Emergent Spacetime and Empirical (In)coherence

Nick Huggett and Christian Wüthrich

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Introduction

Local Beables and Empirical Incoherence
Questions

‘It’s Tuesday so this must be loop quantum gravity’: A Lightening Tour of Some Quantum Theories of Gravity

Spacetime Lattices
Loop Quantum Gravity
String Theory
Non-Commutative Field Theory

Physical Salience

Maudlin’s Challenge
The Upwards Path
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1.1 - Local Beables and Empirical Incoherence

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- Thus, a theory without fundamental spatiotemporal ‘furniture’ is empirically incoherent unless it is possible to derive local beables from it.
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- What about quantum theories of gravity, which put pressure on classical spacetime?
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- What about quantum theories of gravity, which put pressure on classical spacetime?

At bottom, what is the nature and significance of derivations of local beables in quantum gravity?
1.2 - Questions

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- If so, are there formal derivations of local beables? What are they?

- Is a purely formal solution to the problem of local beables adequate?
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First: why bother considering such partial theories?
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2.1 - Spacetime Lattices

- Discrete metrical spacetimes – by itself no more causes problem for local beables than the atomic theory does for apparently continuous material bodies.

- Non-metrical lattices, with primitive ’causal’ relations. ’Derivations’ of spacetimes done via embedding – the dynamical principles that lead to classical spacetimes are unknown. Empirical coherence is not established (CW: redefine local beables in causal terms?)
States as quantum superpositions of spin networks – 'spin foam'.

Superposition means locality 'indeterminate'.

Adjacency of nodes does not entail 'closeness' in the derived metric – the path from nodes to locality is not straight-forward.
Strings look like local beables – they live in a background spacetime.

But . . . dualities suggest/show that the background spacetime is geometrically indeterminate (metrically or topologically) in ways phenomenal spacetime is not – hence they are not the same thing.

Taking dual theories as different representations of the same physical world, one of the representations matches ours – a technical solution to the problem of local beables.
2.4 - Non-Commutative Field Theory

- *Algebraic* commutative geometry:
  - (Roughly) $[x, y] = 0$ characterizes the differential geometry of the plane.
  - Geroch: Einstein algebras characterize models of GTR (Earman).
  - Of course, these algebras have a *representation* in terms of scalar fields polynomial in $x$ and $y$ – fields in classical space(time).
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- **Non-Commutative Geometry:**
  - Deform the algebra of polynomials in \(x\) and \(y\) to \([x, y] = \theta\).
  - The usual apparatus of field theory (action, fibre bundles etc) can be formulated algebraically.
  - A representation in terms of polynomial fields in the plane, but w.r.t. non-commutative, ‘Moyal-\(\star\)’ multiplication – physics is blind to the commutative nature of the plane.
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The algebraic – space(time) free – representation is fundamental: no fundamental meaning to point values.
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3.1 - Maudlin’s Challenge

But one might also try instead to derive a physical structure with the form of local beables from a basic ontology that does not postulate them. This would allow the theory to make contact with evidence still at the level of local beables, but would also insist that, at a fundamental level, the local structure is not itself primitive. . . . This approach turns critically on what such a derivation of something isomorphic to local structure would look like, where the derived structure deserves to be regarded as physically salient (rather than merely mathematically definable). Until we know how to identify physically serious derivative structure, it is not clear how to implement this strategy.

(Maudlin 2007, 3161, emphasis added)
To complain that a derivation is not physically salient as understood by current theory is question begging.

So how do we learn what is physically salient? It’s part of a new theory and supported by the empirical evidence for the theory – consider the Cartesians and Newtonians on action at a distance.

So developing a new account of what derivations are physically salient is part of developing a theory of quantum gravity – conceptual analysis and development.

Lesson for theory: a place for philosophy.
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Lesson for theory: a place for philosophy.
3.3 - The Downwards Path

- Maudlin has things backwards – don’t decide what physical salience is and then validate derivations, rather our best guide to physical salience is successful derivations.

- A sketch of the analytic program: for existing theory fragments, study the 'partial' interpretations given by the statement that 'under such-and-such approximations (etc) the t-terms and o-terms are related thusly'.

- In philosophical terms, a program of empirical analysis of theoretical concepts.

- Lesson for philosophy: work top-down to maintain a controlled examination.
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