Studies in History and Philosophy of Modern Physics 46 (2014) 179–185

Contents lists available at ScienceDirect

Studies in History and Philosophy of Modern Physics

journal homepage: www.elsevier.com/locate/shpsb

Unprincipled microgravity

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ARTICLE INFO

Article history:
Received 8 February 2013
Received in revised form
6 November 2013
Accepted 14 November 2013
Available online 17 December 2013

Keywords:
Microgravity
Quantum gravity
Stochastic gravity
Methodology

ABSTRACT

I argue that the key principle of microgravity is what I have called elsewhere the Lorentzian strategy. This strategy may be seen as either a reverse-engineering approach or a descent with modification approach, but however one sees if the method works neither by attempting to propound a theory that is the quantum version of either an extant or generalized gravitation theory nor by attempting to propound a theory that is the final version of quantum mechanics and finding gravity within it. Instead the method works by beginning with what we are pretty sure is a good approximation to the low-energy limit of whatever the real microprocesses are that generate what we experience as gravitation. This method is powerful, fruitful, and not committed to principles for which we have, as yet, only scant evidence; the method begins with what we do know and teases out what we can know next. The principle is methodological, not ontological.

When citing this paper, please use the full journal title *Studies in History and Philosophy of Modern Physics*

1. Introduction

I argue that the key principle of microgravity is what I have called elsewhere (2009, 2010) the Lorentzian strategy. This strategy may be seen as either a reverse-engineering approach or a descent with modification approach, but however one sees if the method works neither by attempting to propound a theory that is the quantum version of either an extant or generalized gravitation theory nor by attempting to propound a theory that is the final version of quantum mechanics and finding gravity within it. Instead the method works by beginning with what we are pretty sure is a good approximation to the low-energy limit of whatever the real microprocesses are that generate what we experience as gravitation. This method is powerful, fruitful, and not committed to principles for which we have, as yet, only scant evidence; the method begins with what we do know and teases out what we can know next. The principle is methodological, not ontological.

In what follows I attempt to illustrate three things: (1) Those who are attempting to show that quantum gravity is a necessary end state of our gravitation theorizing are simply asking the wrong questions, and so their answers are unlikely to tell us what we want to know; (2) That a version of Einstein's principle/constructive theory taxonomy is (a) operative in the dominant view that quantum gravity is the correct microgravity, (b) in part sustains that view and (c) is missing a taxon appropriate for pre-revolutionary disciplines such as mircrogravity research; (3) That the missing third taxon in Einstein's taxonomy of theories is reverse-engineered approximations, and that this taxon is both real and productive of empirical knowledge, and also that it may turn out to be a necessary propaedeutic for our quest to find a microtheory of gravitation.

The contentious part of my thesis is this: There is as yet nothing we can learn about the fundamental nature of space and time from quantum gravity—because quantum gravity is a fiction. We can, however, and *have* learned a great deal from semiclassical gravity and are likely to learn more from its extension into regimes of higher order correlations between the fluctuations in the quantum fields. There is no positive metaphysical or conceptual thesis here —only the negative one that we don't really know much about the fundamental nature of spacetime, or whether it is even fundamental. There is however a positive methodological thesis—abandon revolutionary tactics and work instead toward peaceful regime change.

For microgravity, as was the case for both statistical mechanics and Lorentz's electrodynamics, general insights can come when we have a program of step-wise corrections available. The jury is still out on whether the ultimate account of microgravity will come from the sudden importation of novel ontology in the form of quantum mechanically described field configuration in parallel to the case in statistical mechanics with its postulation of novel ontology (where also, it should be said, the quantum revolution

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http://dx.doi.org/10.1016/j.shpsb.2013.11.004

was in part caused by deeper insights coming from the application of the reverse engineering perspective to statistical mechanics), or in the form of a newly clarified universal principle as in the case of the special theory of relativity (discovery of which required the insights generated by Lorentz's program).

2. Preliminaries: why not quantum gravity?

The methodological principle I outline below is not a principle of quantum gravity. Indeed the principle isn't really a principle of microgravity either but an application of a more general principle of theory development. That is, it is not a principle that is derived from the assumption that there is a theory to be found that is the correct theory of microgravity and which is also a theory with a quantum mechanical gravitational field. The principle is not predicated on the denial of that assumption, it simply does not rest on it. I use the expression "microgravity" to signal the difference between proposals involving a quantized gravitational field and the more general class of proposals for whatever the microtheory is of the processes that give rise to gravitational phenomena.

Perhaps soon it will not be necessary to say so, but for now, any discussion of this sort must contend with the strong background presumption that the class of microgravity theories is coextensive with that of quantum gravity theories. So I begin there.

2.1. Isn't quantum gravity obviously right?

On one way of understanding what could be the principles of quantum gravity, there are no such principles, or at least we have little reason to think on one hand that they are true and on the other that they have much to do with quantum gravity in particular.

