Theory of temporal extension in special relativity, and a possible connection with "jumpy" light beam photography

Áron Szűcs, PhD
Principal R&D Engineer,
ABB Motors and Generators, Technology Center
&
The University of Pécs, Hungary

“Perhaps a thing is simple if you can describe it fully in several different ways without immediately knowing that you are describing the same thing.”
Feynman Nobel Lecture

"... continue to inspire those who suspect that what is proved by the impossibility proofs is lack of imagination."
John Stewart Bell

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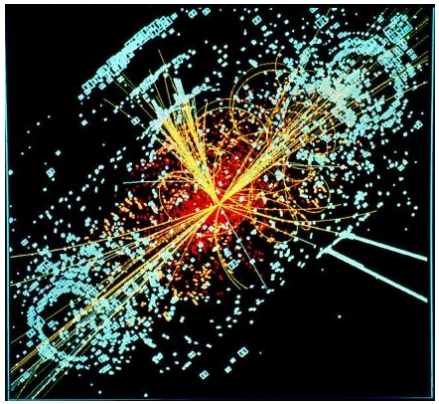
Introduction

- Long story short:
  - An engineer working on coupled simulation develops a numerical method inspired by a physics theory idea.
  - In need of a reference he publishes the theory and receives feedback from physicists for a journal paper, which is published in IOT.
  - Continues to work on the numerical method and would like to consult with mathematicians with experience in both exotic theories and numerical simulations, to advance his coupled modeling technique also.
  - Has some further observations for the impact of the theory for SR and for recent light in flight photography.

Modeling philosophies for systems and multi-physics

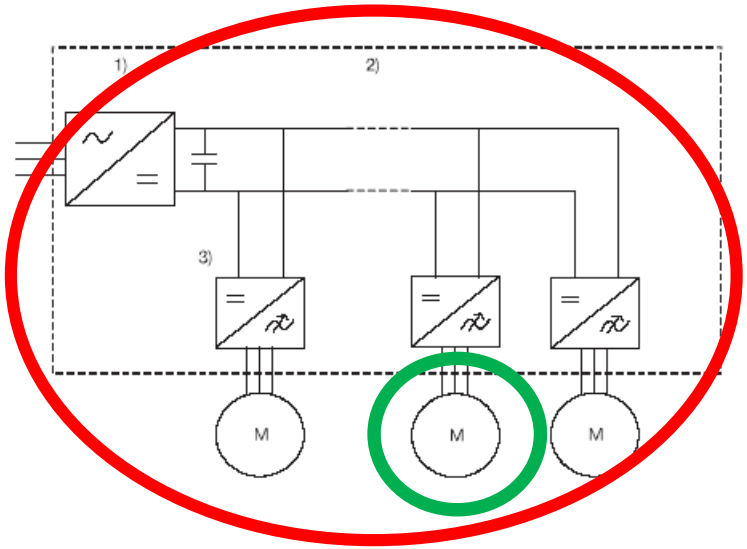
- **Philosophically:** In the physical world is there anything, what is not part of a system, or is not made of sub-systems? Is there other than multi-physics?
  - "System Model making" is part of everyday life...
  - We use reduced models of systems and multi-physics problems
- **Technically:** The "final" goal of a "system model" for a
  - Scientist: The theory of "Everything"!
  - Engineer: Make "the thing" work, within limits! (time also)

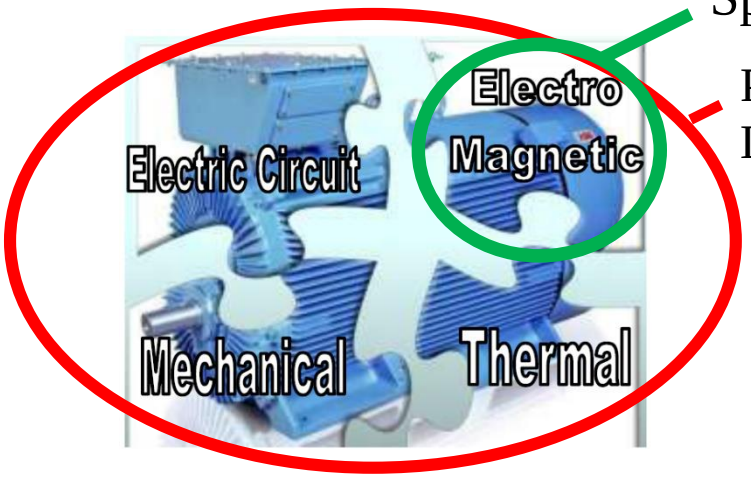


- **Model as much as we need,**
  not as much as we can

Engineering approach to multi-physics and system modeling

- **The engineer's model making principle is: How to simplify in order to keep the relevant properties in the model?**
- The "traditional" engineering approach is the separation of a complex problem into component models and / or physical sub-domains.
- Divide the big problem into subtasks – with clear boundaries – for specialists
- Share work load & responsibility
- Division along component boundaries: **System modeling**
- Division along physical domains: **Multi-Physics modeling**





Specialist

Project manager,
Lead engineer

The intuitive picture of the world … and the lack of it.

