This review article deals with recent developments on multi-loop calculations in $\mathcal{N} = 4$ super Yang-Mills theory, based on the applications of the standard unitary cut methods. The authors first review the method of maximal cuts and discuss its convenience and efficiency in the calculation of multi-loop integrands for planar and non-planar amplitudes in four (and higher) dimensions. The developed techniques are powerful and practically useful but they do not necessarily answer what kind of theoretical principles there are behind the calculations of massless gauge theories. One of the hints for such a question may be obtained by dual relations between color and kinematic factors in the loop integrands, which are proposed/conjectured by Bern and the authors of this article [1, 2]. In the section before last, the authors briefly review this so-called color-kinematic duality and its usefulness in the multi-loop computations in $\mathcal{N} = 4$ super Yang-Mills theory. Its applications to gravity amplitudes are also discussed at the end of this section.

References

[1] Z. Bern, J. J. M. Carrasco and H. Johansson, Phys. Rev. D **78**, 085011 (2008) [arXiv:0805.3993 [hep-ph]].

[2] Z. Bern, J. J. M. Carrasco and H. Johansson, Phys. Rev. Lett. **105**, 061602 (2010) [arXiv:1004.0476 [hep-th]].