Laws beyond spacetime

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(joint work with Vincent Lam)

***Cosmology Beyond Spacetime* Online Seminar Series**

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The compatibility of Humeanism and naturalism

A question:

Are Humeanism and naturalism compatible? More specifically, can one be a Humean about laws of nature and a naturalist who takes fundamental physics seriously?

Thesis

Looking at physical theories beyond empirically established quantum physics and relativity suggests a novel, and much deeper naturalist challenge to Humeanism about laws of nature than those debated before.

$\Rightarrow$ The principal problem that arises is how to even articulate a Humean account of laws in a world that is fundamentally non-spatiotemporal.

An all too common sentiment...

Sklar, Lawrence. Prospects for a causal theory of space-time. In Richard Swinburne (ed.), *Space, Time, and Causality*, *Synthese Library* 157 (1983): 45-62.

Larry Sklar (1983, 45)

> *What could possibly constitute a more essential, a more ineliminable, component of our conceptual framework than that ordering of phenomena which places them in space and time?... We could imagine a world without electric charge, without the atomic constitution of matter, perhaps without matter at all. But a world not in time? A world not spatial? Except to some Platonists, I suppose, such a world seems devoid of real being altogether.*

A generic prediction of fundamental quantum theories of gravity

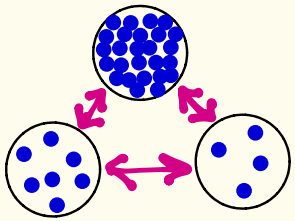
Huggett, Nick and Wüthrich, Christian. Emergent spacetime and empirical (in)coherence. *Studies in the History and Philosophy of Modern Physics* 44 (2013): 276-285.

Huggett, Nick and Wüthrich, Christian. *Out of Nowhere: The Emergence of Spacetime in Quantum Theories of Gravity*. Oxford University Press (under contract).

- Many approaches to formulating a quantum theory of gravity either presuppose or entail that fundamentally, there is neither space nor time—although that denial comes in degrees, and differs from approach to approach.
- In the language of physics: spacetime theories such as GR as 'effective' and spacetime itself 'emergent', much like thermodynamics is an effective theory and temperature is emergent, as it is built up from the collective behaviour of gas molecules.
- In general, the emergence of spacetime is physically contingent in that it may fail under some circumstances.

