UNIFICATION: MOTION OF OBJECTS AND PROPAGATION OF LIGHT

The Principle of relativity of inertial motion

The synchronization procedure that the fleets use relies on the isotropy of inertia for objects in inertial motion. Both the red fleet and the green fleet are in inertial motion; for both fleet inertia is isotropic. Both the red fleet and the green fleet take care to transfer to the "left" and the "right" miniclock the same amount of kinetic energy. Since an identical amount of kinetic energy is transferred to the "left" and "right" miniclock (and given that they have identical mass), their velocity relative to the spaceship they were expelled from will be identical.

When Galilei formulated the principle of relativity of inertial motion the obvious supposition was that velocity-vectors add in the same way as vectors of euclidean space add. The assumption of galilean relativity is an assumption (a most intuitive one) about the chrono-geometric structure of space and time. At first sight it appears that galilean relativity is the only possible embodiment of the principle of relativity of inertial motion.

As discussed in the introduction: the symmetry demands that follow from the principle of relativity of inertial motion narrow down the transformations to the following:

- Transformations between coordinate systems that are at an angle with respect to each other
- Transformation between coordinate systems that are translated with respect to each other
- Transformations between coordinate systems that have a uniform velocity relative to each other

The revolution of special relativity lies in the recognition that there is yet another chrono-geometric structure that embodies the above set of symmetries: Minkowski spacetime. (Palash B. Pal has written up some very neat derivations, showing how both galilean relativity and special relavity satisfy the principle of relativity of inertial motion. Nothing but relativity (PDF-file 64 KB)

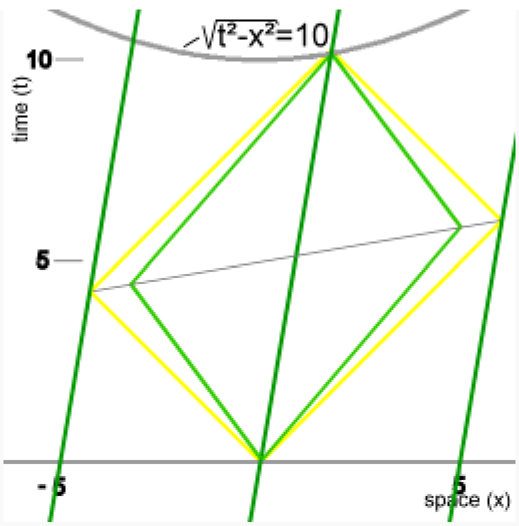
The limit of approaching the speed of light

In the animations the miniclocks have a velocity relative to the fleet of $^4/_5$th of the speed of light. What happens at even faster velocities, approaching the speed of light? Subatomic particles such as protons and electrons can be accelerated to very close to the speed of light and expelled at that velocity. Then both as mapped in a coordinate system that is co-moving with the red fleet and in a coordinate system that is co-moving with the green fleet the particles move very close to the speed of light.

Light

Light itself is at the very extremal point. The physics of Minkowski spacetime is such that light always propagates away from any emitter with a velocity relative to that emitter of *c*, regardless of the velocity of that emitter relative to other emitters. Ultimately, synchronization with particles or synchronization with light relies on the same principle, the principle of inertia.

Fundamental unification: a single principle of inertia



Picture 13. Image
When the synchronization procedure is performed both with pulses of light and with miniclocks the results will match up exactly.

In Minkowski spacetime, the *members of the equivalence class of inertial coordinate systems* have the following properties in common:
- Inertia of particles is isotropic
- Propagation of light is isotropic
The achievement of the special theory of relativity is placing motion of matter

and propagation of light in a unified framework; both motion of particles and propagation of light are described by *a single principle of inertia*. Special relativity dissolves distinction between motion of particles and propagation of light. The key is Minkowski spacetime, the concept of Minkowski spacetime implies unification of the description of motion of particles and propagation of electromagnetic waves.

Thus, centuries after the Copernican revolution, special relativity goes a step further in recognizing inertia as prime organizing principle for dynamics understanding.

Transition: from newtonian to special relativity

The transition from newtonian dynamics to special relativity replaces one metric with another. Newtonian dynamics starts with the assumption that space is euclidean, that the dimension of time is euclidean, and that space and time are independent. Special relativity replaces these euclidean metrics with a single metric: the Minkowski metric.

In the next article, about the general theory of relativity, I will discuss that the transition from special relativity to its successor, the general theory of relativity, once again replaced the metric of spacetime.

Source:

http://www.cleonis.nl/physics/phys256/special.php#section_1