shift in thinking to confront in understanding the concepts presented within this paper. It is highly counter-intuitive due tho the way we have been programmed to think about motion.

In everyday life we are used to thinking of distance and time as being axioms, their units defined by standards (such as a calendar increments, a king's foot, or a prototype platinum-iridium bar) and speed being defined as distance per time.
The modern scientific definition, however, leaves time and speed as axioms, their units defined by standards (decay of cesium 133 atom and speed of light in vacuum). Distance, in turn is defined via those.
But, of course, one could flip those definitions and take distance and speed to be axiomatic and define time using those.
GMT does exactly that, but then gets rid for time as a separate concept altogether. Velocity remains as much of an axiom as it already was.

We can continue to define the units of speed as fractions of c and units of distance as an integer number of Planck's lengths. Planck's length itself is a standard and can not be defined.
In fact if all the Planck's lengths in the universe suddenly doubled in size, and the universe along with it, we would have no way to tell.

12 Reintroducing entropy

The critique in Section 3 was only against the completeness of entropy as an explanation for time. It did not imply the concept of entropy is incorrect. Not by far.
Nor did it imply there is no correlation between time and entropy, only that correlation is not necessarily cause or equivalence.

Therefore, let us now answer the question of how entropy fits into GMT.

Entropy appears to have an overwhelming tendency to increase forward in our perceived time.
But a change in entropy invariably requires motion. Physical motion - the motion of molecules in a gas, the falling of an object toward a black hole, the motion of

Hawkins radiation out of a black hole, the motion of sub-particles out of a decaying atom, etc.
And Boltzmann's old explanation for tendency of entropy to increase simply because of higher number of possible high entropy situations then of low entropy ones still holds for any vectorial change. Recall our discussion of causality in Section 9.

GMT states that time is our name for the direction of each observer's motion in 4D space. And in order for an observer to perceive any object as moving in time, it must be at least partially moving alongside that observer's C direction (motion in four-space).
Thus the ONLY systems in which one can observe change are ones which move at least partially alongside that observer in four-space.
And since change is simply statistically much more likely to result in higher entropy than in low one, entropy in general seems to always increase along each observer's own perceived forward direction of time.

It may seem very contradictory to say that observers moving in opposite directions in time can both observe an increase in entropy, but that is only if one is stuck in our intuitive, ingrained notion of time.
Once time is perceived as only motion in regular space, this seeming contradiction disappears.
Let us consider a specific example. Let us take two independent observers - Alice and Ecila - who are moving in opposite directions in the four-space (see figure 4).

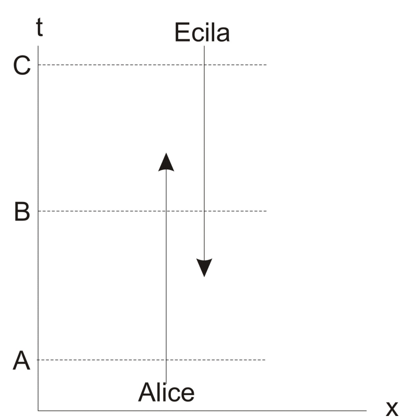

Figure 4

All the various positions each of the observers can hold on their C vectors constitute a mathematical space of states, or phase space (unrelated to the fact that they are also positions in physical space). This space of states along a vector is comparable to Minkowski's *lifeline* of said object.
This description of temporality as just a space of states has indeed been proposed

by many physicists in the past, too many to fully cite here. In fact, it can be argued to be the basis of the Block Universe model.

Let us at first consider the state in which Alice and Ecila are far away from each other and their C vectors point toward each other. Let us call this state m. In Figure 5 this would be marked by Alice being at point A and Ecila at point C.
In this state the entropy in their immediate vicinity may be different, but neither can know about the other's state of entropy because, as pointed out earlier, one can not receive information from the forward direction of their own C vector (in layman language - one can not see the future). Minkowski would have described the two states as being outside each other's light cones.

Now let us consider the state where Alice and Ecila are both at B. Let us call this state n. Naturally, being momentarily negligibly separated, they observe effectively the same state of entropy around themselves, but one that is higher then Alice observed at A or Ecila observed at C.
Lastly, let us consider a state we shall call o where Alice is at C and Ecila is at A. Alice observes entropy higher then Ecila observed at C and Ecila observes entropy higher then Alice observed at A.
Nor can either of them communicate to the other the observed state of entropy anywhere except at B, in which state they observations are in agreement.
There is no contradiction in this.