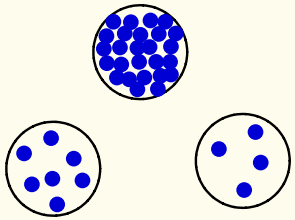
Oriti's levels of spacetime emergence

3: phase transitions bw different phases, 'geometro-generis as non-temporal



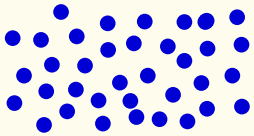
understand phase transitions

2: same DOFs, different perspectives / phases, some non-geometric



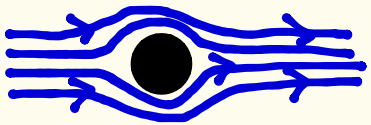
show existence of spacetime phase

1: fundamental DOFs combinatorial, algebraic



take continuum limit

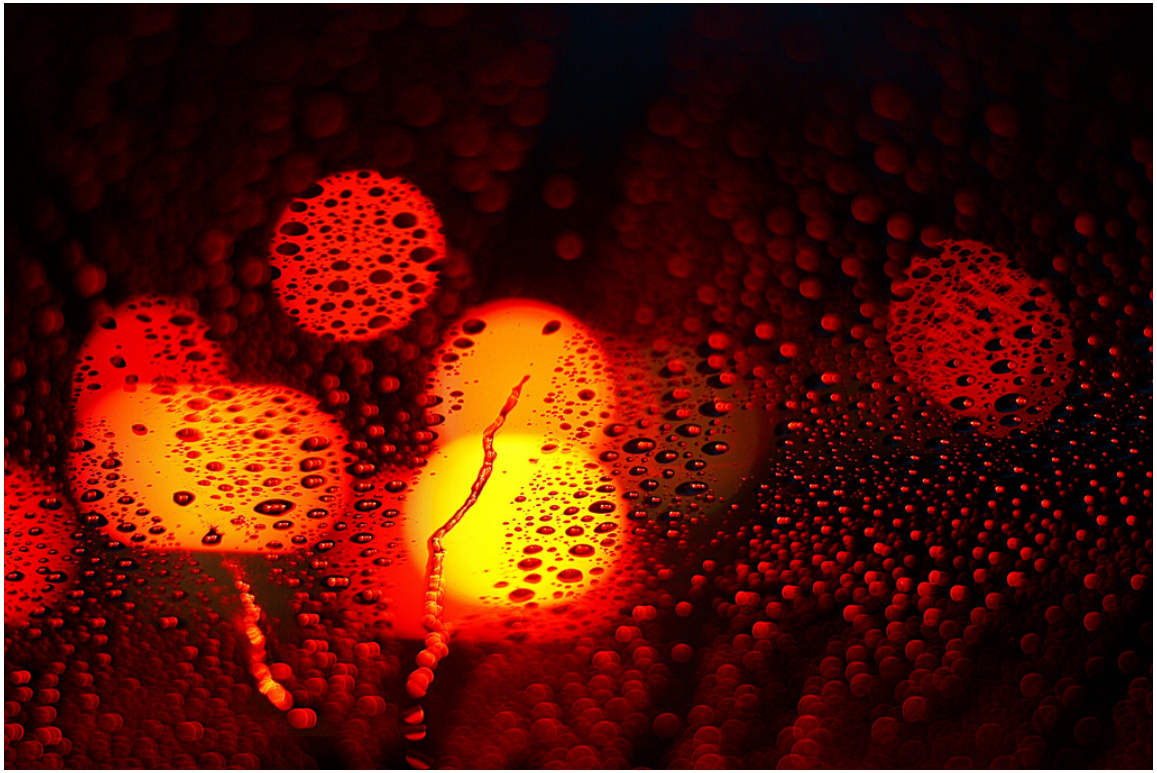
0: - GR
- quantization of geometric DOFs



take classical limit

Daniele Oriti. Levels of spacetime emergence in quantum gravity. Forthcoming in Christian Wüthrich, Baptiste Le Bihan, and Nick Huggett (eds.), *Philosophy Beyond Spacetime*. Oxford University Press.

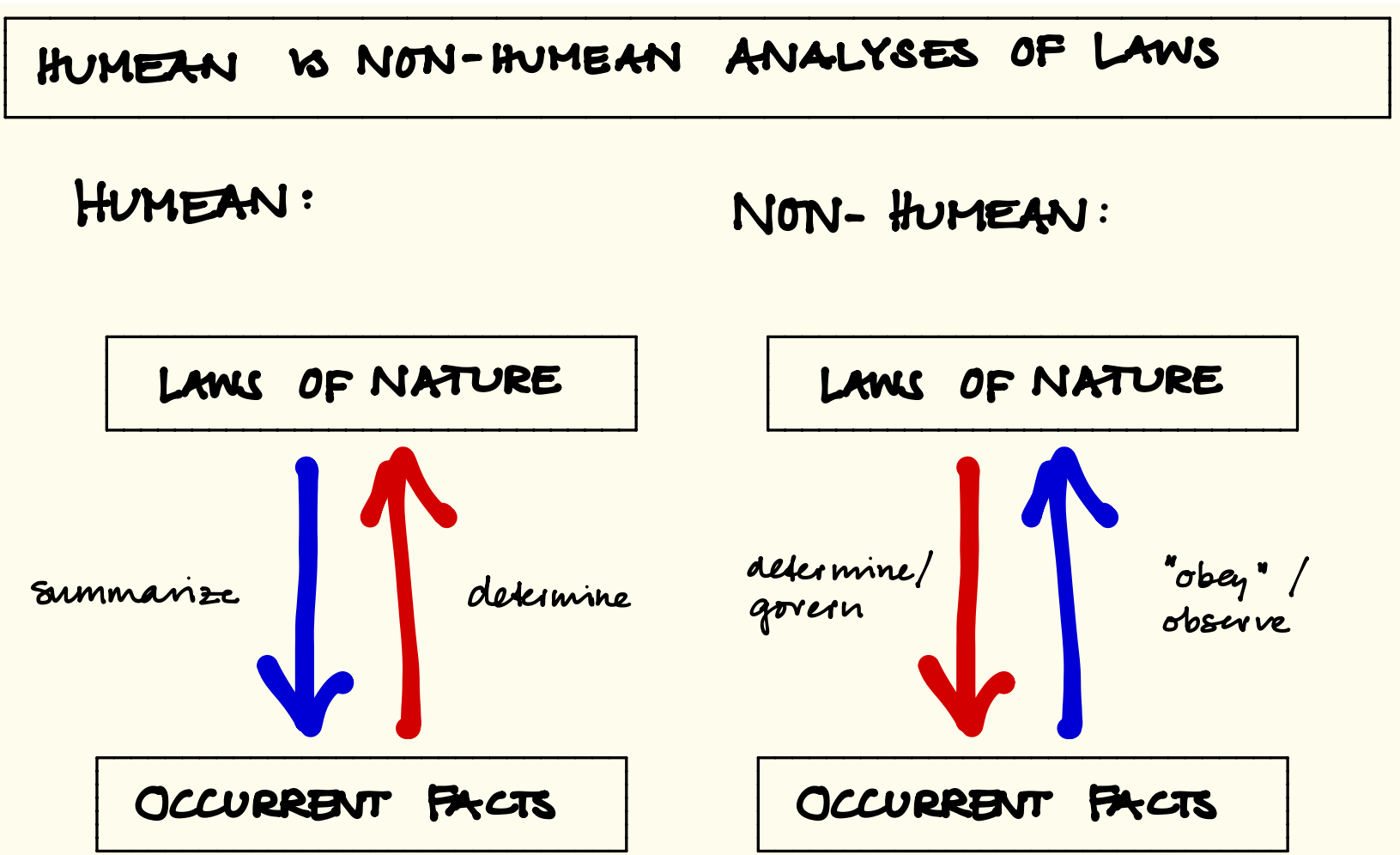
A world not in time? A world not spatial?



