Philosophy of Space, Time and Spacetime: Suggested Paper Topics

Erik Curiel[†]

1. Work through Newton's Laws of Motion in detail (including his particular statement of them and his explication of them in his own commentary on them) to see what geometric spatial structures they presuppose for their formulation, and for their application. (Thus, you also will need to work through in some detail at least one of his own applications of one of the Laws in modeling a physical system.) Do those geometric requirements differ for the different Laws (*i.e.*, are different things needed for the formulation and application of the different Laws)? Explicate and explain the spatial structure Newton posits and argues for in the Scholium on Space and Time. Do these provide all the necessary structures the laws require? If so, justify your answer. If not, argue why not. Either way, discuss the formulation and solution of the Bucket Experiment by application of the Laws, and show how it is made possible or impossible by Newton's stipulated spatial structures.

2. Geroch (1981) constructs a structure he calls 'Galilean Spacetime'. This is supposed to capture the spatiotemporal structure required for the formulation of classical (Newtonian) mechanics. Sketch Geroch's construction, and in particular make explicit and analyse the presuppositions Geroch uses in the construction. Compare his presuppositions, the details of this construction, and the properties of the constructed space with the same for Newton's account of space (both absolute and relative) in the Scholium on Space and Time. Explain the similarities and the differences.

3. Leibniz and Clarke both repeatedly invoke alleged properties of a supernatural being ('God') in order to explain the properties and structures each attributes to space, and in order to defend their claims about the properties. Leibniz in particular attempts to defend (or at least validate) such arguments by describing them as instances of the Principle of Sufficient Reason (PSR). First, explain Leibniz's version of the PSR in general, not as restricted to the special case of the properties or possible actions of a supernatural being, and analyze his use of it in this form in some particular argument he makes. (It will be useful to consult Belot (2001) to help with this.) Then work in detail through at least two substantive arguments by Leibniz that make explicit use of the properties, volitions or possible actions of a supernatural being interpreted as an instance of the PSR. Can the arguments be reformulated so as to use only the PSR in the abstract without relying on the invocation of a supernatural being so as still to draw the same conclusions that it was originally intended to? What conclusions do you draw from this about the strengths of Leibniz's arguments in general?

4. On p. 61 of *Science and Hypothesis*, in characterizing the properties of a geometrical space, such as that of Euclidean geometry, Poincaré says the following: "4th, is it homogenous—that is to say, all is points are identical one with another." Leibniz used exactly this criterion

[†]**Author's address**: Munich Center for Mathematical Philosophy, Ludwig-Maximilians-Universität, Ludwigstraße 31, 80539 München, Deutschland; **email**: erik@strangebeautiful.com

to argue for the ideality of physical space in his debate with Clarke. Do Leibniz's arguments carry over to the structure of abstract geometrical spaces? Ought we, by Leibniz's lights, think of Euclidean space as a derived object supervenient on the relations among the Euclidean objects (lines, circles, triangles, ...) that can live in geometrical space? To answer this, one should begin by explicating Poincaré's claim and assume it to be true (which, on a proper construal, it is). I also recommend using the arguments and consideration of Riemann, Helmholtz or Poincaré himself to address the problem, but that is not strictly necessary: an excellent paper could be written on this focusing only on the possible applicability of Leibniz's own arguments to Euclidean space.

5. Huygens has (at least) two different conceptions of motion, one based on change of relative position, the other based on the presence of velocity differences. Explain each conception, and describe in detail its use in a substantive argument Huygens makes about how the properties, causes and effects of motion may yield insight on the nature of physical space. How are the two concepts related to each other? Can they really be considered two different aspects of the same underlying, more fundamental concept, or are they really just at bottom two separate, different concepts that Huygens uses the same word to refer to? If the former, explain the logical and physical relations that connect them; if the latter, explain whether Huygens is justified in using both to analyse spatial structure, and, if he is, how he is, and, if he is not, what that does to the force of his arguments.

6. Describe and explain in detail the infamous Bucket experiment. What does Newton think it shows, and how? Huygens thought he had his own explanation for the phenomenon. Explain Huygens' account of the experiment, what he thinks it shows, and how. Compare the two accounts. What does each get right and what does each get wrong?

7. In lecture I argued that the views of Newton, Leibniz and Huygens seem, at least in part, to converge with regard to methodology, in that all seemed to hold that we must look to the dynamics of the most well-established theoretical framework in order to constrain metaphysical speculation and argumentation about the nature of space. Based on your own reading of the arguments of these thinkers, and on the exposition of the works of the three in Stein (1977), defend or argue against my claim. Such a defense or argument should include, at a minimum, an analysis of the methodology each of the three actually employs in their extant arguments.