The reader may me moved to feel that this effectively reintroduces the concept of time. But that is only because our sense of time is so intimately intertwined with our sense of causality. Referring back, once again, to Section 9, GMT does not negate the principles of causality, only of the need for the distinct concept of "time" for explaining all known phenomena, in compliance with Ockham's razor.

Most importantly, one must understand that GMT does not seek to invalidate the *experience* of time, but only to demystify it and provide a better physical and mathematical model for the mechanism by which this experience is created. Even if GMT was to be proven to be the one and only known valid model for time, our experience of it would not change. Clearly, even after fully comprehending GMT one will not cease to personally experience the world, the mental construct of time included, in exactly the same way they always have.

13 Why all objects must be in motion. Why all objects must move exclusively at c.

In subsection 4.1 we looked at the fact that the speed of any object in our four-space can be mathematically shown to be equal c. Now let us look at the actual physical mechanism behind this requirement.

The minimal distance at which known physics apply, often simply described as shortest possible distance, is Planck length. Likewise, the shortest time is Planck time. These are the "steps" separating one state of the universe from another in the space of states discussed earlier. Motion can thus defined as the integer number of these steps between the positions of any object in question in two different states. Time can be defined as the integer number of Planck times between these two states. If we divide Planck length by Planck time the resulting figure is exactly equal to c. Mathematically, this may seem as no great surprise since Planck time is often described simply using Planck length with c as a multiplier or vise versa. And indeed it would not be very interesting if either was merely a randomly defined unit. But neither is. They are also, in fact, the actual shortest possible measures of each dimension. In other words, they are actual fundamental physical properties. Both are directly derived from a combination of three universal constants - speed-of-light, gravity, and Planck constant.
Could this be more than an amazing coincidence but rather point to the mechanism which determines these constants and how they relate to each other?

Let us again consider two objects - A, the observer - and B, a moving object.
In this example, we do not necessarily have to think of x and t in GMT's formalism. If one wishes to think of x as "space" and of t as "time", the following arguments will still hold. However, we do need to postulate against teleportation in either space or time (which should be rightly termed *temportation*).[4] That is, we shall speak here only of "normal" kind of motion, where in order to travel from one point to another, an object must traverse all space and all time between those points. Cases of apparently "instant" motion such as in quantum tunneling and possibly between tangled particles shall not be covered here. Such phenomenon are not being considered motion proper as the concept is applied herein (and to date have not been adequately incorporated into the framework of Special or General Relativity).

[4] By "teleportation" we mean here strictly a situation, such as quantum tunneling, where an object or information seems to instantly appear at a different location without being subject to the speed-of-light limit.
The term *teleportation* as used here should not be confused with the way it is commonly used to mean the breaking down of an object into its parameters which are then transmitted as data to be reconstituted back into the object at another location (as famously portrayed in the popular Star Trek television series and in recent years demonstrated in laboratory). Such teleportation is still subject to the light-speed limit and to our discussion.

Recalling the Space of States description from section 12, if we define *adjacent* states as two states that are different by the smallest possible number of these steps to not be identical to each other (i.e.- by one Planck unit), there are several distinct scenarios when we look at any two adjacent states:

1. Each object's positions in the two states differs by exactly one Planck unit. That is, B moved one Planck length and A moved one Planck time.
   1 Planck length / 1 Planck time = c. In other words, B is moving at speed-of-light relative to A.

2. B is less then one unit over and A is 1 unit over.
   This is not possible since we know change of less then Planck length is not possible.

3. B is more the one unit over, and A one unit over.
   At first it may seem like a possibility. But given our postulate against teleportation, in order for that to happen, there had to have been a state in between those in which B had to move only 1 unit. But this would mean that during that state A had to have either moved less than a unit, which we know to not be possible, or it had to have not moved at all between the initial and such intermediate state and then moved one unit. But there is no evidence that objects that are stationary in time while also stationary in space exist. Nor would we have any way of interacting with such objects. It would be questionable if such an object could even be argued to meet a meaningful definition of existence. In fact, it is the author's goal to prove in future papers that any such object, if it hypothetically existed, would actually have zero energy, very much like a subliminal massless object.
   So this scenario is not possible either.

4. B is one unit over and A is less the 1 unit over. Impossible due to same argument as 2.

5. B is one unit over and A is more then 1 unit over. Impossible due to same argument as 3.

6. Both A and B are in the same positions in both states. Impossible due to same argument as at end of 3.

Thus we see that the ONLY motion possible for any object in the universe is at c.[5]
Furthermore, since we see that the difference in the positions of ANY object between

[5] The only potential exceptions are, of course, quantum tunneling and between tangled particles, which already known not to be subject to the same understanding of motion and to date have not been incorporated into Relativity.

two adjacent states is always exactly equal to 1 Planck unit, the adjacent states can just as well be defined as two states in which every component of the universe has been shifted in position by exactly 1 Planck length.