Beyond Spacetime, `beyondspacetime.net`

General project by Nick Huggett and CW on the 'emergence' of spacetime from less-than-fully spatiotemporal degrees of freedom; more specific project by Vincent Lam and CW to work out the implications for analyses of laws of nature.

Laws of Nature



Laws of Nature

THE ROUGH GUIDE TO LAWS OF NATURE

HUMEAN (no 'necessary connections')

BEST SYSTEMS ANALYSIS

WHAT THERE IS:

MOSAIC OF LOCAL MATTERS OF PARTICULAR FACTS

(eg. distribution of point-particles in spacetime)

LAWS are AXIOMS or THEOREMS OF 'BEST' DESCRIPTION OF MOSAIC, i.e. BEST BALANCE BETWEEN SIMPLICITY AND STRENGTH.

NON-HUMEAN ('governing conception')

PRIMITIVISM

WHAT THERE IS:

LOCAL MATTERS OF FACTS (eg. initial configurations of particles in spacetime) + LAWS

LAWS are IRREDUCIBLE, PRIMITIVE POSITS.

DISPOSITIONALISM

WHAT THERE IS:

LOCAL MATTERS OF FACTS (eg. initial configurations of particles in spacetime) + DISPOSITIONS

LAWS derive from DISPOSITIONS WHICH INHERE IN OBJECTS.

in both cases: PRIMITIVE MODALITY

Humean laws in a spacetime-less world

- Although not scientifically established yet, let us suppose that this suggestion of non-spatiotemporality will be borne out by our best physics.

Question:

Is a Humean analysis of laws of nature viable in a world that is not fundamentally spatiotemporal?

Humean supervenience

David Lewis. *Philosophical Papers: Volume II*. Oxford University Press: Oxford, 1986.

Thesis (Humean supervenience)

"Humean supervenience... is the doctrine that all there is to the world is a vast mosaic of local matters of particular fact, just one little thing after another... We have geometry: a system of external relations of spatiotemporal distance between points. Maybe points of spacetime itself, maybe point-sized bits of matter or aether or fields, maybe both. And at those points we have local qualities: perfectly natural intrinsic properties which need nothing bigger than a point at which to be instantiated. For short: we have an arrangement of qualities. And that is all. There is no difference without difference in the arrangement of qualities. All else supervenes on that." (Lewis, ix f)

- The supervenience base contains only local non-nomic facts and spatiotemporal relations, 'weaving' these facts into a 'carpet'.
- Thus, these basic occurrent facts metaphysically precede modal and nomic facts.