- Wave Particle duality – Double slit experiment
- Heisenberg Uncertainty principle
- Probability wave function
- Bell's Theorem

"Albert Einstein called the intuitive or metaphoric mind a sacred gift. He added that the rational mind was a faithful servant. It is paradoxical that in the context of modern life we have begun to worship the servant and defile the divine."
Bob Samples, 1976

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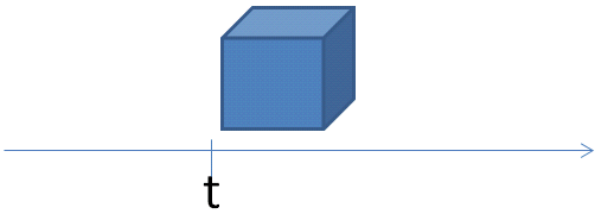
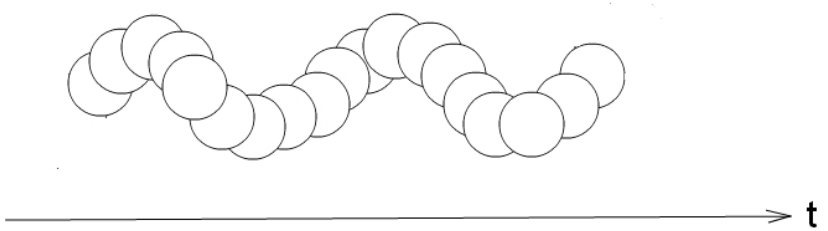
John Stewart Bell

- Special relativity
- Locality vs. Non-locality, Need for a new understanding emerges?
- How about String theory, E8, and other TOE candidates …

Observations in QM and Spec. Rel. pointing to temporal extension.

- Space-Time is an accepted concept and Space and Time cannot be separated.
- Symmetries in QM are defined for both spatial and temporal coordinates.
- Special and General relativity show ”strong coupling” between space and time. (e.g.: Lorentz factor)
- Quantum space time - quantized time (could it mean extension?)





- Particles in QM must occupy several spatial coordinates at the same time. (Probability wave function, Schrodinger, Bell, Copenhagen interpretation)
- **Why not to allow extension in time the same way as we experience in spatial directions? Could it be the key to an intuitive picture?**

Formulations in Quantum Symmetries and Special Relativity pointing to temporal extension.

- Contrary to pure rotations which transform spatial coordinates into each other in space time, Boost matrices in Lorentz group describe a transformation of temporal coordinates to spatial and vice versa to describe transformations between frames with relative velocity.

Pure rotations

$$\hat{R}_x = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \cos(\Delta\theta) & -\sin(\Delta\theta) \\ 0 & 0 & \sin(\Delta\theta) & \cos(\Delta\theta) \end{pmatrix}$$

$$\hat{R}_y = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & \cos(\Delta\theta) & 0 & \sin(\Delta\theta) \\ 0 & 0 & 1 & 0 \\ 0 & -\sin(\Delta\theta) & 0 & \cos(\Delta\theta) \end{pmatrix}$$

$$\hat{R}_z = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & \cos(\Delta\theta) & -\sin(\Delta\theta) & 0 \\ 0 & \sin(\Delta\theta) & \cos(\Delta\theta) & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Lorentz Boost –Spacetime rotation

$$\hat{B}_x = \begin{pmatrix} \cosh(\varphi) & \sinh(\varphi) & 0 & 0 \\ \sinh(\varphi) & \cosh(\varphi) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$\hat{B}_y = \begin{pmatrix} \cosh(\varphi) & 0 & \sinh(\varphi) & 0 \\ 0 & 1 & 0 & 0 \\ \sinh(\varphi) & 0 & \cosh(\varphi) & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$\hat{B}_z = \begin{pmatrix} \cosh(\varphi) & 0 & 0 & \sinh(\varphi) \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \sinh(\varphi) & 0 & 0 & \cosh(\varphi) \end{pmatrix}$$

- This kind of transformation would allow – and could also be interpreted as – a transformation of spatial extensions in a certain dimension into temporal length and back between moving frames.
- Such interpretation points to the possibility of temporal extension of physical objects.

Relativity of Simultaneity hinting temporal length.

Einstein's observation was that events which seem simultaneous for the standing observer, are not so for the moving observer. The events can be transferred from one coordinate system to the other by the Lorentz transformation.

Relativity of Simultaneity hinting temporal length.

