Comment on: "The role of dynamics in the synchronization problem", by Hans C. Ohanian Am. J. Phys. 72 (2), 141-148 (2004)

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Hans C. Ohanian[1] claims to "defeat" the conventionalist thesis of clock synchronization[2,3] using an argument based on dynamics. My aim here is to show that his argument does not succeed.

Ohanian writes, "[The conventionalist] thesis rests on the belief that the adoption of the nonstandard synchronization leads to a self-consistent description of physical phenomena, without any demonstrably erroneous experimental consequences." But he does not claim to defeat the thesis on this basis. Indeed, he writes, "Reichenbach's nonstandard synchronization permits a consistent description of physical phenomena."

Why, then, does Ohanian reject the thesis? He shows that with a nonstandard synchronization Newton's second law contains pseudoforces and thus is not in its "standard form" $\mathbf{F} = m\mathbf{a}$. He writes, "The fundamental error of Reichenbach and his followers ... [is that] they failed to appreciate that the time variable *must* be chosen in such a way that the laws of dynamics [i.e., Newton's laws] keep their standard form." (My emphasis.)

But why must Newton's laws take their standard form? Ohanian writes that Einstein's definition of an inertial frame "demands" that Newton's laws "must be valid". Einstein's "demand" cited by Ohanian reads "Let us take a system of coordinates in which the equations of Newtonian mechanics hold good." There is no indication that Einstein would have rejected nonstandard synchronizations and their nonstandard forms of Newton's laws. And if he would have, we need not follow him in a definition.

Thus Ohanian has only shown that *if* Newton's laws must take their standard form, then nonstandard synchronizations are ruled out. But he has given no reason that the laws *must* take their standard form.

Ohanian's articulation of the conventionalist thesis above, "nonstandard synchronization leads to a self-consistent description of physical phenomena", is a triviality. It also misses the point of the thesis, as I now discuss.

In Newtonian mechanics there is a universal time t which provides a unique synchronization: two events are simultaneous if they occur at the same t. Synchronization methods, for example clock transport, are merely operational procedures for actualizing the already existing synchrony given by t.

In special relativity there is no universal time. Every student of the theory learns that synchronization is frame dependent. The conventionalist thesis goes further, recognising that even in a *single* nonaccelerating frame, the theory does not supply a unique synchronization.[4] Thus synchronization in the frame must be *defined*.

This is why Einstein calls the synchronization method in his 1905 paper a *definition* (his emphasis), not an operational procedure. He thought this an important enough point that even in a popularization of relativity he wrote that his definition "is in reality neither a *supposition nor a hypothesis* about the physical nature of light, but a *stipulation* which I can make of my own freewill in order to arrive at a definition of simultaneity."[5] Reichenbach also emphasises that synchronization is a matter of definition.[6]

Several conditions have been proposed to rule out nonstandard synchronizations.[2,3] Malament's condition, that the simultaneity relation be defined from the causal connectibility relation, has elicited the most interest. Ohanian's condition, that Newton's laws take their standard form, is the latest. There is no reason that we must accept any of them.

Ohanian has not defeated the conventionalist thesis.

There is no need to use Newton's first or second laws in the definition of an inertial frame, despite the near universal use of the first law, and Ohanian's use of the second. I have defined an inertial frame as one in which accelerometers read zero and clocks are Einstein synchronized.[7] The accelerometers can be as simple as a cube with identical springs attached from its corners to a weight at its center. If accelerometers read zero, then we can attempt to Einstein synchronize clocks. My paper gives testable necessary and sufficient conditions that this is possible. (Perhaps surprisingly, the conditions do not imply that the speed of light is isotropic.[7]) If the conditions are satisfied, then we can Einstein synchronize all clocks in the frame with some "central" clock. Then every pair of clocks will be synchronized and remain so. Since the definition is independent of Newton's laws[8], they can then be tested empirically. In our universe they are valid (in their standard form).

There is a difficulty in using Newton's laws in the definition of an inertial frame: how can the laws be *laws* if they are part of a *definition*? I know of no nonsubtle way around this difficulty. It does not arise if Newton's laws are not part of the definition of an inertial frame.

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Note added. Ohanian devotes the entire third paragraph of his Reply to an argument scarcely mentioned in his paper: simplicity. I agree that *if* the laws of physics must take their simplest form, then nonstandard synchronizations are ruled out. But he has given no reason that the laws *must* take their simplest form. If Ohanian wants a criterion to rule out nonstandard synchronizations, why not use the simplest and most direct of all: that the the one way speed of light must be isotropic?

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[1] H. Ohanian, "The role of dynamics in the synchronization problem," Am. J. Phys. **72**, 141-148 (2004).

[2] A. Janis, "Conventionality of Simultaneity", The Stanford Encyclopedia of Philosophy (Fall 2002 Edition, Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/fall2002/entries/spacetime-convensimul/>.

[3] R. Anderson, et al., "Conventionality of Synchronisation, Gauge Dependence and Test Theories of Relativity," Physics Reports **295**, 93-180 (1998).

[4] A. Grünbaum, *Philosophical Problems of Space and Time* (Knopf, New York, 1963), p. 343ff.

[5] A. Einstein, *Relativity: The Special and General Theory*, 15th ed., Crown, New York, 1952.

[6] H. Reichenbach, *The philosophy of space & time* (Dover, New York, 1958), p. 127.

[7] A. Macdonald, "Clock synchronization, a universal light speed, and the terrestrial redshift experiment," Am. J. Phys. **51**, 795-797 (1983).

[8] Except for a very special case of the first law: to say that accelerometers read zero is equivalent to saying that objects placed at rest remain at rest. This involves neither dynamics nor clocks.