Pointillism about laws

Paul Signac. La calanque (1906).

'When the actual world is not even possible'

Non-spatiotemporality and modality

Christian Wüthrich. When the actual world is not even possible. In G. Darby, D. Glick, and A. Marmodoro (eds.), *The Foundation of Reality: Fundamentality, Space and Time*. Oxford UP (2020), 233-253.

- Under the supposition that quantum theories of gravity are correct in their implication that spacetime is not fundamental, Lewis's pluriverse, for all its ontological abundance, does not contain our (actual) world.
- On Lewis's account of modality, our world comes out as metaphysically impossible.

Humean supervenience and quantum non-locality

- Humean supervenience has often been criticised for its apparent incompatibility with quantum non-locality.
- Whatever the verdict of this debate may be, let us grant that the Humean can respond to the challenge, perhaps by extending their supervenience base to include non-local facts.
- Although a purely local arrangement of facts would have been attractive for the Humean, extending it to accommodate quantum non-locality seems not in violation of the Humean spirit of forbidding necessary connections.

Humean supervenience and quantum gravity

- The challenge from quantum gravity runs deeper than that from quantum non-locality: if the world is fundamentally non-spatiotemporal, then what it means to be a spatiotemporal arrangement is not even statable.

$\Rightarrow$ The 'mosaic' or 'carpet' metaphors of the set of basic occurrent facts must be given up entirely, even if that mosaic included non-local facts; the supervenience base cannot be articulated in any spatiotemporal terms at all.

- But: this does not imply that there cannot be a way to express a Humeanly acceptable set of non-nomic facts that can serve as supervenience base.
- In other words, can we still have a Humean carpet (if not a Humean mosaic)?

Why the Humean needs some glue

- In order for a world to be unified (and perhaps isolated from other worlds), the particular contingent facts also require some form of 'weave' or 'glue' in the supervenience base to turn them into a world.
- For Lewis, spatiotemporal relations perform this job; clearly these are no longer available.
- What kind of relations could take over this weaving or glueing job?
- Arguably, these relations should be appropriately external, i.e., they ought to be relations which the particular facts could stand in or not as a matter of contingent circumstance.

The search for a new supervenience base

- As should be obvious for the naturalist, this should be determined a posteriori.
- What a new supervenience base for the naturalistic Humean project might be will then turn on the favoured approach to quantum gravity.

$\Rightarrow$ This in turn will depend on what these approaches take to be the occurrent facts, and on what 'connects' them, i.e., by virtue of what do they exist in the same world, as the spatiotemporal relations in charge of that task before can no longer offer that duty.

- These connections ought to be assured by external relations and cannot in any way be nomic or modal (no necessary connections).

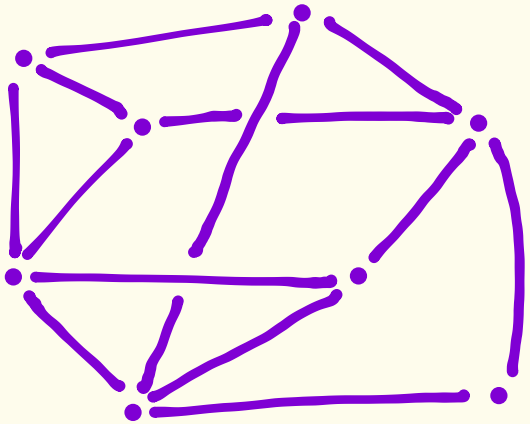
Slogan:

'Glue', but no 'nomic voltage'.

