# CHAITANYA PARANJAPE

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## Education

**Indian Institute of Technology (ISM) Dhanbad** **Dhanbad, India**
*Bachelor of Technology in Engineering Physics, Cum. GPA: 9.46/10.0* *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

[1] **C. Paranjape**, D. Stolarski, and Y. Wu, "Analysis of Higgs production through vector boson fusion at the LHC," 2021. (e-print work in progress).

[2] **C. Paranjape** and G. Heinrich, "Higgs plus three-gluon amplitude at one loop with pySecDec," 2021.

[3] **C. Paranjape** and T. Ahmed, "Integration by parts identities and Scattering amplitudes," 2020.

**Undergraduate Thesis**

[4] **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 $pp \to qqHZ$ 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 $H \to b\bar{b}$ decay mode.
- Designed a custom FastJet+Delphes simulation framework to employ modified boosted Higgs search algortihms, 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*

- Appliying the feature of numerical evaluation of weighted sums of integrals onto an intricate 1-loop example as a basis for multi-loop calculations [2]. **GitHub Code**
- Numerically evaluating the 1-loop amplitude for $gg \to gH$ 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,** **Cracow, Poland**
*Particle Physics Summer Student Intern (PPSS-2020) under* ***Dr. hab. Andrzej Siodmok*** *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. **GitHub Code**
- Training and testing effectiveness of various machine learning models with Python libraries like Keras and Tesnsorflow. **GitHub Code**
- Devised a Generative Adversarial Network based on the idea of 'Replication', to successfully replicate the cluster decays into pions.

**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 identitites 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 ∗ LaTeX

## 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. Trigiante*
- An introduction to Quantum Field Theory ( $\rightarrow$ Chapter 6) *M. Peskin & D. Schroeder*
- Lie algebras in particle physics ( $\rightarrow$ Chapter 7) *H. Georgi*

## Research Interests

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