Abhiram Kaushik

Work experience

Postdoctoral fellow	**Institute of Mathematical Sciences**, Chennai, **India**	AUG 2019-PRESENT
Research Associate	**Indian Institute of Science**, Bangalore, **India**	AUG 2018-JULY 2019
Teaching Assistant	**Indian Institute of Science**, Bangalore, **India**	
	Statistical Mechanics - II	JAN-APR 2015
	Quantum Mechanics - II	AUG-NOV 2015

Research Experience

Theoretical Physics Group, Institute of Mathematical Science, Chennai
Postdoctoral Researcher AUG 2019-PRESENT
As a postdoctoral researcher, I am currently working on two different projects:

1. **Constraining the $g \to \pi^0$ fragmentation function with collider data and studying the inclusion of theory uncertainties in FF fits** *(with E. R. Nocera, R. M. Godbole and P. J. Mulders)*

   Traditionally fits of fragmentation functions were perform d using data on semi-inclusiv deep-inelastic scattering (SIDIS), which is not dir dly sensitive to the gluon fragmentation functions. There are only two fits of pion fragmentation functions that in luded collider ($pp \to \pi + X$) data. These are the AKK08 and DSS fits. Of these the former does not include any treatment of FF uncertainties. The latter includes an assessment of uncertainties using the Lagrange multiplier technique, which however does not allow one to faithfully extrapolate the uncertainties onto predictions made with the FFs. Therefore there is a need for FFs of pions the a) include collider data and b) include a systematic treatment of uncertainties. In this work, we aim to address this issue for the case of π^0 FFs.

   Our starting point is the NNFF1.0 FF set which is a recent fit of pion FFs to e^+e^- and SIDIS data that is performed using a Monte Carlo methodology that allows for a faithful propagation of uncertainties from the input data to prediction. By reweighting the NNFF1.0 FF set with data on π^0 production from RHIC and LHC we find that we can significatly constrain the gluon-to-π^0 fragmentation function.

   Furthermore we are als studying the impact of theory uncertainties on in the context of FF fits. Traditionally theory uncertainties have been neg cted in the context of PDF/FF fits since they were assum d to be insignificant compared to the uncertainties in the data. However with increasingly precise data available, especially from the LHC, this is no longer the case. Recently the NNPDF collaboration have

investigated the impact of theory uncertainties on PDF fits We aim to extend such an investigation to the case of FF fits.

2. **A mathematica package for the unified treatment of Harmonic Polylogarithms and Harmonic Sums** *(with V. Ravindran)*

   Harmonic Polylogarithms (HPLs) are a generalisation of Nielsen's polylogarithms which satisfy a product algebra. They appear in the evaluation of Feynman integrals in higher order calculations in massless perturbation theory. They form a basis set of functions using which, the divergent and non-divergent parts of the Feynman integrals can be written. Through a Mellin transform, HPLs are also related to Harmonic Sums — a class of iteratively nested sums obeying a shuffle algebra — that appear in the calculation of Feynman diagrams. In this work we are developing a Mathematica package that can handle the algebras of both HPLs and Harmonic Sums as well as their transformation into each other through Mellin and Inverse Mellin transforms.

Centre for High Energy Physics, Indian Institute of Science, Bangalore
Research Associate JULY 2018-JULY 2019
As a research associate at IISc, I continued working with my advisor on the topics of my PhD thesis, which is detailed in the section below.