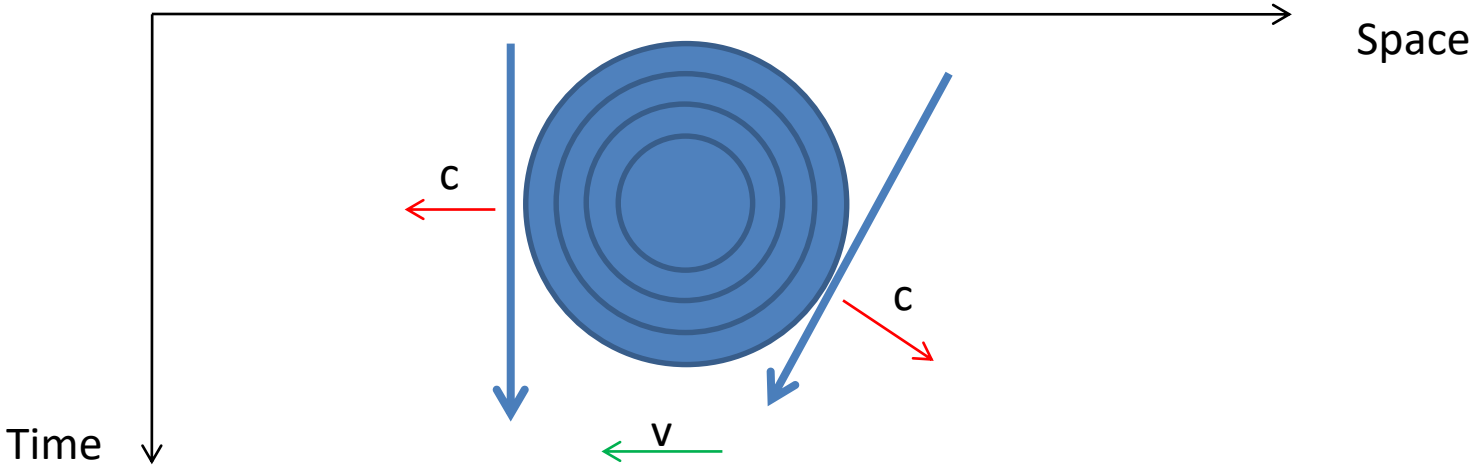
Einstein's observation was that events which seem simultaneous for the standing observer, are not so for the moving observer. The events can be transferred from one coordinate system to the other by the Lorentz transformation.

Now we add a rope between the lightning strikes and request a transformation of the rope from the standing system to the moving one. The result will be a rope with a temporal length.

Consequently, temporal length does not seem to be such an impossible idea…

An alternative meaning of the Lorentz factor in Special relativity in Euclidian space time.

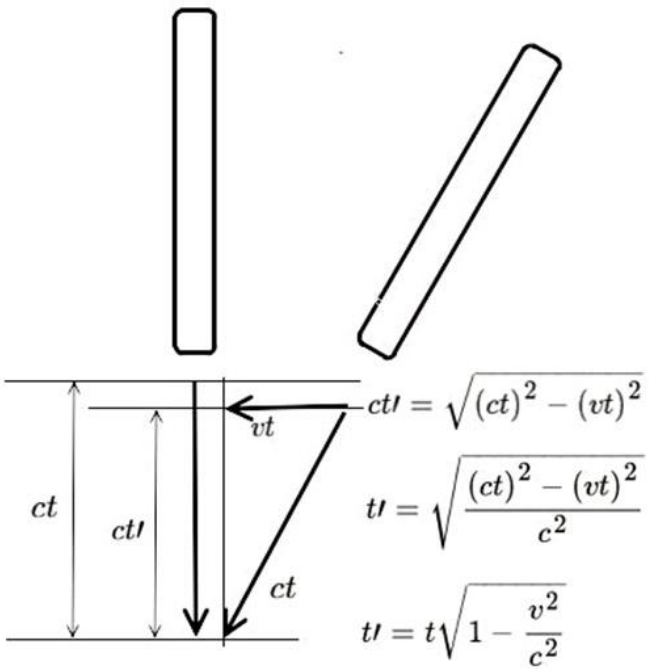
- Introducing a temporal length of an observer, allows the definition of ”perpendicularity” in a space time plane.
- As a consequence an ordinary wave can have the same speed in a space time ”aether” relative to observers moving at different speeds.



- This provides an intuitive picture of special relativity and constant speed of light for observers moving at relative speeds.

An alternative meaning of the Lorentz factor in Special relativity in Euclidian space. Time dilatation.