13.1 Interesting side note

The often pondered question: "Why is the speed of light what it is?", is most commonly answered by invoking the entropic principle: "It just is. If it was any other value one would be asking the same question." A somewhat unsatisfactory answer as it gives us no insight into the mechanism
The configurations of the Higgs fields described by the so-called Mexican hat graph demonstrates that it was likely to settle around the value it did after the formation of our universe. But the above paragraph demonstrates that it is nothing more then the 1:1 ratio between symmetric dimensions and thus could not have been anything else. The real question is: "Why is the Higgs unit is what it is?"'
Though that in turn, is probably a meaningless question, for if it were to be scaled up or down, none would be the wiser as it is in fact the natural unit by which everything else is scaled, as pointed out by Planck when he wisely described them as *natural units*.
The only remaining valid question, then, is: "Why humans happen to be the particular range of proportions they are to the universal scale?" - hardly an interesting questions from a physics perspective.
We can even say that referring to c as a "universal constant" is somewhat superfluous, since as we can see it is actually itself results exclusively from the value of $\hbar$ - already a defined universal constant.[6].

14 Simplicity and symmetry

GMT's elegance (meaning simplicity and symmetry) manifests in other ways.
The following are some examples of how this actually shows up mathematically.

14.1 Vector designation

Currently, in order to describe a motion vector we need to specify three variables:

1. The direction of the vector
2. The rate of change along a "space" dimension
3. The rate of change along the "time" dimension

[6]Of course effectively this is indeed what happens when we use Planck's natural units where c=1

With GMT we need only specify the vector's direction.
Since the speed is constant, it need not be specified. The vector's component onto any specific axis is also already implied in the above information.

14.2 Fewer definitions

In another illustration take the concepts of time as space and accept them as being described as two different types of dimensions as is done in General Relativity.
For this we need to define or accept as axioms three terms:

1. The concept of space.
2. The concept of time.
3. The concept of dimension. For since both time and space are described as dimensions, but are not identical, the concept of dimension itself is a separate distinction.

In GMT, on the other hand, not only is "time" eliminated, but as a consequence we no longer have to distinguish between "space" and "dimension". The two become synonymous.

14.3 Mathematical symmetry - example 1

It is said that infinities (or singularities) are a measure of our in ignorance.
The well known Lorentz transformations only apply to below-light-speed relative motion. At speeds of $v \geq c$ the equations become meaningless giving us such atrocities as devisions by zero and square roots of negative numbers.
Of course this has not been much of a problem given that velocities outside that range are not usually encountered in our universe for objects to which time dilation and length contraction apply (i.e- massive objects). But what if one tries to include massless objects or the theoretical tachyons (which may yet prove to be real)?
As a matter fact, due to the square root in them, Lorentz transformations do not actually give you a definitive answer - ever. Each calculations yield two possible correct solutions - a positive and a negative. We simply then guess the correct one and conveniently ignore the other.
But even if we are to accept this, in order to cover all mathematically possible values of v_x, we must provide, two completely separate sets of equations (4 equations in total) to describe what is, in fact, a smooth mathematical continuum. Hardly a mathematical elegance.

Not only are [1] and [2] simpler and already cover all possible values, but we can actually use Figure 1 from this model to come up with a generalized form of Lorentz transformations to also cover all values, should we wish to do so:[7]

[7] Given that these are only given as examples, their actual derivation is not very pertinent to this article and is therefore left out, but can be easily verified by the reader.

Length contraction as:

$$L' = L * \sqrt{1 - \frac{(v - \lfloor v/c \rfloor * c)^2}{c^2}} \quad \text{for} \quad v \neq \lfloor v/c \rfloor * c \tag{8}$$

and

$$L' = \infty \quad \text{for} \quad v = \lfloor v/c \rfloor * c \tag{9}$$

And time dilation as:

$$t' = \frac{t}{\sqrt{1 - \frac{(v - \lfloor v/c \rfloor * c)^2}{c^2}}} \quad \text{for} \quad v \neq \lfloor v/c \rfloor * c \tag{10}$$

and

$$t' = 0 \quad \text{for} \quad v = \lfloor v/c \rfloor * c \tag{11}$$

Compare this with GMT's equations (1) and (2) which include all the same information.

