# Erlend Aakvaag

PhD student University of Bergen

I started my PhD position around the interception of the Grieg project in March 2021. My initial research project was supposed to be a study of the CP violation in the Higgs fermion sector in the Higgs decay vertex with ATLAS Run 2 data, giving an experimental perspective for task 3. However, the ATLAS analysis covering this topic was close to being finalised when I started. Instead I have been/am involved with the following research projects:

CP violation in VBF Higgs production with the ATLAS detector

Analysis conducted in close collaboration with the University of Freiburg, studying CP violation in the VBF production vertex. The analysis probes the CP structure of Higgs-Vector boson interactions by studying events from the $H \to \tau\tau$ decay channel with ATLAS Run 2 data. The analysis is in the final stages and the aim is to have public result by the end of summer 2024 and a greater ATLAS combination including multiple decay channels by fall 2024. I have represented and presented this analysis on multiple occasions (ATLAS internal):

- *ATLAS Higgs Workshop* October 2023 Tokyo, Japan
- *ATLAS HLepton Workshop* March 2024 CERN, Geneva
- *ATLAS HLepton Editorial Board request talk* March 2024 CERN, Geneva
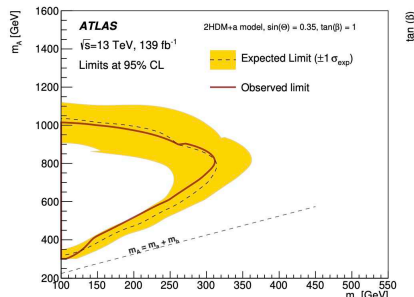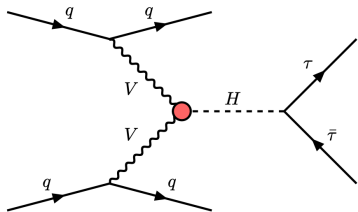
Mono-Higgs Dark Matter search with the ATLAS detector

I was involved in the mono-higgs dark matter search published in JHEP September 2023. No evidence for new physics beyond the Standard Model was found. The results were interpreted in the context of the 2HDM+a model featuring two scalar Higgs doublets and a pseudoscalar singlet field, and 95% exclusion limits were set set on the parameters of the model. Model independent limits were also set on BSM physics with mono-higgs topology.

Paper:
- 10.1007/JHEP09(2023)189

Talks/Posters:
- *Conference "Early Universe"* June 2023 Bergen, Norway
- *ESHEP 2023 poster* September 2023 Grenaa, Denmark
- *NORCC workshop* September 2021 Online

Additional activities

Technical work for the ATLAS experiment
Derived tau ID scale factors for new software release of the ATLAS Athena framework using Wtaunu events. Still technically involved with this work, although with low priority.
Talks (ATLAS Internal):
- *ATLAS Tau CP workshop* February 2023 CERN, Geneva
- *ATLAS Tau CP workshop* March 2024 CERN, Geneva

Outreach talks
- *Masterclass 2022* April 2022, Bergen
- *Higgs presentation University visit CERN* November 2023 CERN

Future plans and perspectives

Future plans
My plan is to start writing my thesis once the current analysis I am working on is completed. This will hopefully happen over summer, and I will then finish my PhD by the end of 2024. Further plans are less certain, but I am currently looking into potential postdocs within the ATLAS experiments as well as opportunities in industry.

