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Nota di contenuto	1. Introduction -- 2. Unitarity implies anomalous thresholds -- 3. Primer on the analytic S-matrix 4 -- Singularities as classical saddle points -- 5. Branch cut deformations -- 6. Glimpse at generalized

dispersion relations -- 7. Fluctuations around classical saddle points -- 8. Conclusion Appendix. Review of Schwinger parametrization.

Sommario/riassunto

This book provides a modern perspective on the analytic structure of scattering amplitudes in quantum field theory, with the goal of understanding and exploiting consequences of unitarity, causality, and locality. It focuses on the question: Can the S-matrix be complexified in a way consistent with causality? The affirmative answer has been well understood since the 1960s, in the case of 22 scattering of the lightest particle in theories with a mass gap at low momentum transfer, where the S-matrix is analytic everywhere except at normal-threshold branch cuts. We ask whether an analogous picture extends to realistic theories, such as the Standard Model, that include massless fields, UV/IR divergences, and unstable particles. Especially in the presence of light states running in the loops, the traditional i prescription for approaching physical regions might break down, because causality requirements for the individual Feynman diagrams can be mutually incompatible. We demonstrate that such analyticity problems are not in contradiction with unitarity. Instead, they should be thought of as finite-width effects that disappear in the idealized 22 scattering amplitudes with no unstable particles, but might persist at higher multiplicity. To fix these issues, we propose an i-like prescription for deforming branch cuts in the space of Mandelstam invariants without modifying the analytic properties of the physical amplitude. This procedure results in a complex strip around the real part of the kinematic space, where the S-matrix remains causal. We illustrate all the points on explicit examples, both symbolically and numerically, in addition to giving a pedagogical introduction to the analytic properties of the perturbative S-matrix from a modern point of view. To help with the investigation of related questions, we introduce a number of tools, including holomorphic cutting rules, new approaches to dispersion relations, as well as formulae for local behavior of Feynmanintegrals near branch points. This book is well suited for anyone with knowledge of quantum field theory at a graduate level who wants to become familiar with the complex-analytic structure of Feynman integrals.