Centre for High Energy Physics, Indian Institute of Science, Bangalore
Graduate Researcher AUG 2013-JULY 2018
Advisor: Prof. Rohini M. Godbole
Thesis Title: *Heavy flavour and direct photon probes of the gluon Sivers function*
Summary of work: The exploration of the proton's spin structure in terms of contributions by quarks, anti-quarks and gluons is an important domain of research in modern-day nuclear and particle physics. In recent years, the transverse-momentum structure of the nucleon — which is described in terms of *transverse-momentum dependent parton distribution functions (TMDs)* — has become a focus of this field. In my work, I have endeavoured to construct and assess various prospective probes for a TMD called the *gluon Sivers function. Sivers functions* describe an anisotropy in the transverse momentum distribution of partons in a proton (or in general any hadron) that is transversely polarised with respect to the beam axis. They are linked to the orbital angular momenta of partons in the nucleus, and also to non-trivial rescattering effects. An experimental confirmation of a non-zero value for the gluon Sivers function would indicate that there is a non-zero gluonic contribution to the orbital angular momentum of the proton. In my work I have studied various processes which involve the production of heavy flavour and direct photons ($ep^\uparrow \to J/\psi + X$, $p^\uparrow p \to J/\psi + X$, $ep^\uparrow \to D + X$, $p^\uparrow p \to D + X$, $p^\uparrow p \to \gamma + X$) to assess — from a phenomenological standpoint — their efficacy in probing a possible non-zero gluon Sivers function. This involved examining them in terms of production rates, impact of the Sivers function in experimentally accesible kinematic regions, sensitivity to existing models of the gluon Sivers function, effects of the QCD evolution of the TMDs and finally, on sensitivity to initial and final state scattering effects. All of these studies could inform current and future efforts to constrain the gluon Sivers function.

Scientific publications

1. R.M Godbole, A. Kaushik, A. Misra, S. Padval
   "Probing the Gluon Sivers Function through direct photon production at RHIC"
   arXiv:1810.07113 [hep-ph]
   Phys. Rev. D **99**, 014003 (2019)

2. R. M. Godbole, A. Kaushik, A. Misra
   "Transverse single-spin asymmetry in the low-virtuality leptoproduction of open charm as a probe of the gluon Sivers function"
   arXiv:1709.03074 [hep-ph]
   Phys. Rev. D **97**, 076001 (2018)

3. R. M. Godbole, A. Kaushik, A. Misra, V. Rawoot, B. Sonawane "Transverse single spin asymmetry in $p^\uparrow + p \to J/\psi + X$"
   arXiv:1709.03074 [hep-ph]
   Phys. Rev. D **96**, 096025 (2017)

4. R. M. Godbole, A. Kaushik, A. Misra
   "Transverse single spin asymmetry in $p^\uparrow + p \to D + X$"
   arXiv:1606.01818 [hep-ph]
   Phys. Rev. D **94**, no. 11, 114022 (2016)

5. R.M Godbole, A. Kaushik, A. Misra, V. Rawoot "Transverse single spin asymmetry in $e+p^{\uparrow} \to e+J/\psi+X$ and Q^2 evolution of Sivers function - II"
arXiv:1405.3560 [hep-ph]
Phys. Rev. D **91**, 014005 (2015)

Names and details of referees

1. Prof. Rohini M. Godbole
Centre for High Energy Physics,
Indian Institute of Science
E-mail: rohini@iisc.ac.in

2. Dr. Emanuele R. Nocera
NIKHEF,
Amsterdam
E-mail: e.nocera@nikhef.nl

Conference talks

1. Gave a talk in **DIS 2019**, Torino, on work done in Phys. Rev. D **99**, 014003, "Probing the GSF through direct photon production at RHIC".

2. Gave a talk in **Light-Cone 2017**, Mumbai, on work done in Phys. Rev. D **97**, 076001, "Transverse single-spin asymmetry in the low-virtuality leptoproduction of open-charm as a probe of the gluon Sivers function".

3. Gave a talk in **DAE-BRNS Symposium**, University of Delhi in December 2016 titled "Probing the gluon Sivers function in $p^{\uparrow}p \to D + X$ and $ep^{\uparrow} \to D + X$", based on Phys. Rev. D **94**, 114022 (2016) and Phys. Rev. D **97**, 076001.

Technical Skills

I am competent in the use of C++ and FORTRAN in High Energy Physics applications: I have used Vegas and other multi-dimensional integration routines in setting up inclusive cross-section calculations.

I am competent in Mathematica, including in the handling of HEP applications such as FeynCalc and FeynRules.

I am also familiar with the use of the standard HEP Monte Carlo applications such as Pythia, MadGraph etc.