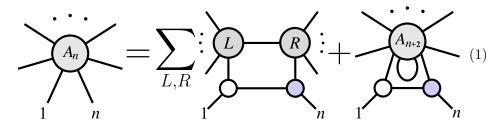# ON-SHELL PHYSICS AND THE POSITIVE GRASSMANNIAN

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I will describe the recent and profound advances in our understanding of quantum field theory and the connections between its analytic structure and the geometry of the positive part of Grassmannian manifolds. I will briefly review the recursive tools recently developed to understand the Feynman expansion more efficiently in terms of on-shell graphs, and describe how these tools extend to all-loop orders; in the case of planar, $\mathcal{N} = 4$ SYM, the all-loop version of the BCFW recursion relations, expressed in terms of on-shell graphs becomes:

$$ \tag{1} $$

I will explain the deep connection between on-shell graphs, the positive Grassmannian, and combinatorics. A simple consequence of this connection will be a complete classification of on-shell functions and all their relations for planar $\mathcal{N} = 1, \ldots, 4$ SYM as well as for pure Yang-Mills ($\mathcal{N} = 0$). Time permitting, the application of these techniques to the case of non-planar scattering amplitudes will be described.

Keywords: Scattering amplitudes, quantum field theory, the positive Grassmannian, combinatorics

[1] N. Arkani-Hamed, J. L. Bourjaily, F. Cachazo, S. Caron-Huot, and J. Trnka, "The All-Loop Integrand For Scattering Amplitudes in Planar $\mathcal{N} = 4$ SYM," *JHEP* **01** (2011) 041, arXiv:1008.2958 [hep-th].

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[3] N. Arkani-Hamed, J. L. Bourjaily, F. Cachazo, A. Goncharov, A. Postnikov, and J. Trnka, "Scattering Amplitudes and the Positive Grassmannian," *in prep.*