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Emergent Gravity from Topological Quantum Field Theory: Stochastic Gradient Flow Perspective away from the Quantum Gravity Problem

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We propose a scenario according to which the ultraviolet completion of General Relativity is realized through a stochastic gradient flow towards a topological BF theory. Specifically, we consider the stochastic gradient flow of a pre-geometric theory proposed by Wilczek. Its infrared limit exists, and corresponds to a fixed point where stochastic fluctuations vanish. Diffeomorphism symmetries are restored in this limit, where the theory is classical and expressed by the Einstein-Hilbert action. The infrared phase then corresponds to the classical theory of General Relativity, the quantization of which becomes meaningless. Away from the infrared limit, in the pre-geometric phase of the stochastic gradient flow, the relevant fields of the Wilczek theory undergo stochastic fluctuations. The theory can be quantized perturbatively, generating corrections to the classical Einstein-Hilbert action. The stochastic gradient flow also possesses an ultraviolet fixed point. The theory flows to a topological BF action, to which general non-perturbative quantization methods can be applied. Two phase transitions occur along the thermal time dynamics, being marked by: i) the breakdown of the topological BF symmetries in the ultraviolet regime, which originates the pre-geometric phase described by the Wilczek theory; ii) the breakdown of the parental symmetries characterizing the Wilczek theory, from which General Relativity emerges. The problem of quantizing the Einstein-Hilbert action of gravity finally becomes redundant.

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