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Non-perturbative renormalization group flows in quantum gravity: A safe way to the quantum nature of spacetime

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The perturbative quantum-field theoretic treatment of General Relativity leads to a non-renormalizable theory. This implies that the underlying quantum theory is not predictive at sufficiently high energies, precisely where quantum-gravity effects are supposed to be dominant. Many different approaches were and are followed in order to construct a predictive theory of quantum gravity. In many situations, a significant departure from standard quantum field theory methods is required. In this talk, I will review the basic aspects of the so-called asymptotic safety scenario for quantum gravity in which a predictive theory of quantum gravity is proposed based on the existence of a non-trivial renormalization group fixed point - the Reuter fixed point. Moreover, I will discuss some recent results obtained in this field that not only provide further evidence for its realization but also explore some potential phenomenological tests for this approach to the quantum structure of spacetime.