Local and Global Relativity Principles (abstract)

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This paper discusses the relationship between a global version of the special principle of relativity and a local version of the principle. The local principle is

(1) It is physically necessary that if the same type of experiment is conducted in isolated laboratories that are both moving inertially, then the outcomes of those experiments are the same.

I call this a local principle because it is about particular experiments, particular subsystems of the universe. It is also an intra-world principle: it places constraints on the outcomes of same-type experiments *within* each physically possible world, without (on the face of it) placing any constraints on the outcomes of same-type experiments that occur in different physically possible worlds. There is also a global version of the special principle of relativity. Roughly speaking, the global principle says that if you take the entire material content of a physically possible world, and speed it up by the same amount in the same direction at each time, you end up with another physically possible world. A more precise statement of the principle is:

(2) All transformations between inertial frames are dynamical symmetries of all true theories.

In flat relativistic spacetime this amounts to the demand that Lorentz transformations be dynamical symmetries.

(2) is regarded as the correct modern formulation of the special principle of relativity. But you might worry that it does not capture the entire content of the principle of relativity, as intuitively understood. These worries are driven by the suspicion that (2) does not entail (1). Some interpreters claim that Galileo's statements about relativity are best understood as affirmations of (1). A statement of the principle of relativity that did not capture what Galileo was saying would surely be leaving something out. In addition, since our direct empirical evidence is evidence about what goes on in the actual world, that evidence directly supports (1), not (2). So if (2) does not entail (1), we are not doing enough to make our theories relativistic if we merely ensure that they are compatible with (2). Finally, some have complained that (2) lacks empirical content. It merely says that if a certain world is possible, then so is a world that is qualitatively indiscernible from it. But the principle of relativity certainly has some empirical content.

If (2) does not entail (1) then these complaints about (2) may have some force. My aim is to defend (2) against those who would demote it. To dispel the doubts I argue that (2) does, in fact, entail (1). I also explain why a counterexample to this entailment offered by Tim Budden is not genuine.

There seem to be principled reasons why (2) cannot entail (1). (2) is a conditional principle: it says that if a world is permitted by the laws, then some other world is also permitted by the laws. But it appears to place no unconditional constraints on which worlds are physically possible. It places no constraints on what goes on within any one physically possible world. So how can it entail (1), which does place constraints on what goes on within each world?

My answer: (1) does not merely put constraints on what happens within any one physically possible world. For (1) is about isolated laboratories, and it is a necessary truth about isolated laboratories that the outcomes of experiments in them do not depend on what is going on outside the laboratory. This fact forges a connection between the local and the global principle. My proof that (2) entails (1) relies on this fact.

That (1) uses the concept of an isolated laboratory helps me prove that (2) entails (1); but it also raises some problems. What is an isolated laboratory? Although there are relatively precise sufficient conditions for a laboratory to be isolated, adequate necessary and sufficient conditions for a laboratory to be isolated must make use of the concept of causation.

While I would prefer to avoid resorting to causal talk, I need a definition of "isolated laboratory" to evaluate purported counterexamples to the claim that (2) entails (1). I discuss Budden's counterexample and one other. Budden's is the more detailed example: he presents laws set in "optical spacetime," which is (roughly) flat relativistic spacetime with the added structure of a preferred congruence of timelike straight lines. Both these examples are theories in which (2) is true but in which (in some model of each theory) two experiments of the same type are conducted in inertially moving laboratories that are not at relative rest and have different outcomes. I claim that these are not genuine counterexamples because the inertially moving laboratories are not truly isolated.