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Positivity Properties of Scattering Amplitudes

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Positivity properties in quantum field theory (QFT) are often associated with fundamental principles such as unitarity and causality. Yet, in many cases, these properties arise from deeper mathematical structures.

In this talk, we explore an infinite set of positivity constraints obeyed by certain amplitudes—and related observables—that go beyond conventional expectations. Specifically, we highlight regions where these quantities and all of their signed derivatives are positive, a striking behavior known in mathematics as complete monotonicity. We begin by introducing completely monotone (CM) functions and their key properties, including their integral representations. We then demonstrate how fundamental objects in QFT, such as scalar Feynman integrals, exhibit this property. Building on this, we present evidence that a variety of observables—such as Coulomb branch amplitudes, the cusp anomalous dimension, and remainder functions in planar $\mathcal{N}$=4 super Yang–Mills theory—exhibit complete monotonicity across multiple perturbative orders. We further show that some observables belong to an even more restricted subclass of CM functions, known as Stieltjes functions, which in particular allows for very good approximations of these observables using rational-functions.

We conclude by outlining potential applications of these constraints to the numerical bootstrap of Feynman integrals and to the ongoing study of positive geometries in quantum field theory.

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