Sheet 1

In this video lecture, let's call it the Bern Clock Redux, we're going to review a very important day in the history of physics. This particular discussion will be divided into two parts. And, taken more generally, this lecture is a prequel to a previous video lecture entitled, "Michelson's Error". We will begin with a scenario that helps us enter a very serious discussion. This scenario will open with our concept of the Aether as it was understood in the 1880s. In today's rendering of physics, the concept of an Aether is considered superfluous.

Now collecting notes, in this previous video lecture, "Michelson's Error", the 1887 interferometer was deconstructed, and sadly it could be misinterpreted that the deconstruction relies on some formal acceptance of the Aether, when only the rudimentary time/rate problem is being examined. In other words, the value of the assay developed in "Michelson's Error" seems to favor, even require, the concept of the Aether, and that is perhaps because Michelson was trying to prove the Aether existed with his efforts, when, in fact, the interrogation is a purely mathematical examination that requires no physical aspects. The fact that the Aether might seem affirmed as an after-thought by the deconstruction has little to do with the effort of the assay.

This present discussion, serving as a precursor to "Michelson's Error", will consider very simple, very flat time/rate scenarios. And in that regard, we harken back to the Cartesian model that much preceded any concept of the Aether. Thus, in the Classical period, we understood that a person could move from point A to point B through space and know it was that person that was moving - with a particular rate in a particular direction. Here's the key point – in classical times space was a reference frame, but with the advent of Special Relativity and the establishment of Relative Rest, space lost its value as a frame of reference. Absolutes disappeared, and the Cartesian realm became a ghostly facade.

So let's look at this first scenario with hopes that we can lend some aid to the argument in "Michelson's Error" by teasing out some of the ghostly artifacts that seem to persist.

Sheet2

Here, we find it has finally happened that Elon Musk has invented a transparent spacesuit that is only two molecules thick. And we see him wearing it as he floats somewhere outside of our Milky Way galaxy. Now we ask ourselves, what does it mean when we consider the question: “what is his frame of reference?” It looks to be sure that the only true frame of reference is the space around him. He floats as an unbounded entity enveloped by a sphere that contains – well – everything. Now what is critical to this question has to do with how radiation is flowing through the frame of space all around him? So what does that mean?

Sheet 3

Well, it means this: if a star goes supernova one light-year away from where he floats, then, when the resulting wave-front gets to him, he will have a very bad day.

Sheet 4

He will be dis-associated by the radiation blast. Which leaves us to consider the exact same supernova happening 500 light-years away.

Sheet 5

At 500 light-years away, he might get a bit of a radiation burn when the wave-front arrives, but the damage to him would be minimal. And this is because in his frame of reference, which is all of universal space, there is a phenomenon operating on both blasts of radiation.

Sheet 6

Of course, we're talking about the inverse-square law, which is responsible for the different outcomes EM would experience. This is because the inverse-square law maintains that as radiation migrates through space, its energy dynamic falls off with distance. Meaning, if the supernova is only one light-year away, the radiation hasn't dissipated very much. And so it is a very hi-energy wave-front that hits him. The supernova occurring 500 light years away, however, sends a wave-front that, on arrival, is much reduced through dissipation by dint of this inverse-square law.

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So all of this is easy enough, but let’s throw in a complication. So let's say a racetrack appears, and EM finds himself going round and round it at very near the speed of light. Under Einstein's edicts, his local time, to all frames that look upon him, has very nearly stopped. But, again under Einstein’s edicts, EM carries on as though time is passing with the same normalcy that it had before the racetrack appeared. The problem is that this race track is still only one light-year away from the deadly supernova, and regardless of what definition of time applies to him, this blast wave is going to come through and evaporate him.

Sheet 8

And it will evaporate him at - and the only term I can think of is - the universal rate that this wave-front maintains with respect to his original, meaning spatial, frame of reference. So it seems that energy is being delivered by dint of a singular time reference that does care what is the allocated time reference for EM. In-other-words, if EM is a-okay when time stops for him, how can he then be dissolved by a wave-front that is passing through the ambient space he occupies. Moreover, the radiation blast itself is moving at light-speed and so can be said to have its passage of time equal to zero, and yet the inverse-square law is not stopped. The inverse-square law is helping us to see ghostly vestiges of Cartesian reasoning.

The point of this scenario, this space-as-a-frame-of-reference scenario is to consider seriously that the radiation is very actively distributing its energy through this region of space at one transmission rate. Now, as we've mentioned earlier, in the 1880s terms, the transmission medium of light was presumed to be the ubiquitous Aether - mainly because light exhibited properties of a wave, and waves are thought to require a medium. And so, the Aether was invented as a medium to transmit these wave functions. Light was also, and again, we thank Einstein, interpreted as quantized. And so it had properties that are particle-like. Light is quite the chimera.

