Quantum Gravity: no spacetime, no laws?

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Abstract

What are laws of nature? How do they operate in the world? Rivers of ink have flown to dispute the nature of laws. Since laws of nature are usually assumed to be laws of physics, it is good practice for naturalised metaphysicians to follow up on the developments of physics to test their positions. In recent times, philosophers have turned to QG to evaluate extant metaphysical analyses of laws of nature (Matarese, 2019; Cinti and Sanchioni, 2021; Lam and Wüthrich, 2023; Lam and Oriti, 2024) and have discovered that the aforementioned questions about laws are worth to be asked again in light of QG, for proposed accounts of lawhood do not do the job anymore.
QG programs aim to describe the physics at the Planck scale. Despite starting from distinct assumptions and employing different methodologies, all approaches to QG postulate structures in which classical spatiotemporal notions such as distance and duration are nowhere to be found (Rovelli, 2004; Kuchař, 2011; Huggett and Wüthrich, 2025). For this reason, spacetime is said to have disappeared from QG and is expected to emerge in the classical limit of a theory of QG. At present, due to technical and conceptual issues, this endeavour is far from being conquered, despite it being a crucial step towards a full theory of QG.

Now, for the purposes of this paper, what we are interested in are not the specifics of spacetime disappearance (that is an outcome of the quantization procedure),(1) but a more general series of results of QG: (i) that QG describes a level of reality that is more fundamental than an emergent one; (ii) that QG programs postulate structures devoid of explicit spatiotemporal notions; (iii) that spatiotemporal features of the emergent level depend in a significant way on the more fundamental and non-fully-spatiotemporal QG structures, in the sense that specific aspects of the bottom layer are expected to (at least partly) explain features of the emergent one.(2)

As stated, a complete theory of QG is still missing. However, being QG mainly a research branch of physics, we might expect that a full account will employ what we might call "QG laws" to describe the kinematics and, importantly, the dynamics of QG structures.(3) This is quite obvious if we consider standard scientific practice, according to which it is the job of the laws to explain (or at least to constitute part of the explanation of) their instances.(4) Since the main issue in QG is indeed to recover relativistic spacetime, the hope is that we will be able to map the QG laws to the Einstein field equation (EFE) via a limiting procedure.
How are we to understand QG laws? Recent discussions have shown how difficult it is to accommodate standard Humean and non-Humean analyses of laws within the QG regime. If the difficulties in updating existent accounts of laws are insurmountable, what options are we left with? In my talk, I will discuss three routes that might be undertaken once one realises QG's challenges for traditional accounts of laws.(5) The first is to accept that our

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metaphysics of laws is limited to spatiotemporal realms, thus giving up any chance of updating traditional accounts of laws in QG. The second consists in taking laws as emergent in the same sense as spacetime is (Lam and Wüthrich, 2023; Lam and Oriti, 2024). The third suggests considering the recently developed position of laws as constraints (Adlam, 2022; Chen and Goldstein, 2022; Chen, 2024) to account for QG laws. I will present and criticise the first two routes on the basis of the role that QG laws play in explaining spacetime emergence and argue that QG laws can be understood in terms of constraints. If QG laws do indeed play some role in explaining spacetime emergence, giving up any possibility of understanding them (thus undertaking the first route) means also giving up on understanding the recovery of spacetime. Similarly, if we take the second route and consider laws as emergent we give up on understanding the QG regime, for without laws it is unclear what else might explain QG structures.(6) On the other hand, the third route offers a way to conceptualise the modal force of non-spatiotemporal physical laws. In this regard, it will be crucial to reflect on how the notion of explanation must also be revisited in QG.

(1) The main aim of canonical approaches to QG is indeed to quantize the spacetime geometry of GR.

(2) Although we are still waiting for a precise definition of emergence, the notion has not been considered incompatible with reductionism (Butterfield, 2011; Crowther, 2016, 2018; Huggett and Wüthrich, 2025) and it is usually characterised as providing novel and robust features in the derived level of reality, although variations might be found in different authors.

(3) While accounts like LQG have a well-developed kinematics, the dynamical part of the theory is still not fully understood (Rovelli, 2004; Wüthrich, 2006).

(4) Emery (2018) has emphatically pointed out that the laws are (part of) the 'because' of their instances.

(5) The routes presented here do not exhaust the set of possibilities to understand QG laws. Rather, they are to be considered as possible reactions (some of which already suggested in the literature) to the difficulties in updating our metaphysics of laws in QG.

(6) One might object that QG presents features so alien to standard physics that the expectation for there to be laws of QG is ill-founded. This point is taken, for it might be, in the end, that QG will force us to abandon standard physics practices and come up with new mechanisms to explain, among other things, spacetime emergence. However, this paper rests on the assumption that unless it is shown that a full theory of QG is devoid of laws, it is reasonable to expect there to be laws in QG, which is domain of physics.

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