- If the observer and the observed both have temporal length an intuitive meaning for the Lorentz factor can be derived with simple geometrical assumptions in Euclidian space:

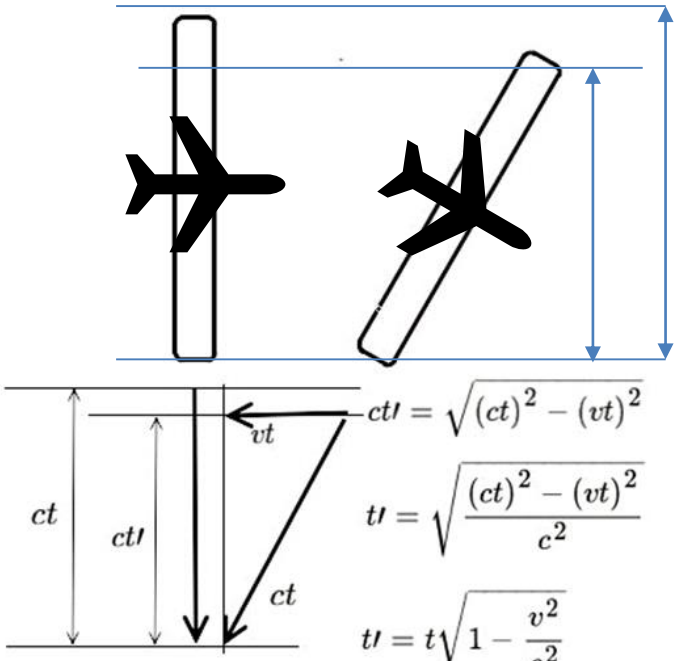


- Similarly some of the hard to comprehend ideas of special relativity and the Lorentz term can be self explanatory when the temporal length of the observers and observed objects – not only point like features on the time line – is admitted.

- In this model, two boats are travelling parallel with a speed of “c” on lake Balaton. Suddenly one of the captains sets his boat on a collision course at a speed of “v” towards the other boat. If the total speed of the boats remains equal and constant, the parallel distance traveled by the boats associated with the “virtual passing of time”, t’ can be computed from one boat’s perspective of the other. Independently from which boat is used as reference Fig.2 shows that the ratio of the perceived passing of time becomes the Lorenz factor.

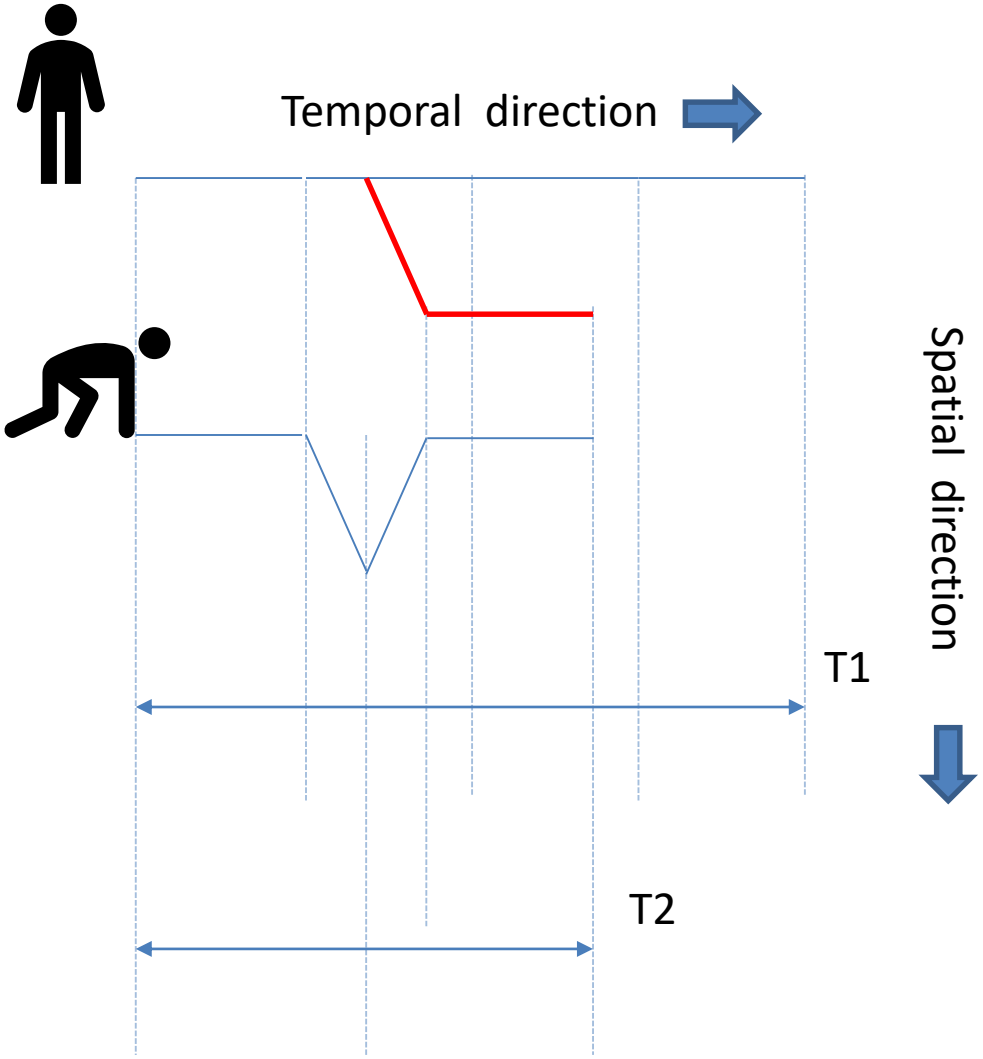
An alternative meaning of the Lorentz factor in Special Relativity in Euclidian space. Length contraction.

