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# Beyond Quantum Gravity principles, structures and phenomena

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Modern theoretical physics is founded on two pillars: quantum mechanics and general relativity. And yet, despite tremendous theoretical efforts, the bridge between the two pillars has not so far been univocally established. In parallel, the possible quantum nature of gravity is probed through dedicated experiments [1] and astrophysical observations [2]. The tension between gravity and the quantum raises foundational questions: Are relativistic symmetries and the spacetime structure broken by the quantum effects? Is the gravitational interaction classical, quantum or maybe neither of these? How does the classical macroworld emerge from the quantum microworld?

The constitutive objective of the project is to establish a novel theoretical framework to address these questions rigorously. The central motivating hypothesis reads: *Further progress in conciliating general relativity and quantum theory requires models, that go* both *beyond classical spacetime* and *beyond local quantum mechanics.* The specific goals of the project are two-fold:

Firstly, we aim at establishing a new universal mathematical formalism for probabilistic theories on spacetime. Its purpose is to integrate the modern 'beyond-quantum' theories based on information processing [3–5] with the structure of a relativistic spacetime, following our precursory work [6–9].

Secondly, we aim at understanding the processes of quantum-to-classical transition and black hole evaporation. The working hypothesis, supported by our preliminary research [10–12], is that gravity is *not classical*, but also *not locally-quantum.* Consequently, we conjecture that a beyond-quantum-gravity mechanism could explain the emergence of the classical. We further suspect that the same mechanism is responsible for the enormous growth of entropy in the gravitational collapse. Finally, we posit that another beyond-quantum-gravity mechanism induces the flow of information from under the black hole trapping horizon to the Hawking radiation.

## References


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