What, after all, could lead us to believe that some proposed principle of quantum gravity is true? Maybe it is an empirical generalization that we have picked up elsewhere in our physical theorizing and experimental practices. If so then it seems unlikely that the principle is really a *principle of quantum gravity* proper, as opposed to a principle that bears on the question of how the fundamental theory of gravity is likely to turn out but which is, after all, a fact about theorizing generally or about the physical world generally. Is the principle then, perhaps, a principle of quantum gravity property and self-evident? First, that does not seem to accord very well with the history of physics since the principle would apparently conflict with other things once thought to be true. If the principle was self-evidently true it's at least plausible that things inconsistent with it are pretty obviously false. But in any case it is similarly difficult to see what self-evident proposition could apply in particular to quantum gravity and not be a more general physical principle.

But to maintain a position of this sort faces a prima facie hurdle: apparently we know very well that gravity is quantized. So maybe the correct principle is something we come to this way: we know that gravity is about the coupling between matter on one hand and spacetime geometry on the other, and also that matter is quantum mechanical. So something that must be true in order to get these independent principles together is a principle of quantum gravity. There are several proposals for what this principle could be, but most seem to rely on some kind of unification thesis. Rovelli (2001), for example, has offered what seems to be the clearest articulation of a general argument in favor of quantizing the gravitational field (Callender & Huggett, 2001).

> We have learned from GR that spacetime is a dynamical field among the others, obeying dynamical equations, and having independent degrees of freedom. A gravitational wave is extremely similar to an electromagnetic wave. We have learned from QM that every dynamical object has quantum properties, which can be captured by appropriately formulating its dynamical theory within the general scheme of QM.
>
> Therefore, spacetime itself must exhibit quantum properties. Its properties, including the metrical properties it defines, must be represented in quantum mechanical terms. Notice that the strength of this therefore derives from the confidence we have in the two theories, QM and GR. (109)

Smolin has recently spelled out some consequences of the Rovellian unification thesis.[1] At least Smolin articulates some features of what a quantum gravity theory would be like that proceeds in accordance with certain rules. But the assumption here, as in Rovelli's case, is the same: that a basic unification thesis tells us that our microtheory of gravity really is a quantum gravity, and also constrains that theory in significant ways. Smolin is less dogmatic in his presentation than Rovelli, simply saying that he is teasing out some of the generic consequences of a unification of gravity with quantum mechanics. More precisely, Smolin (2009, p. 550) is teasing out the consequences of the following four principles (Oriti, 2009):

1. Quantum mechanics.
2. Partial background independence (of spacetime).
3. Discreteness (in the sense that the Hilbert space has a countable basis given by discrete or combinatorial structures).
4. Causality (in the sense that the event structure define a partially ordered, or causal set).

However on very natural readings of these proposed claims they are either question-begging or do not lead us in the direction of quantum gravity rather than the more general microgravity. Note that the second principle requires that we need not find out that spacetime is non-fundamental. Perhaps though this could be put less tendentiously by saying that there is no fixed background spacetime. Still, we clearly have not learned in any unequivocal way that spacetime must have quantum properties. Indeed we know very well that there are satisfiable axioms for semiclassical theories—that is, theories that couple quantum operators to classical variables via expectation values. These are perhaps ugly and objectionable for other reasons, but that all matter fields and electrodynamical fields and weak fields and strong fields are governed by quantum mechanical laws simply does not entail that all dynamical fields are so governed. Another, weaker and more general, unification claim might be just that gravity and quantum mechanics must be unified in one coherent physical theory. But if all that is necessary is to construe unification via some peaceful coexistence, then there is no ground for thinking that spacetime itself must exhibit quantum properties.[2] And

[1] A terminological point: Rovelli (2011) at least in his Zakopane lectures on loop gravity identifies the unification aim as to find some underlying field such that its phenomenology is, in the right limits, the phenomenology of two or more other fields, in the way that the electroweak theory unifies quantum electrodynamics and the theory of the weak force. This appears more as the *output* of a unification scheme than as the demand for unification in the first place, where unification need not a priori take the form of an entity that does the unifying rather than merely a theory that is the unification of the phenomenology and/or principles of two or more other theories. We can see this by considering a parallel case: nothing about the fact that theories of electricity and magnetism are unified in Maxwell's theory tells us that the electric field and the magnetic field are aspects of the single electromagnetic field—that must wait for the special theory of relativity, a theory that is explicitly constructed to unify two domains, electrodynamics and mechanics, via a consistent formulation of the light principle and the relativity principle. I will be using "unification" in its more generic sense.

[2] Apparently there is a minor conceptual confusion to clear up here. To say that the quantum nature of matter is relevant to what we observe about the metric field is one thing. To suggest that the metric, or spacetime, must exhibit quantum properties is quite another. The spacetime of Wald's axiomatization of linearized semiclassical gravity is a purely classical field and has no strictly quantum