But, for our simple case here,

Sheet 9

we have to accept that even today, we're very fearful of some gamma ray burst from a star going nova in our local star cluster. Though such a nova, given the known distribution of stars around us, would necessarily be 20 or 30 light years away, it would still be considered very, very dangerous to Earth. And that's because - forget Earth's local time modulation - the energy from such a bursting supernova will travel at *c* through space. And if the inverse-square law does not have enough time to dissipate the wave-front, or the law does not have enough space to dissipate it - take your pick - then we will be blasted and Earth seriously damaged by this this burst.

And so, comparing the two supernovas in this case, the distance between them is critical, and we are very wont to use a Cartesian argument for this distance – in other words, something that reminds us of an absolute measure - when we apply the inverse square law. And when things are perceived to have relativistic velocities – EM racing around the track - then you must factor in length contraction, which quickly creates a complex rendering for such scenarios as this.

All of this said, I think, globally, an astronomer will still say, "Please, let's not have a supernova anywhere within the next 100 light-years, please no, a lot of damage could happen." And that plea is based on our concept of time, and our concept of length - however misbegotten they may seem when other cross-linked frames of reference examine us.

If we are seeing ghostly vestiges of Cartesian analysis exemplified by the inverse-square law, where very simple time/rate behaviors can develop in open space, then perhaps we can look at something that was just delivered to us from the Hubble telescope not long ago, and give it an extra spin.

Sheet 10

Stop--- setup varistar

Varistar video

What we see here are a series pulses emanating from a variable star that Hubble observed. When strung together in a time-lapse sequence we can behold a scintillation that would scarcely reveal itself without such time-lapse condensation. There is a very interesting Cartesian argument to be made here.

Sheet 11

What we're seeing are nearly perfect spheres of radiation leaving a star and imprinting a wave into the surrounding dust clouds. Assume that - at some point of tangency to one of these pulses - we establish a mirror that reflects a beam straight back along the path on which it is traveling. Our key assessment here is that when the light has been reflected back, it will pass through a point in space, from which, the source has already moved. This observation helps us establish the Cartesian idea that a point in space is a meaningful thing.

Sheet 12

Indeed, we know it's a meaningful thing, because astronomers have told us from the earliest days, that when they aim a telescope at a point of light in space, they can gather pertinent data about the star on which they are focused, but they understand, the star is truly no longer at that point in space. They are looking at a path that would go straight back through the point in space where the source and the light separated. And the general Cartesian value this suggests is that the star, as it moves along its path in space, produces, meaning – emits, a bit of radiation that begins a journey through space, with its origin actually being the point in space where the source and the star separated. And so begins a very real, very simple time/rate progression, structured in a very Cartesian reality. The photon will leave that point in space and travel what would have to be considered a vector. This particular photon will travel in a specific direction, at a specific velocity. And all other photons that leave the star, in all their independent spherical directions, are defined the same way. They're all going off into space carrying the energy that will interact with space, itself, by virtue of the inverse-square law, all based on this point in space. This overview helps us establish a Cartesian-class locus to which we can apply a very simple time/rate expression, if we want to study what happens to this pulse of light as it leaves the star.

So, part one of this discussion is trying to explain how - if one is uncomplicated about it - one can see very structured elements and conditions, which go on to inform reconstructed exercises using very simple time/rate analysis, where we find length and the transmission of entities to be unwavering - whether they be mass-like or radiation-like.

Additionally, we can include in such cases, the very obvious physical manifestation of light as a clearly described vector in Cartesian space, when we look at starlight aberration in our telescopes.

Sheet 13

Aberration of Starlight - The apparent displacement of a star's position as a consequence of Earth's motion through space and the finite speed of light.

This definition of Starlight aberration is making our Cartesian case where we see it describing the vector nature of light integrating with the pure motion of Earth. All of the light beams have very specific vector-paths to follow, and as the telescope on a moving Earth tries to collect them, the incoming rays are offset by the time they get to the bottom of the telescope.

The logic scenarios we have examined provide an important prologue that brings forward some ideas seemingly laced with ambiguities because Special Relativity and Relative Rest demand so much revision of very basic ideas.

Sheet 14

In a Cartesian context, a space traveler can move from point A to point B at some given velocity. In a relativistic context, point A leaves a relative rest observer and point B approaches said observer – each manifesting the same rate. Also, both point A and B are shrunk due their motion by $l(\sqrt{1-u^2/c^2})$; and time for them is dilated by $t/\sqrt{1- u^2/c^2}$.

We are making much of these Cartesian artifacts that still seem to be with us, even after the Relativistic Revolution, to hi-lite a key issue that anchored the thinking by Einstein that occurred on that important day we mentioned at the outset.