14.4 Mathematical symmetry - example 2

In GMT there is no longer need for the opposite sign in front of one of the dimensions as opposed to the other three, like in Minkowski's equations.
Where Minkowski's reads:

$$x^2 + y^2 + z^2 - ict^2 = s^2 \tag{12}$$

GMT's equivalent, when using consistent units all around (second=light-second, etc.), would be:

$$v_x^2 + v_y^2 + v_z^2 + v_t^2 = c^2 \tag{13}$$

eliminating that awkward asymmetry.
And when specifically using natural units, just:

$$v_x^2 + v_y^2 + v_z^2 + v_t^2 = 1 \tag{14}$$

And if one must have fixed distances instead of rates of motion, then one simply multiplies each variable by t - time elapsed in observer's frame of reference, before incorporating it into the equation, making it:

$$x'^2 + y'^2 + z'^2 + t'^2 = t^2 \tag{15}$$

Where x', y', z', and t' are distances traveled in each dimension by a relatively-moving object and t is distance traveled by observer in its own time direction.

Another example is the fact that Minkowski's specially-defined space-time distance ΔS now becomes simply "distance".

14.5 Direct geometric representation

One of the most striking features of GMT is its ease or directness of representation. The drawing of graphs in mathematical representation of real-world events has always been a highly beneficial tool for the ability to create clear mental images of the correlation of the different variables. But GMT takes the explanation to a different level where the geometric descriptions of the graphs are also the descriptions of actual real world geometry. GMT, by it's name, is nothing more then a description of simple, real-world 4D geometry.
In other words, whereas Mankowski's charts of past and future light cones are only just that - charts, Figure 1, for example, can be said to be an actual drawing of a 2-dimensional slice of our space, save for the fact that the speeds are represented by the lengths of arrows (but their factual directions in said space are directly pointed at by the actual directions of the arrows). There are no imaginary axes existing only on paper.

15 Falsifiability

In its current state, GMT is primarily a new interpretation of existing information. As such it may seem as being in same standing as Hugh Everett's so-called Many-Worlds interpretation of quantum physics as an alternative to the older Copenhagen interpretation.
Its usefulness comes from explaining more elegantly some of the existing known phenomena and addressing some of the unanswered questions from the other models of time. It incorporates answers to these questions or does is with more simplicity, and , more importantly, demonstrates the lack of need for the superfluous concept of time as a separate phenomenon.

Unlike the above mentioned quantum physics interpretations, however, GMT is not inherently untestable.
For example, Charles R. Keeton of Rutgers and Arlie O. Petters of Duke developed a way to test for the existence of a 4th space dimension by looking for tell-tale miniature black holes within our own solar system[13]. National Science Foundation is funding their research which, as of last update, is awaiting data from the Fermi Gamma-ray Space Telescope (formerly Gamma-ray Large Area Space Telescope) launched by NASA in 2008.
Their methodology relates to a relatively-large curled-up dimension resulting from interpretations of a Randall-Sundrum brane-world model and therefore may not directly applicable for testing for 4-dimensional space as described by GMT, but it demonstrates the potential for such tests.[8]

[8]The two scenarios are not mutually exclusive and if Keeton/Petters team's turns out proven, we may actually be in a 5-large-dimensional space with one dimension curled up and 4 flat. Author

Only time will tell (no pun intended) which models will hold in light of new discoveries. Meanwhile it is the author's hope it may at the very least give new direction for further research.

15.1 Possible scenarios for testability

The next couple subsections are meant as only very general examples of the sort of scenarios for falsifiability that may be available - one in cosmology and one in the realm of Planck's length proportions. The more detailed study of such or any other possibilities should be subject of separate papers and work by experts in those applicable fields.

15.1.1 Remote receding objects

As stated by Hubble's Law - the space in our universe is known to be expanding at approximately 68 m/sec per Megaparsec.
If time indeed exists as no more than a 4th dimension of space with no one of said four dimensions being unique, then the Geometric Model of Time predicts that time must also be expanding at same rate (adjusted for units, where 1 sec. = 1 light-second).
Let us take two objects (see Figure 5) A and B which have zero *peculiar velocity* relative to each other within space. That is to say there is no relative motion between then EXCEPT due to the expansion of space. Because Time Dilation only has effect in relation to motion withing co-moving frames, it has no bearing here.

