

# CHAITANYA PARANJAPÉ

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## Education

**Indian Institute of Technology (ISM) Dhanbad**

Bachelor of Technology in Engineering Physics, Cum. GPA: 9.46/10.0

**Dhanbad, India**

Expected May 2022

## Relevant Coursework

- Computer Programming \* Methods of Applied Mathematics \* Numerical and Statistical Methods \* Waves & Acoustics \* Electronics & Optical communication \* Applied Optics \* Classical Mechanics \* Mathematical Physics \* Quantum Mechanics \* Electrodynamics \* Solid state physics \* Statistical mechanics \* Low temperature physics & Superconductivity \* Astrophysics & Cosmology
- Precision Phenomenology at Colliders by Prof. Dr. Gudrun Heinrich, KIT : My solutions to exercises

## Online Courses

- Special theory of relativity (Stanford University, Coursera) \* Data Analysis with Python (IBM, Coursera) \* QM & Mastering QM (MIT 8.04x-8.05x, EdX) \* Particle Physics (University of Geneva, Coursera) \* Quantum Field Theory (IIT Madras, NPTEL)

## Academic Achievements

- Mitacs Globalink Research Scholar 2021
- DAAD WISE Research Scholar 2021
- Rank 1 Undergraduate student at Department of Physics, IIT Dhanbad
- All India Rank of 7428 in JEE(advanced) 2018

## Publications & Technical reports

- C. Paranjape**, D. Stolarski, and Y. Wu, "Analysis of Higgs production through vector boson fusion at the LHC," 2021. (e-print work in progress).
- C. Paranjape** and G. Heinrich, "Higgs plus three-gluon amplitude at one loop with pySecDec," 2021. (Conference proceeding to be submitted to IOPscience JPCS).
- C. Paranjape** and T. Ahmed, "Integration by parts identities and Scattering amplitudes," 2020.

## Undergraduate Thesis

- C. Paranjape**, D. Stolarski, and B. Panda, "Unifying the dark QCD with Standard Model," 2021 (Work in progress).

## Research experience

**Theoretical particle physics group, Carleton University**

**Ottawa, Canada**

Mitacs Globalink Research Intern (GRI 2021) under **Dr. Daniel Stolarski**

March 2021–Sept 2021

- Aim to probe the Higgs couplings to vector bosons ( $\kappa_W, \kappa_Z$ ) with the analysis of  $pp \rightarrow qqH$  through vector boson fusion.
- Designed cuts based upon the vector boson fusion topology to suppress the large background contribution ( $\sim$  signal yield  $\times 10^4$ ) in  $H \rightarrow b\bar{b}$  decay mode.
- Designed a custom FastJet+Delphes simulation framework to employ modified boosted Higgs search algorithms, finally controlling the background to ( $\sim$  signal yield  $\times 4$ )
- Proposed to conclusively rule out the  $(\kappa_W, \kappa_Z) = \pm(1, -1)$  point with more than 95 % CL at the HL-LHC with our analysis strategy. [1]

**Institute for Theoretical Physics, Karlsruhe Institute of Technology**

**Karlsruhe, Germany**

DAAD Wise Research Scholar 2021 under **Prof. Dr. Gudrun Heinrich**

June 2021–July 2021

- Applying the feature of numerical evaluation of weighted sums of integrals onto an intricate 1-loop example as a basis for multi-loop calculations [2].
- Numerically evaluating the 1-loop amplitude for  $gg \rightarrow gH$  by expressing the form factors as a weighted sum of Master integrals. Identified the symmetry between form factors to calculate helicity amplitudes.
- Calculated the Master integrals with expansion by regions method in the Heavy Top Limit by expanding in power series of  $(1/m_t^2)$ .
- Performed an error analysis to test the validity of error bounds depending on the scale of the invariants and confirming a relative precision of at least  $10^{-4}$  on the weighted sum.
- This example can serve as a concrete basis to extend the proposed techniques to advancement of multi-loop calculations.