EXAMPLES OF 'OCCURRENT' FACTS

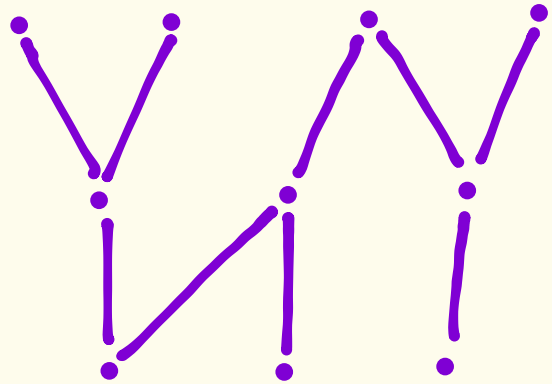
(1) LOOP QUANTUM GRAVITY

WHAT THERE IS:
spin network states



(2) CAUSAL SET THEORY

WHAT THERE IS:
causal sets



LAWS in either case: AXIOMS or THEOREMS OF THE THEORIES DESCRIBING THESE STRUCTURES.

The non-nomic supervenience base

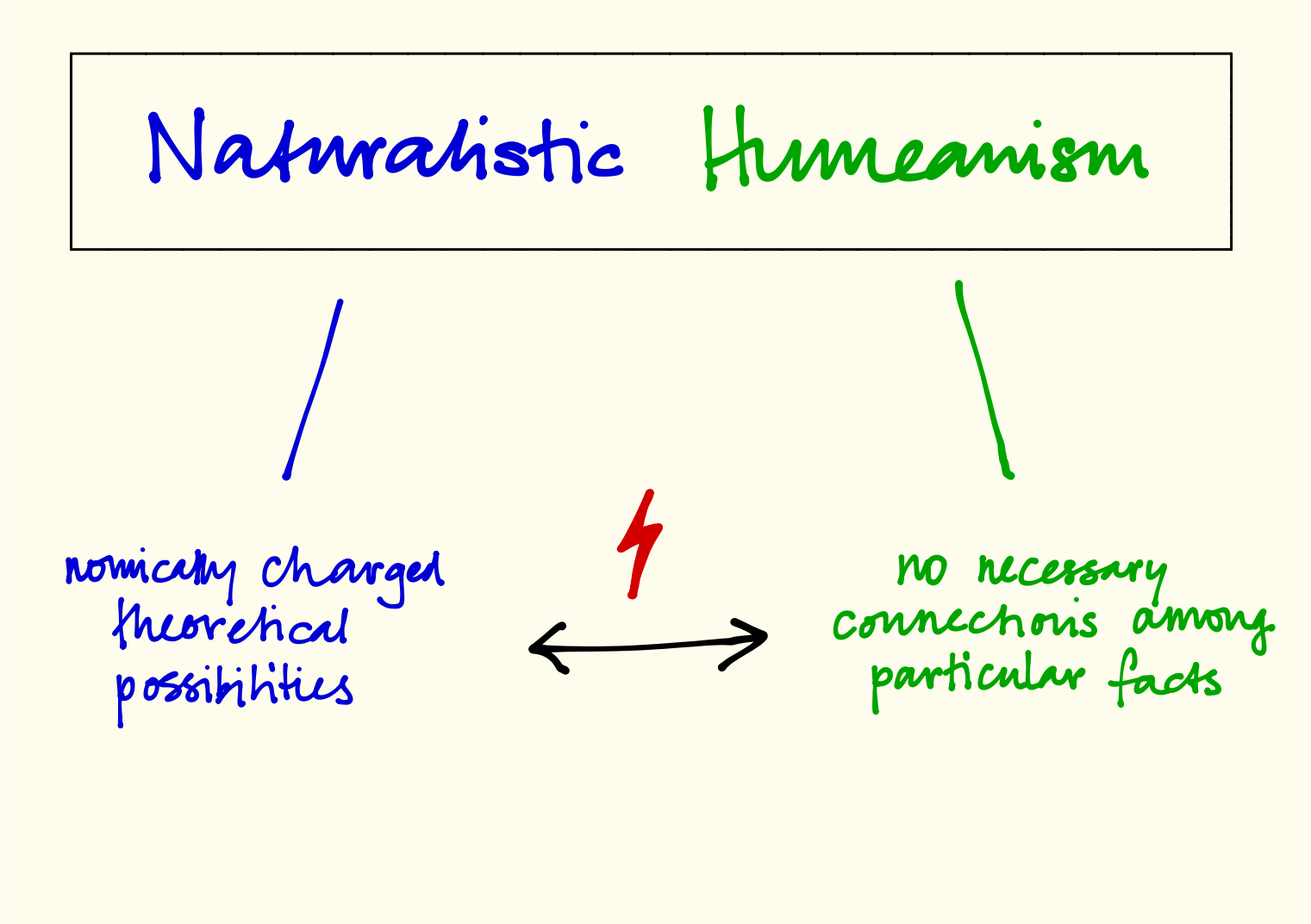
- An important remaining issue then is what guarantees that the facts in these basic sets are non-modal or non-nomic?
- Traditionally, the principle of free recombination, according to which elementary entities such as facts or states of affairs are freely recombinable in that any combination or permutation generates a metaphysically possible world, underwrites the non-nomicity of the supervenience basis.
- Generally, philosophers do this pre-theoretically; not so a naturalist who looks at quantum gravity: theories guide us as to what are basic facts and permissible combinations thereof.