Sheet 15

It seems that Einstein worked for the best part of a decade trying to resolve how Newton's world view squared with Maxwell's worldview, and vise-versa. On a certain day in May, 1905 Einstein had a long discussion concerning the matter with his confidant Michele Besso, at the end of which Einstein essentially surrendered deriding himself for having failed and announced that he was to be done with the problem. But later that evening, after he had returned to his apartment, the Bern clock tolled and that put him in mind of the streetcar that ran near it. All of a sudden, he is imagining the streetcar to be leaving the clock-tower at light-speed, Einstein riding along with it. He notices his wristwatch is running properly, but the Bern clock had stopped. It is here that the idea of clocks running at different speeds broke like a storm in his mind. And working assiduously he finished a paper that introduced Special Relativity six weeks later.

Our project here leaves us to look doubly hard at his first impression of the clock and the streetcar. And as we have noted Cartesian artifacts throughout this discussion, it is critical that we note how completely Cartesian this first impression really is. Without any reference to the Aether and without discounting it, Einstein produces a completely common time/rate scenario in this construction of this racing streetcar and frozen clock. The light leaving the clock can be described as an entity having a rate through space; the streetcar can be described as an entity having a rate through space. They are both traveling the same direction which is germane to their integration with one another. The information carried by the light-beam, as Einstein achieves light-speed, alights on his eyes - and no other can catch up. If that light is carrying information indicating it is 12:00pm, i.e. noon, then the clock will freeze at noon and never report even one second after. Newton, Galileo, Descartes - all understand this outcome perfectly. Were Einstein to slow the streetcar, Bern clock would slowly begin to move - and by the time the streetcar found itself at rest, both clock and wristwatch are keeping the same time. In his seminal paper Einstein works out that the Bern clock is subject to a classic time/rate expression; it slows with respect to his wrist-watch by $t/\surd 1- u^2/c^2$. This is correct and reasonable, but to solve his larger Maxwellian problem, he must witness all clocks in the universe to stop while he is at light-speed on the streetcar. Thus an observer moving at c perceives himself in a perfectly normal state, this makes Maxwell happy. Said observer witnesses all other clocks to have stopped; Maxwell shrugs and says hmmm? Einstein comforts him and reports that all clocks have their own time keeping, and that makes Maxwell's equations work because each is in its own Relative Rest state. Maxwell happy again. Newton, astonished, walks off the playing field. Einstein shrugs "I only went where the empirical thinking led me…"

With this passion play ended, we are here to complete the Bern clock scenario using Einstein's first impression, which was completely Cartesian. It is an important exercise and helps support the thinking in "Michelson's Error".

Which brings us to Einstein on the speeding streetcar car experiencing a frozen Bern clock. His experience as we've noted exists because light carrying its information from the clock is flowing through space at the same rate and in the same direction as he is on the streetcar; the Bern clock cannot update.

Sheet 17

So here we see it, we see the basic setup for a Bern clock Redux. Except in this case, we're going to have a Bern clock, South Station and a Bern clock, North Station. And what we're going to find is that they are separated by ten light-minutes. And along the way, at every one light-minute mark, we have a motion-activated streetlamp that will indicate any passage of an entity moving along the track. We're going to look at this setup as if the streetcar were traveling very, very near the speed of light.

Bern video

So let's put Einstein and his streetcar in motion, watching as he travels from Bern clock, South Station towards Bern clock, North Station Here he goes. Halfway there already. And he finally gets to Bern clock, North Station. Now let's pull him back and reassess. If we're saying that he's moving at near the speed of light, let’s accept that it is the speed of light he’s travelling as he passes Bern clock, South Station. So, sure enough, he finds himself seeing that Bern clock South reports it is 12 noon. And it will report that time for the continuation of his journey, all the way through to the Bern clock, North Station. He is simply traveling with the wave-front that has, like a snapshot, only one collection of information in it. And so as he looks back, he sees the Bern clock, South Station only reporting noon, it never changes. So he travels 10 light-minutes from the Bern clock, South Station to the Bern clock, North Station - and all he ever sees from the south-station clock is it reporting 12:00.

Now we notice there's a clock keeper at the Bern clock, South Station. And he, of course, sees Einstein and the streetcar pass and disappear into the distance. And exactly two minutes later as registered by the clock above his head, he sees a flash from the first motion activated streetlamp Einstein triggers as he passes. It has flashed and sent a signal back to the South Station. Well, okay. It took Einstein a light-minute to get there, and then it's going to take a light-minute for the flash to get back. So for his local time, the clock keeper sees Bern clock South, reporting 12:02 when this signal from the first streetlamp gets back to him. And guess what is globally true from the Cartesian argument? Well, it is globally true from the Cartesian argument regulating this scenario that Einstein would in fact be at that instant two light-minutes away. And here’s the conservancy of the argument: from now on, as Einstein triggers each streetlamp, light goes back towards South Station as he travels toward North Station, both at the same rate. And so the clock keeper at South Station will see a flash every two minutes, and he will see the tenth flash a twenty minutes after noon. It took Einstein 10 minutes to get to North Station and light 10 minutes to get back to him. Einstein’s journey to North Station took 10 minutes, the incremental reporting took 20 minutes. The clock keeper, good at his Cartesian analysis, knows Einstein is in fact 20 minutes down the line when the flash from the North Station arrives - simply confirming that he made the ten-minute journey on time – assuming he was to arrive at North Station at ten after the hour.