- If the observer and the observed both have temporal length an intuitive meaning for the Lorentz factor can be derived with simple geometrical assumptions in Euclidian space:



If we switch the ships to airplanes and instead of a collision they pass over each other, there is a natural shortening of the spatial length of plane parallel with the direction of travel in the “spatial” direction. This shortening is visible intuitively and due to the simple perpendicular rotation of the case, the Ratio of the shortening is still the Lorentz factor.

The twin paradox in temporal length view in Euclidian space time.



The twin paradox states that the moving twin will age slower and the aging difference is calculated according to the Lorentz factor. The simple visualization here combined with the equations shown before give the exact same conclusion in a simple Euclidian space time model.

The red line shows the case when the standing twin launches after his brother and their “age“ matches afterwards.

Obvious consequences of Temporal length

- Particles become 4D physical objects with corresponding 4D symmetries. (SO(4))
- A particle can actually occupy several spatial locations along its temporal length
- Particles can interact along their temporal length
- Quantum symmetries get new intuitive meaning, considering one more ”space like” dimension in 4D.

And that brings us to …

The emerging consequences of Temporal length

The symmetry perspective:

- The tension between the non - locality of quantum physics and the locality of relativistic phenomena is reduced / eliminated, because spatial distribution along temporal length does not contradict locality and spatiotemporal symmetry.
- 4D Rotation **along planes including the temporal axis** keeps temporal symmetry unchanged
- 4D Rotation **along planes including only spatial axes** might interchange temporal extension into spatial and vise versa (or might not like rotation along stationary planes e.g.: x-t)
- ”Coupling” between space and time gets a new intuitive meaning
- Rotational direction along temporal axis is a ”new” property. (Or could it actually be related to spin?)
- “Real 4D cross section” exists intuitively for advanced theories. (E8)

Summarizing the intuitive view provided by temporal length

- The introduction of temporal length brings new intuitive perspective to interpret not so intuitively explainable phenomena:

1. Quantum symmetries
2. Special relativity
3. Double slit experiment
4. Heisenberg uncertainty principle and locality
5. Bell's theorem

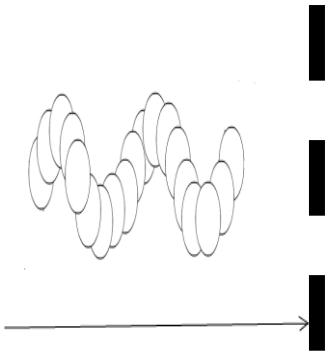
Special relativity and temporal extension

- Next to the advantage of getting an intuitive picture introduced by the ”temporal length” there is a good chance that with a proper choice of parameters:
  - Speed of ”boats”
  - Speed of waves in the aether
  - Geometrical surface of the ”lake”

  we could match special and general relativistic predictions.

Double slit experiment and temporal length

- With the possibility of several spatial locations along the temporal extension the question is how one 4D particle can interact with two slits in 4D?



- A macro world phenomenon in 3D giving an intuitive hint of such interaction. A “1D” object flying through a “2D” hole in “3D”.

Heisenberg Uncertainty principle and the probability wave function in light of temporal length.

$$\Delta x \cdot \Delta p \geq \frac{h}{2}$$

The uncertainty when determining a spatial location and momentum of a particle can be translated to a spatiotemporal distribution / volume.

A measurement when interacting with the particle at a spatial location along its temporal extension would directly correlate with the collapse of the wavefunction to one location. Imagine two rotating spirals colliding with one another or with a hyper sphere…

A 4D geometry could be matched to correspond with the propability wavefunction along the temporal length.

Bell's inequality and temporal length

- "… continue to inspire those who suspect that what is proved by the impossibility proofs is lack of imagination." John Stewart Bell

- What is the consequence on Bell's theorem on **Local realism** if the "hidden variable" represented by the spatio temporal shape of the particle is actually equivalent with the propability wavefunction predictions?

- If the particle has a well defined actual spatial distribution along its temporal length the Bell inequality can simply be a proof of that shape.

