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Perturbative QFT Meets Number Theory

Ivan Todorov

Bulgarian Academy of Sciences

Abstract

The last few decades, especially the period between the discovery of the top quark at Fermilab in 1995 and the first run of LHC in 2010, was a romantic time of unconstrained imagination for people engaged in “mathematical high energy physics”. The part of it that makes contact with the reinvigorated high energy experiments turned out to be good old (perturbative) quantum field theory. Happily, it did not make mathematically minded theorists redundant – substituted by computer programmers. The zoo of Feynman graphs and corresponding multidimensional integrals that express the scattering amplitudes is been tamed by the presence of a well structured family of special functions and associated numbers studied by algebraic geometers and number theorists. They provide the germ of a rational basis for such amplitudes. The numbers in question also appear as residues of the poles to be subtracted from a primitively divergent Feynman amplitudes. In the first few orders of perturbation theory (up to six loops in the massless φ^4 theory) the family of multiple polylogarithms and multizeta values serves the job. It is equipped with the rich structure of a double shuffle and a Hopf algebra which enables us to find various relations among them and to study the monodromies and what physicists call “unitarity cuts” of Feynman amplitudes.

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