## Institute of Nuclear Physics Polish Academy of Sciences,

Particle Physics Summer Student Intern (PPSS-2020) under Dr. hab. Andrzej Siodmok

Cracow, Poland

July 2020–August 2020

- Aim to devise a machine learning approach for Hadronization, expanding upon the current cluster model.
- Designed custom Analysis handler with Herwig to prepare data-sets for particular cluster decays.
- Training and testing effectiveness of various machine learning models with Python libraries like Keras and Tensorflow.
- Devised a Generative Adversarial Network based on the idea of 'Replication', to successfully replicate the cluster decays into pions.

GitHub Code

GitHub Code

## Study project in precision calculations

under Dr. Taushif Ahmed

Sept 2020–Dec 2020

- Studied the framework of QFT and application of Integration by parts identities for evaluation of loop amplitudes.
- Explored the mathematical structure of IBP identities through the standard topology of loop integrals like 1-loop bubble & tadpole, 2-loop massless self energy diagram [3].
- Employed the use of LiteRed to study the IBP Reduction process for advanced examples and investigated strategies for automation at multi-loop level.

## Conferences

### Advanced Computing and Analysis Techniques in Physics Research - ACAT 2021

December 2021

Virtual and IBS Science Culture Center, Daejeon, South Korea

Presentation slides: PDF

- Presented the application of latest pysecdec features based on my work [2]. Contribution

### Canadian Undergraduate Physics Conference - CUPC 2021

November 2021

Ryerson university, Toronto, Canada

Presentation slides: PDF

- Presented the results of our analysis for Higgs production through VBF-VH channel [1].

### Summer students project presentations - Carleton 2021

Septemeber 2021

Carleton university, Ottawa, Canada

Presentation slides: PDF

- Presented a novel analysis strategy for Higgs production through VBF-VH channel [1].

### Particle physics summer student presentations - PPSS 2020

July 2020

Institute of Nuclear Physics Polish Academy of Sciences, Cracow, Poland

Presentation slides: PDF

- Presented application of GAN model for hadronization of pions based on my work as a summer student.

## Technical Skills

MC event generation: MadGraph5 \* Pythia \* Delphes \* Herwig

Jet analysis: FastJet \* Delphes

Amplitude calculations: pySecDec \* LiteRed \* FeynCalc

BSM model building: FeynRules \* LieART

Environments/Tools: Linux \* Git/Github \* ROOT \* Python \* C/C++ \* Mathematica \* L<sup>A</sup>T<sub>E</sub>X

## Independent study

- Introduction to Quantum Mechanics (Complete) D.J. Griffiths
- Introduction to Elementary particles (Complete) D.J. Griffiths
- From Special Relativity to Feynman Diagrams (Complete) R. D'Auria & M. Trigiant
- An introduction to Quantum Field Theory ( → Chapter 6) M. Peskin & D. Schroeder
- Lie algebras in particle physics ( → Chapter 7) H. Georgi

## Research Interests

- Development of mathematical techniques for theoretical particle physics research,  $\mathcal{N} = 4$  SYM, String theory
- QCD and nuclear theory research : perturbative QCD, non-perturbative QCD, hadron structure with Lattice QCD
- Advancement of multi-loop calculations for precision phenomenology
- Application of Effective field theories for Quark gluon plasma, SM extensions  $\sim$  Higgs sector & dark matter

## Service & Mentoring

- Organizing seminars in the Department of Physics to provide exposure to UG students in various areas of physics research. Mentoring junior UG students for physics research.
- Part time physics and mathematics tutor at the Wakade's classes (Mumbai) for high school students.
- Indian National Service Scheme (NSS) Cadet actively taking part in community service activities.
- Directing short films, video editing and cinematography as a senior member of IIT Dhanbad's official cinematography club - Lights Camera ISM.
- Working with robotic projects like obstacle avoider or hand gesture bots to participate in technical competitions.