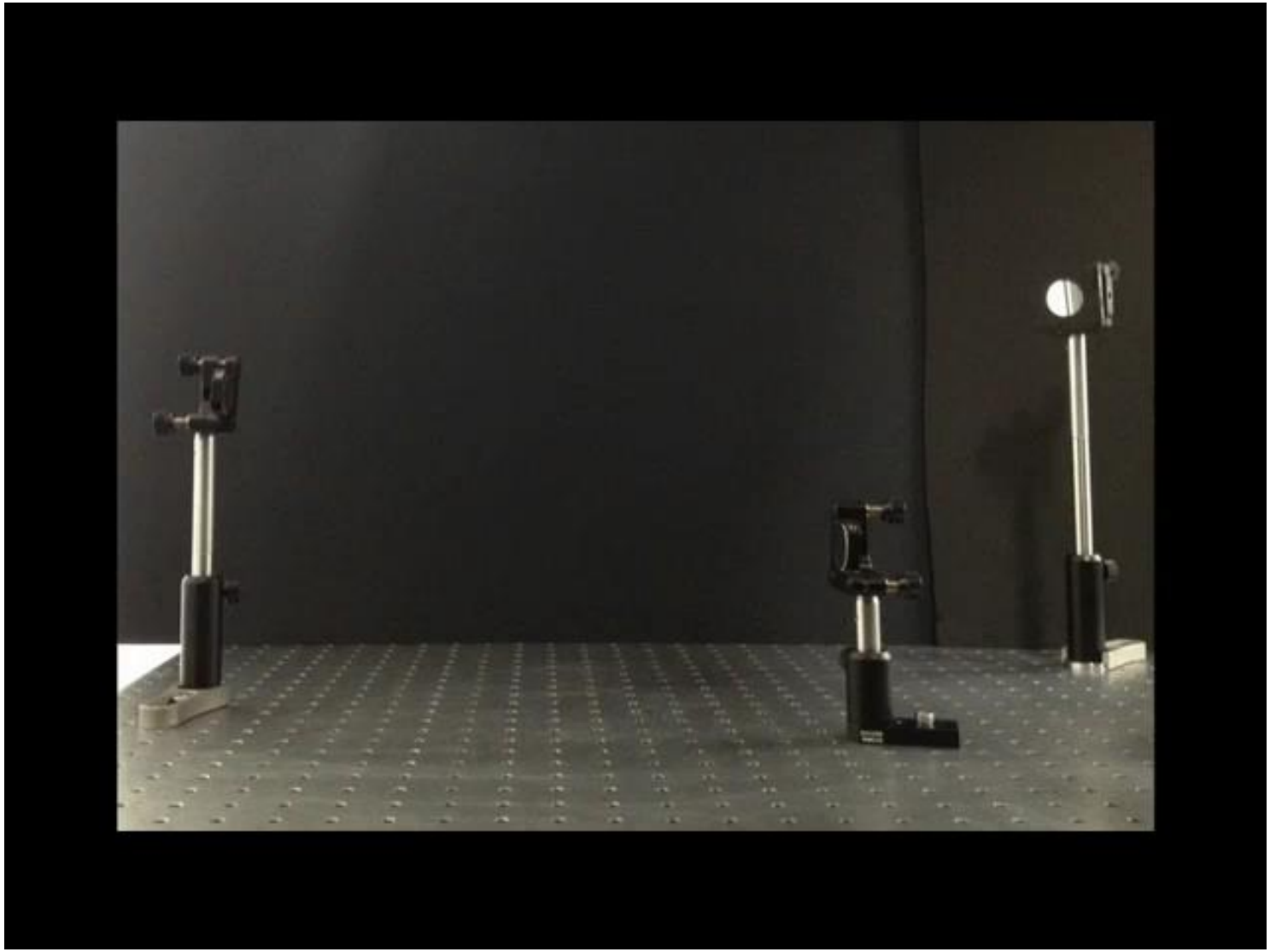
Jumpy light beam photography & Temporal length

- two papers from different authors have measured the travel of light beams by "fast photography" with substantially different methods. In both presented videos the light beams travel in an apparently "jumpy pattern", speeding up and decelerating periodically. As the two methods of photography are fundamentally different, but their result is similar in the sense that both light beams appear to travel in a "jumpy" fashion, this phenomenon might have a physical meaning.

- **nature.com/articles/ncomms7021** (**video**)

- **advances.sciencemag.org/content/3/1/e1601814.full** (**video**)

Gariepy et. all– light in flight video:



Jinyang et. all - videos

Single-shot real-time video recording of a photonic Mach cone induced by a scattered light pulse

