Notes on Physics from Symmetry

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This document contains my personal notes on Jakob Schwichtenberg's Physics from Symmetry (Schwichtenberg, 2015).

1. Special relativity

In special relativity, **inertial frames of reference** are coordinate systems moving with constant velocity relative to each other. Special relativity has two basic postulates:

1. **The principal of relativity**: The laws of physics are the same in all inertial frames of reference.
2. **The invariance of the speed of light**: The velocity of light has the same value c in all inertial frames of reference.

Theorem 1.1 (Invariant of special relativity). *Consider two events A and B in an observer O's frame of reference. Let the time interval measured by O between the two events be (Δt), and the three spatial intervals be (Δx), (Δy), (Δz). Then, the quantity*

$$(\Delta s)^2 \coloneqq (\Delta ct)^2 - (\Delta x)^2 - (\Delta y)^2 - (\Delta y)^2 \tag{1.1}$$

is **invariant** *between all frames of reference. I.e.*

$$(\Delta s') = (\Delta s) \tag{1.2}$$

for any inertial frame of reference O'.

Definition 1.1 (Proper time). *Proper time, τ, is the time measured by an observer in the special frame of reference where the object in question is at rest. In this frame of reference,*

$$(\Delta s)^2 = (c\Delta\tau)^2. \tag{1.3}$$

In the infinitesimal limit

$$(\mathrm{d}s)^2 = (c\,\mathrm{d}\tau)^2. \tag{1.4}$$

Physically, Defn. 1.1 means that all observers agree on the time interval between events for an observer who travels with the object in question.

References

Schwichtenberg, J., 2015 *Physics from symmetry*. Springer.