$\Rightarrow$ But any such base is nomically charged...

The tension between Humeanism and naturalism

- Problem: in those theories, facts are not freely recombinable—they are only combinable in ways permitted by the theory.
- But to invoke a theory to license permissible recombinations amounts precisely to imposing laws on these basic facts, thus creating 'necessary connections'.

The tension between Humeanism and naturalism



The tension between Humeanism and naturalism

- On pain of a self-defeating circularity, it seems as if the Humean must reject that it is those theories which underwrite the non-nomicity of the supervenience set.

$\Rightarrow$ The naturalist Humean finds herself in the awkward position of accepting what our best fundamental theories tell us what binds particular matters of fact (to get the 'glue'), without accepting the theory 'fully' (trying to avoid the nomic voltage).

A desperate question:

Is there any hope that this tension can be navigated?

A proposal to be explored: kinematics vs. dynamics

- Proposal: take the kinematically possible models of a theory as metaphysical possibilities (furnishing the glue), and its dynamically possible models as nomological possibilities (thus avoiding the nomic voltage in merely kinematically possible worlds)
- This is pleasing to the naturalist, as it stays very close to the structure of physical theories.
- But there are some difficulties...

Too naturalistic? Not sufficiently Humean?

1. The proposal presupposes a natural distinction between kinematics and dynamics of a theory; this distinction cannot obviously be maintained in quantum gravity.
2. Too naturalistic: does it stay too close to a particular physical theory (or at least framework) to span the full gamut of metaphysical possibilities?
3. Insufficiently Humean: to what extent can we say that the kinematic possibilities are not nomically charged? In other words, are only dynamical laws really laws?

Another proposal

- Proposal:[1] don't look to physical space, look at the state 'space', or the configuration 'space' of fundamental theories
- Since the theories of interest will all be quantum theories, we have a configuration space or a Hilbert space which can be assumed as fundamental.

$\Rightarrow$ Use another space such as these as a foundation for the Humean supervenience base.

- Again, this is an interesting proposal, but there are some problems...

[1] Thanks to Jonas Waechter

Back to square 1?

1. It does seem to presuppose a specific space, but each system has its own state/Hilbert space. Thus, we would get, at best, a free recombination for that system only (though of course that system can be the universe).
2. Even if there is a way to generalize this to resolve the first difficulty, it would still make free recombination semi-hostage to a particular theory (or family of theories), leading back to the tension between naturalism and Humeanism encountered above...

Conclusion: general

- The tentative result that spacetime disappears at the fundamental level would, if borne out, force radical reconceptions of what it is to be a law of nature.
- This would be the case for all three approaches, as they all presuppose fundamental spacetime.
- In fact, the required revisions seem to be so sweeping that it opens the question of whether the approaches would survive into the new era or whether an altogether different way of thinking about laws of nature will be needed.

Conclusion: implications for Humeanism

- Non-spatiotemporal physics deprives the Humean of a natural supervenience basis on which to apply some form of free recombination to generate metaphysical possibilities devoid of necessary connections.
- This points to a general tension between Humeanism (about laws) and naturalism: how can we navigate the demands of freely 'gluing' worlds without charging them nomically and obtain a sufficiently naturalistic and sufficiently Humean account?
- Perhaps this is impossible: we may not be able to look to scientific reasoning while suppressing how it projects necessity or nomicity into the world.
- When push comes to shove, we ought to remember that Humeanism is optional, while naturalism is mandatory.