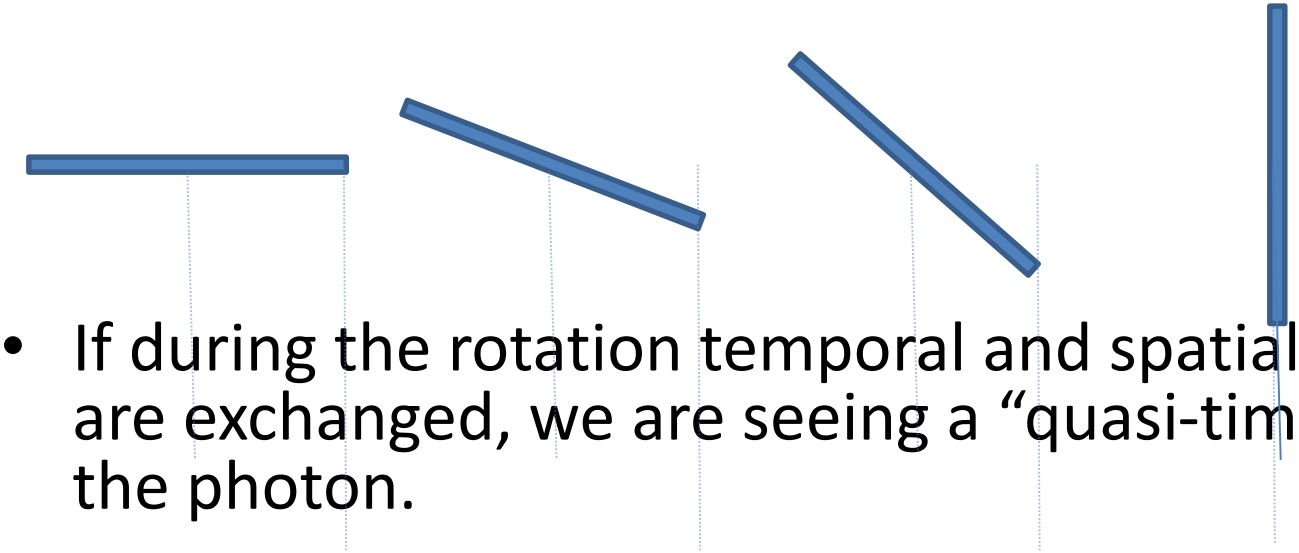
Jinyang Liang*, Cheng Ma*,†, Liren Zhu*, Yujia Chen, Liang Gao‡ and Lihong V. Wang§

Temporal extension view of jumpy light beam photography

- Realizing that the temporal length view of photons allows for a rotation around a spatiotemporal plane (time and a spatial direction perpendicular to the direction of travel, or two spatial planes (perpendicular to the rotation of travel), the following simple model can visualize the effect we could be seeing on the videos.

The “rotating flying stick” effect

- Similarly to the retrograde motion of planets a flying Rotating stick could be seen as proceeding with slowdowns and jumps from a distance.



- If during the rotation temporal and spatial extensions are exchanged, we are seeing a “quasi-time travel” of the photon.

Numerical method inspired by the temporal length idea

- The targeted problem is the elimination of unwanted numerical oscillations in coupled numerical problems.

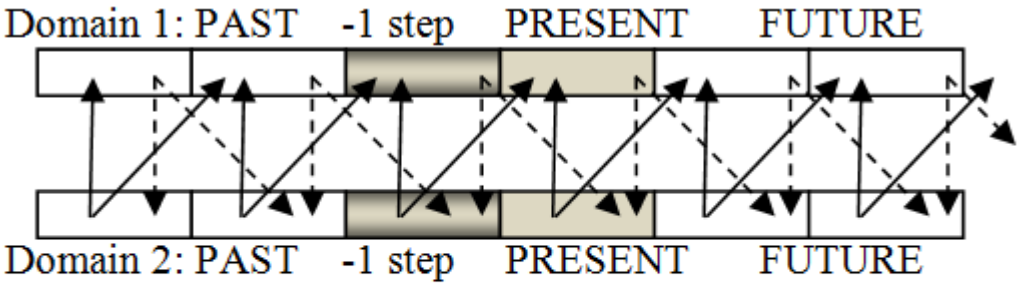


Fig. 3. Schematic picture of the traditional view of interaction in coupled problems between domains. Only consecutive time steps affect each other. "Virtual temporal length" of the model: 2 time steps.