Now, we know Einstein will only see the South Station clock reporting 12:00 noon for the entire journey, but what does Einstein see as he trains his telescope on Bern clock, North Station? Well, the instant he leaves Bern clock, South Station, he begins to spy on Bern clock, North Station. But what does he see? Well, he sees light that has traveled 10 minutes to get to this point in space he occupies beneath Bern clock South. So he sees Bern clock North reporting ten minute to midday, even though he's passing through the South Station that's reporting exactly 12 noon. Assuming they are properly synchronized, he understands that it took ten minutes for light to get his current point in space. So he's not lost. He says, "Oh, the clocks are very well coordinated here." And so it goes, as he gets to the first street lamp, two minutes have lapsed on the clock at Bern North. Obviously, as light made its way to Bern South from Bern North, Einstein made his way to Bern North at the same rate. And so it goes - for each streetlamp he encounters - two more minutes have lapsed on Bern clock North. As Einstein reaches the fifth streetlamp on his journey, the Bern clock North reads 12 noon. And when he gets to Bern clock, North Station, it reads 10 minutes after noon.

So what is Einstein to make of his collected data. One clock reports zero time has elapsed; the other reports that 20 minutes have elapsed. If Einstein is allowed to understand that the light traveling with him from Bern clock South was passing each streetlamp at c, and he also can know the distance between the two stations, then first-order deduction would tell him that ten light-minutes passed as he went from South Station to North Station. He was traveling at c and space conserved the integrating behaviors, as it should if energy is to dissipate in accordance with the inverse square law.

Of course, the South tower clock keeper, now aware of Einstein's paper, observes Einstein to be moving at c and applying the relativistic operator $t/\sqrt{1- u^2/c^2}$, he is certain that time has stopped for Einstein.

What we have been exploring in the Bern clock Redux are the issues that seem to super-circulate when one considers very simple time/rate scenarios that must be overlain by Special Relativity and Relative Rest. Consider Einstein on his way to Bern clock North – as he passes a streetlamp, light leaves it at c, which overtly leaves Einstein to be separating from that wave-front at 2c. Now watch the fandango that occurs which Lorentz supposedly fixed. Somehow 1 light-second per second must disappear. Conveniently, Einstein at his uniform velocity can't know he is moving; he is at relative rest to the scenario – for him all other entities possess motion. He therefore is allowed to apply his special math operators to any such entities. For Einstein, the clock keeper's time at Bern South has slowed by $t/\sqrt{1- u^2/c^2}$, which effectively means it has slowed to zero. Also, applicable to the clock keeper is the contraction of length. When Einstein applies $l(\sqrt{1- u^2/c^2})$ to clock keepers frame it also shrinks to zero. Now we must be careful - this contraction applies to the dimension along which the frame{clock-tower} is moving. But of course it is moving straight away from Einstein so it shrinks down to one thin film – there is no depth of field for the clock-tower. It is worth recalling Einstein's original impression of the clock stopping - and noting that no information will update due zero differential velocity between light and streetcar. What we must keep uppermost in our minds is the fact that, forget the hands, no other information will update. By proper Cartesian reasoning, Einstein understands, assuming he achieves light-speed just as he passes Bern clock South striking Noon, that image will never update. Meaning the Bern clock will never recede into the distance. That snapshot of information will lie gently, unchanged forever, as a film upon his eyes. It seems he took the next six weeks to concoct the math that would define this film resting in his eyes – its time shrunk to zero and its depth of field shrunk to zero. What we're attempting to say is that he might have consulted Bern Clock North in the middle of his cogitations. It could be that it can be said that Bern clock North is approaching him at c and maybe one could apply Einstein's operators to the tower, but space is impregnated with information that forces the clock's manifestation to update itself in Einstein's frame. Einstein would perceive the North clock as running, not normal to his local time, but hyper-normally. And, of course, Bern clock North's depth of field could not be forced to zero by the length contraction operator. Einstein could easily perceive a bird flying behind the clock and a bird flying behind that one and so on - as time updates, so does depth of field.

Again I am only one who thinks Relative Rest blinders an otherwise sentient creature. In "Michelson's Error" I try to show how such a creature might reason through and then build a device that thwarts this blindness. I am only hopeful the good listener will go on to entertain "Michelson's Error" with a thought that some of this Cartesian thinking has merit.