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Scale and Conformal Invariance in Quantum Field Theory

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The behavior of coupling constants in quantum field theory under a change of energy scale is encoded in the renormalization group. At fixed points of the renormalization group flow, quantum field theories exhibit conformal invariance and are described as conformal field theories. The larger spacetime symmetry of conformal field theory is not the smallest possible extension of Poincare invariance. Indeed, scale invariance could occur without conformal invariance which would lead to scale field theories. We thus investigate the theoretical implications of scale invariance without conformal invariance in quantum field theory. We argue that renormalization group flows of such theories correspond to recurrent behaviors, i.e. limit cycles or ergodicity. We discuss the implications for the a-theorem, and use Weyl consistency conditions to show that scale invariance implies conformal invariance at weak coupling in four-dimensional quantum field theory. Finally, we clarify the necessary and sufficient conditions for conformality and present new types of conformal field theories.

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