Numerical method inspired by the temporal length idea

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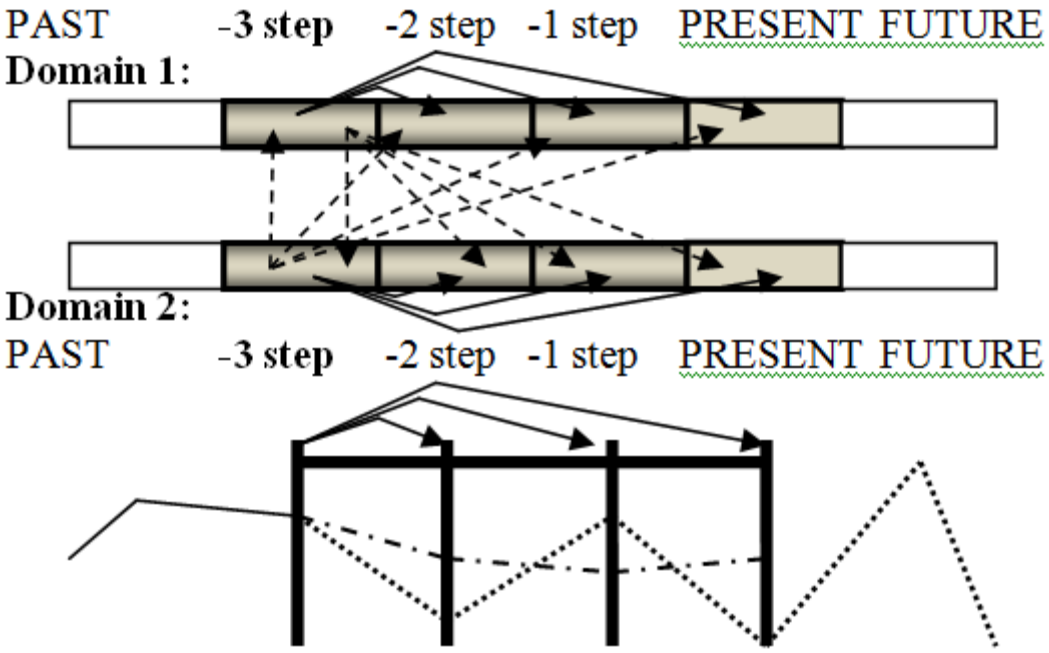

Fig. 4. A schematic picture of a 4 time step long model. Only the effects of the time step "-3" are indicated, with arrows, but other time steps can have similar effects. The model with temporal length acts as a "comb" with "4 teeth" smoothing the time functions on the fly, removing oscillations.

An inspired idea for formulation of models with temporal length in QM

- In the numerical formulation consecutive time steps are coupled through coupling matrices which can effect eddy-currents, voltage sources, nonlinear magnetic properties, etc. It a multi-physics coupling through time steps.

$$\begin{bmatrix} A_1 & C_{11} & T_{AA12} & T_{BC12} & T_{AA13} & T_{BC13} \\ C_{12} & B_1 & T_{AC12} & T_{BB12} & T_{AC13} & T_{BB13} \\ 0 & 0 & A_2 & C_{21} & T_{AA23} & T_{BC23} \\ 0 & 0 & C_{22} & B_2 & T_{AC23} & T_{BB23} \\ 0 & 0 & 0 & 0 & A_3 & C_{31} \\ 0 & 0 & 0 & 0 & C_{32} & B_3 \end{bmatrix} \begin{bmatrix} a_1 \\ b_1 \\ a_2 \\ b_2 \\ a_3 \\ b_3 \end{bmatrix} = \begin{bmatrix} R_{a1} \\ R_{b1} \\ R_{a2} \\ R_{b2} \\ R_{a3} \\ R_{b3} \end{bmatrix}$$

When “past time steps” are affected also by the preceding steps, the formulation is like in (1), with a 3 time step temporal length model. Here An and Bn are the traditional system matrices and an and bn are variable vectors of sub domains and/or components I n the n-th time step toward the past. The n>1 An and Bn matrices could be unit matrices in some formulations. The C matrices represent the coupling between the domains and the T matrices represent the coupling between different time steps along the temporal length. If the formulation requires that future time steps must affect, and suitably “comb” the past time steps to shape, than the zero matrices in (1) would also be replaced by corresponding T coupling matrices. If the past time steps only affect the present time step, the formulation is like in (1) but T_{AA23}, T_{BC23}, T_{AC23}, T_{BB23} are 0 matrices.

Summary & Proposal for validaton

- Temporal length of particles and all physical objects is hinted by existing theories including quantum symmetries and relativity.
- Wedding QM and Relativity has proven to be a significant challenge and the temporal length of particles seems to promise a “game change”.
- 4D objects and their interaction in space-time might not be that easily intuitive as those in 3D but would offer an intuitive alternative picture, regarding the challenges to interprete ”local realism”.
- Jumpy Light in Flight measurement with non-coherent light beam, could validate the theory partly if the ”jumpiness” would dissappear.
- The further development of the numerical temporal length approach for coupled simulations would welcome comments from mathematicians working on similar topics.

Thank You!

The intuitive picture of the world … and the lack of it.

- The paper suggests the theory of temporal extension for fundamental particles as a key to interpret and understand quantum symmetries and related quantum and relativistic phenomena. While space-time as a principal world view is accepted and utilized in fundamental theories, certain traditional concepts of time have not been challenged before. Such a conception is the view that physical objects can only have a point like feature on the time line. When introducing a more space like quality of time, which allows the temporal extension for physical objects and particles, a fundamentally new world view arises. In this view quantum symmetries and certain relativistic phenomena become more intuitive to describe and deal with. The temporal length theory offers to eliminate the tension between the non - locality of quantum physics and the locality of relativistic phenomena. The paper will provide a detailed description of the theory.