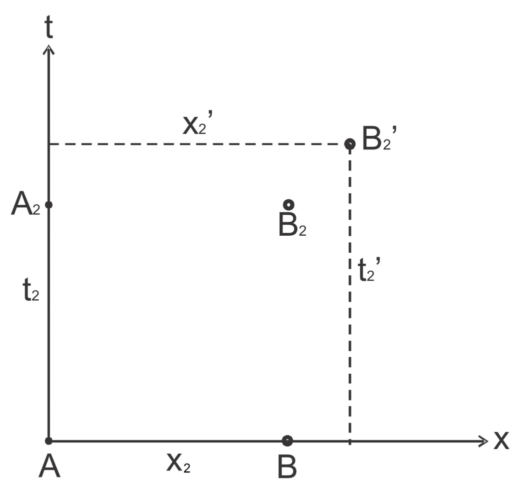

Figure 5

currently in dialog with Dr. Keeton to determine any unlikely overlaps in testability.

We start with A at $t = 0$ and $x = 0$, and with B distance $x = x_2$ away from it and also at $t = 0$ (from A's perspective and using same definition of simultaneity as given originally by Einstein).
Now, let us consider the two objects at time t_2 later.
A is now at $t = t_2$ and $x = 0$ (marked A_2). In a static universe B would now be at $t = t_2$ and $x = x_2$ (shown as B_2). However, in an expanding universe such as ours B would be at some larger distance x'_2.
And if, as the Geometric Model of Time predicts, time is indistinct from space than it should also be further away on the t axis by equal amount at a $t = t'_2$ (marked by B'_2).
That means that from A's perspective B traveled further in time. That is to say that to A it would appear as though time is moving faster for B.
Finding confirmation of this would serve as evidence for the validity of this Geometrical Model of Time.

15.1.2 Curled up dimensions

Other potential testabilities may present themselves within the Quantum Theory and/or Superstring or M-Theory (SS/M).
For instance, one of the questions often addressed in the study of SS/M is whether the additional 6 curled up dimensions are indeed all dimensions of space or if any of them may be additional dimensions of time.
One of the advantages of GMT is that it gives us a framework within which to actually answer to this question.
According to GMT, no actual separate time dimension exists and it is only the name given to the direction in our n-space in which each of us is moving.

Purely mathematically speaking, therefore, the answer would be - no, there are no other dimensions of time. An object can only move in one sum direction (or it would split and become two objects). And so whatever its combined motion vector is, regardless of through which dimensions, is its "time".
However, since the symmetry of the dimensions is broken in SS/M (some dimensions are flat and some curled up), it makes a lot more practical sense to break up this vector and think of the components as two different time lines one in curled-up, small dimensions and one in flat, large ones.

Since time is now defined as motion through space, we know it must exist in both types of dimensions - small and large, because we know motion exists in both.
There are then two possibilities:

1. This motion (i.e. - "time") is broken up between the two types of dimension based on a pre-determined ratio that does not change for all particles.
2. An object can divert its motion freely between all dimensions.

If option 1 is correct then we would simply have to say that speed of light is, and

has always been, somewhat larger than we thought because a fixed portion of it has been directed into one of the curled up dimensions. But there would have to be a mechanism by which this strict balance was determined and maintained. With no explicit indication of such, we must assume option 2.
Option 2 would mean that portions of object's c velocity can freely move between the small and large dimensions. In such case we should see a difference in a particles maximum speed through space when it changes to another particle (meaning when its pattern of motion through the curled up dimensions changes).And the total difference should be predictable by the analysis of the amount to motion each particles has in each of the smaller dimensions.

In either option 1 or 2, there should be some measurable difference we can look for. Why, then, have we not detected such a difference?
The answer is probably because A) We haven't looked for it and B) It is too small to be detected by current experiments.
Since the curled up dimensions are on the Planck's scale in size, we would require a measuring resolution somewhere around those scales to detect such variations.

That does, nevertheless, give us a place to look for falsifiability.

Some will argue that any predictions requiring measurements so far outside our current capability are pointless, but that has not prevented countless physicists from spending decades studying and developing SS/M despite the same objections. And science and technology have an uncanny habit of surpassing all our own expectations.

A concrete example can be made referring back to the work of Keeton and Petters. [13]
If their prediction of a much larger curled-up dimension in a range of as much as around 1mm turns out correct, it would also put the potential for detecting this "time leakage" within a reasonable range.

16 Conclusion

A purely geometric interpretation of time and space, where there is no distinction between any of the four dimensions is consistent with Theory of Relativity and other observations, while providing a much simplified and more elegant description than currently generally accepted models.
More specifically GMT demonstrates that the concept of "time" as its own distinct phenomenon is necessary for an accurate description of the universe.

17 Looking Forward

GMT also opens possibilities for new models or interpretations of other phenomena, currently under development by the author, such as a reinterpretation of rest mass as a kinetic energy of to the motion of an object through the t dimension, giving $E = Mc^2$ a much more literal interpretation.

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