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Loops, polytopes and splines. (English) Zbl 1342.81355

Summary: We uncover an unexpected connection between the physics of loop integrals and the mathematics of spline functions. One loop integrands are Laplace transforms of splines. This clarifies the geometry of the associated loop integrals, since a $n$-node spline has support on a $n$-vertex polyhedral cone. One-loop integrals are integrals of splines on a hyperbolic slice of the cone, yielding polytopes in AdS space. Splines thus give a geometrical counterpart to the rational function identities at the level of the integrand. Spline technology also allows for a clear, simple, algebraic decomposition of higher point loop integrals in lower dimensional kinematics in terms of lower point integrals – e.g. an hexagon integral in 2d kinematics can be written as a sum of scalar boxes. Higher loops can also be understood directly in terms of splines – they map onto spline convolutions, leading to an intriguing representation in terms of hyperbolic simplices integrated over other hyperbolic simplices. We finish with speculations on the interpretation of one-loop integrals as partition functions, inspired by the use of splines in counting points in polytopes.

MSC:
81T18 Feynman diagrams
41A15 Spline approximation
52B11 $n$-dimensional polytopes

Keywords:
gauge-gravity correspondence; scattering amplitudes; AdS-CFT correspondence; conformal and W symmetry

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References:


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