2.3: Additional Postulates

Learning Objectives

- Learn more postulates for spacetime, inertial frames of reference, equivalence of inertial frames and relativity of time

We make the following additional assumptions:

Postulate 3 (P3): Spacetime

Spacetime is homogeneous and isotropic. No time or place has special properties that make it distinguishable from other points, nor is one direction in space distinguishable from another.[1]

Postulate 4 (P4): Inertial frames of reference exist

These are frames in which particles move at constant velocity if not subject to any forces[2]. We can construct such a frame by using a particular particle, which is not subject to any forces, as a reference point. Inertial motion is modeled by vectors and parallelism.

Postulate 5 (P5): Equivalence of inertial frames

If a frame is in constant-velocity translational motion relative to an inertial frame, then it is also an inertial frame. No experiment can distinguish one preferred inertial frame from all the others.

Postulate 6 (P6): Relativity of time

There exist events 1 and 2 and frames of reference defined by observers o and o' such that $o \perp r_{12}$ is true but $o' \perp r_{12}$ is false, where the notation $o \perp r$ means that observer o finds r to be a vector of simultaneity according to some convenient criterion such as Einstein synchronization.

Postulates **P3** and **P5** describe symmetries of spacetime, while **P6** differentiates the spacetime of special relativity from Galilean spacetime; the symmetry described by these three postulates is referred to as Lorentz invariance, and all known physical laws have this symmetry. Postulate **P4** defines what we have meant when we referred to the parallelism of vectors in spacetime (e.g., in figure 1.3.2). Postulates **P1-P6** were all the assumptions that were needed in order to arrive at the picture of spacetime described in chapter 1. This approach, based on symmetries, dates back to 1911[3]. Surprisingly, it is possible for space or spacetime to obey our flatness postulate **P2** while nevertheless having a nontrivial topology, such as that of a cylinder or a Möbius strip. Many authors prefer to explicitly rule out such possibilities as part of their definition of special relativity.

References

1. For the experimental evidence on isotropy, see www. edu-observatory.org/physics-faq/Relativity/SR/experiments.html\ #Tests_of_isotropy_of_space
2. Defining this no-force rule turns out to be tricky when it comes to gravity. As discussed in ch. 5, this apparently minor technicality turns out to have important consequences.
3. W. v. Ignatowsky, Phys. Zeits. 11 (1911) 972. English translation at en.wikisource.org/wiki/Translation:Some_General_Remarks_on_ the_Relativity_Principle