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Research activity

Much of my work, during the last three year of my PhD studies has centered around exploring novel approachs to probe colour flow and soft substructure of jets, which is beyond the traditional borders of Perturbative Quantum Chromodynamics (pQCD), namely globalness and infrared & collinear(IRC) safety.

During our last project[I], I have introduced infra-red and collinear safe projections of jet pull and performed their resummation. The theoretical understanding of these observables led us to the introduction of novel azimuthal asymmetry distributions that measure the radiation pattern by looking at the difference between the jet pull vector pointing towards and away from the other jet of interest. As expected, these asymmetries essentially depend on soft radiation, while collinear contributions cancel out, similar to [1]. Due to their sensitivity to wide-angle soft radiation, these asymmetries could play an important role in assessing subleading colour correlations. Moreover, the definition of the asymmetries essentially introduces a new boundary in phase-space which renders the all-order structure of these observables richer.

More information about my research during the last year are listed below, which can divided into three parts:

- Azimutal Asymmetry
  Right after my last year's report, I finished the NLL predictions for the safe projection of pull, for the process $q\bar{q} \to H\left(b\bar{b}\right) Z\left(l^+ l^-\right)$, at both parton and hadron level. we found that both the pull magnitude and our novel safe projections agreed with the Monte Carlo results. Furthermore, I have also performed the Monte-Carlo study of these distributions for the colour singlet decay $H \to b\bar{b}$. In order to emphasise these features, we have defined the (pull) asymmetry distributions and performed a fixed-order calculation. We dound that the asymmetries are sensitive to odd powers of the jet radius, in the small-R expansion. The above studies have resulted into a publication in JHEP[I].

  The global part of pull asymmetries have been resummed up to NLL accuracy. However, because of their sensitivity to soft radiation, the leading non-trivial contribution of pull asymmetry starts from NLL accuracy, thus the non-global logarithms (NGLs) need to be resummed to provide accurate predictions. For higher logarithm accuracy the two-loop soft function is needed, similar to the calculation of hemisphere soft function [2].

- Resummation of Non-Global Logarithms
  The resummation of non-glonal logarithms an be achieved by solving a non-linear evolution equation. Therefore, I have concentrated my research on a novel approach to solving differential equations using artificial neural networks, which was proposed in [3]. This method can dramatically speed up needed theory calculations and I am applying it to solve the BMS equation in order to resum leading NGLs.

During the end of last November, I have visited Durham, UK in order to collaborate with Prof. Michael Spannowsky. With his help, I have build the differential equation solver with both Numpy and PyTorch. In particular, the calculation can be further simplified with the symmetry of the BMS equation [4]. Then I have performed the calculation with my code for both the fixed-order and dressed-gluon approximation [5] from the expansion of BMS equation, which the result agree with both of them very well [5, 6], and now we are trying to achieve higher order results (up to 8-loops). Furthermore, inspired by the dressed-gluon approximation [7], I have also improved the fixed-order perturbative convergence via the Borel resummation.

- Soft evolution with full colour
  However, the BMS equation only include leading color accuracy [8]. For the evolution equation with the subleading color effects [9], the full solution is still under development. Therefore a novel approach for the resummation with full color is important. Applying this method to study the effect of colour correlations in observables like the pull asymmetry would be interesting.

  Recently, I was awarded the MCnet fellowship, for working with Prof Steffen Schumann's group in Göttingen. The purpose of this fellowship is to perform the resummation of the recently introduced pull asymmetries and implement it into a numerical code that can be used for phenomenology. Furthermore, I have accepted an offer for a postdoc position at Technion - Israel Institute of Technology, which will start in Jan 2021.

Conferences and Summer Schools

Jul 2020 International Workshop on Boosted Object Phenomenology, Hamburg (Online)
Video-poster: Calculation for NGLs with Neural Networks
Jun 2020 MCnet Machine Learning School, Lund (Online)
Dec 2019 Milan Christmas Meeting 2019, Milano
Talk: Probing Colour Flow with Jet Pull

Publications

[I] A. J. Larkoski, S. Marzani and **C. Wu**, "Safe Use of Jet Pull," doi:10.1007/JHEP01(2020)104 [arXiv:1911.05090 [hep-ph]].

[II] S. Marzani, M . Spannowsky and **C. Wu**, "Resummation of Non-Global Logarithms with neural network," in preparation.

[III] A. J. Larkoski, S. Marzani and **C. Wu**, "Azimutal Asymmetry," in preparation.

References

[1] S. Catani, M. Grazzini, and H. Sargsyan, "Azimuthal asymmetries in QCD hard scattering: infrared safe but divergent," *JHEP*, vol. 06, p. 017, 2017.

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[3] M. L. Piscopo, M. Spannowsky, and P. Waite, "Solving differential equations with neural networks: Applications to the calculation of cosmological phase transitions," *Phys. Rev. D*, vol. 100, no. 1, p. 016002, 2019.

[4] Y. Hatta and T. Ueda, "Jet energy flow at the LHC," *Phys. Rev. D*, vol. 80, p. 074018, 2009.

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[9] S. Caron-Huot, "Resummation of non-global logarithms and the BFKL equation," *JHEP*, vol. 03, p. 036, 2018.

[10] S. Höche and D. Reichelt, "Numerical resummation at sub-leading color in the strongly ordered soft gluon limit," 1 2020.