8. Riemann and Helmholtz both make use of the idea of the mobility of geometrical figures to ground the idea of the congruence of such figures. They both argue that the possibility of judging congruence lies at the foundation of the possibility of defining and reasoning with geometrical structures. They further both claim that the actual mobility of real physical objects grounds the possibility of the kinds of measurements we actually need to make in order to try to ascertain the geometry of physical space. Work through the methods and arguments of each and explain how they are similar and how they differ. Pay particular attention to the role that the idea of approximation plays in each's account, and to the kind of physical operations and theoretical structures each thinks relevant to the kinds of argument at issue, and also to the difference between the kinds of role that physical experiment and

simple perception play in the arguments of each. (It will be useful to use the discussion of Stein (1977) as a springboard and touchstone for your own arguments.)

9. Reconstruct in your own words and arguments Poincaré's analysis and explanation of the relation between geometry and experience, and how it leads to Poincaré's claim that the choice of a geometry for physical space is a "convention". Of course, you will also need to explain in detail what exactly a convention is for Poincaré, and what is involved in "choosing" one. Explain his claim that we do not represent geometrical objects to ourselves, but rather only reason about them, paying particular attention to the way that Poincaré's account of the different spaces attached to the different sense modalities (sight, touch, musculature) leads to that conclusion. Evaluate his arguments.

10. Does Poincaré think that there is a metaphysically real, distinguished geometrical structure to physical space, but that we can just never learn it with complete certainty? Or does he think that the idea of a metaphysically real, distinguished geometrical structure to physical space is just confused, and possibly even incoherent?

11. Explain in detail how Poincaré's example of the "thermally inhomogeneous" world supports his conventionalism. In particular, use it to explain how Poincaré views the relationship between the dynamical principles of a physical theory and the abstract geometrical structures used to formulate and apply those principles.

12. I claimed in lecture that Riemann's (proposed) methodology is superior to those of Helmholtz and Poincaré; explain and evaluate the claim, including its consequences for what kinds of inferences about physical geometry each methodology warrants one to draw.

13. Explain and recapitulate in your own words the argument for the claim of Malament (1977) that the relation of simultaneity in special relativity is relative, but is not conventional. Consider a published objection to Malament's claim (*e.g.*, Grünbaum (2010), Hogarth (2005), Janis (1983), or Sarkar and Stachel (1999)), and explain the objection and evaluate its force. Do you find it convincing?

14. Explain the debate between Putnam (1967) and Stein (1991). In particular, first explain Putnam's arguments that there can be no objective becoming in special relativity, and then explain the construction of Stein that purports to show the fallacy of Putnam's argument. Second, explain Stein's positive argument in favor of the idea that there can be relativized objective becoming in special relativity. Do you find Stein's positive arguments cogent and convincing?

References

Belot, G. (2001). The principle of sufficient reason. *The Journal of Philosophy 98*(2), 55–74.

Geroch, R. (1981). *General Relativity from A to B*. Chicago: University of Chicago Press.

Grünbaum, A. (2010). David Malament and the conventionality of simultaneity: A reply. *Foundations of Physics 40*(9–10), 1285–1297. doi:10.1007/s10701-009-9328-3. Preprint: `http://philsci-archive.pitt.edu/archive/00000184/`.

Hogarth, M. (2005). Conventionality of simultaneity: Malament's result revisited. *Foundations of Physics Letters 18*(5), 491–497. doi:10.1007/s10702-005-7539-1.

Janis, A. (1983). Simultaneity and conventionality. In R. Cohen and L. Laudan (Eds.), *Physics, Philosophy and Psychoanalysis: Essays in Honor of Adolf Grünbaum*, Number 76 in Boston Studies in the Philosophy of Science, pp. 101–110. Dordrecht: D. Reidel.

Malament, D. (1977). Causal theories of time and the conventionality of simultaneity. *Noũs 11*(3), 293–300. Symposium on Space and Time.

Putnam, H. (1967). Time and physical geometry. *Journal of Philosophy 64*, 240–247.

Sarkar, S. and J. Stachel (1999, June). Did Malament prove the non-conventionality of simultaneity in the special theory of relativity? *Philosophy of Science 66*(2), 208–220. doi:10.1086/392684.

Stein, H. (1977). Some philosophical prehistory of general relativity. In C. G. Earman, J. and J. Stachel (Eds.), *Foundations of Space-Time Theories*, Volume VII of *Minnesota Studies in Philosophy of Science*, pp. 3–49. Minneapolis: University of Minnesota Press.

Stein, H. (1991). On relativity theory and openness of the future. *Philosophy of Science 58*(2), 147–167. doi:10.1086/187456.