Experience as a young researcher in the Grieg Project
The Grieg project funded my PhD, which allowed me to engage in very interesting research. I've gained strong professional and academic experience from this research and it has allowed me to travel the world to communicate and discuss my work. I have also obtained a wide scientific network which I am sure will come in handy if I decide to pursue a further career in high energy physics.
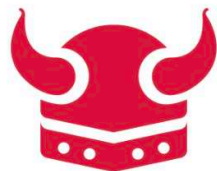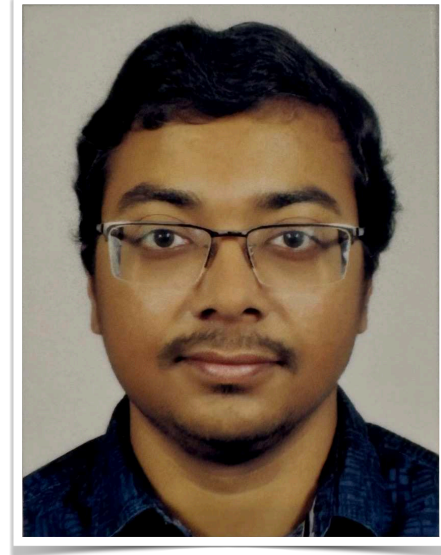
Amit Adhikary

I have worked on theoretical constraints on vector-like fermions models. On that regard, I have looked into the possible effects on electroweak phase transition and di-Higgs production process. I have also worked on searches for mono-jet signature at the LHC, which can arise from well-motivated BSM model such as inert Higgs doublet model.

The research experience I have gained in the Grieg project was instrumental for obtaining the second postdoc position in Centre de Physique Theorique, Aix Marseille University, Marseille, France, in the group of Aoife Bharucha.

Publications:

- *"Long-lived NLSP in the NMSSM"*, **Amit Adhikary**, Rahool Kumar Barman, Biplob Bhattacherjee, Amandip De, Rohini M. Godbole and Suchita Kulkarni, Phys. Rev. D 108, 035020.

- *"Prospects for Exotic $h \to 4\tau$ Decays in Single and Di-Higgs Production at the LHC and Future Hadron Colliders"*, **Amit Adhikary**, Shankha Banerjee, Rahool Kumar Barman, Brian Batell, Biplob Bhattacherjee, Camellia Bose, Zhuoni Qian and Michael Spannowsky, Phys.Rev.D 109 (2024) 5, 055008.

- *"Revisiting $b \to c\tau\nu$ anomalies with charged Higgs boson"*, Nilakshi Das, **Amit Adhikary** and Rupak Dutta, [arXiv:2305.17766 [hep-ph]], Under review in JHEP.

Talks:

- *Mono-Higgs searches at the HL-LHC*, Conference of Norwegian Financial Mechanism "Early Universe" project; Jun 14-15, Bergen

- *Revisiting the $b \to c l\nu$ anomalies with charged Higgs boson*, PLANCK 2023; 22-26 May, Warsaw

Nikolai Fomin

GRIEG Research Summary:

Research activity within the Grieg Collaboration:

1. Searches for Dark Matter with mono-Higgs signatures with the dataset gathered by the ATLAS collaboration in 2015-2018.
2. Studies of new sources of CP violation in H->$\tau\tau\gamma$ decays.

Related Talks:

- NorCC Particle Physics Workshop - 24.05.22, Geilo, Norway
- TRIUMF seminar on DM searches - 05.07.23, Vancouver, Canada
- 31st International Workshop on DIS - 10.04.24, Grenoble, France

Future Plans:

- Postdoc at University of Cambridge since 01/03/24.
- Further involvement with ATLAS BSM Higgs searches - more data, fresh ideas.
- Work on ATLAS inner tracker (ITk) system, upgrade of the current Inner Detector.

Involvement in the GRIEG project has allowed me to branch out into new directions in my research, to establish connections with researchers inside and outside ATLAS collaboration, and provided financial support to successfully reach the project goals.

Publications:

- ATLAS collaboration, "Search for dark matter produced in association with a Higgs boson decaying to tau leptons at√s = 13 TeV with the ATLAS detector." **J. High Energy Phys. 2023**, 189 (2023). https://doi.org/10.1007/JHEP09(2023)189
- ATLAS collaboration, "Combination and summary of ATLAS dark matter searches interpreted in a 2HDM with a pseudo-scalar mediator using 139 fb−1 of s√=13 TeV pp collision data", submitted to **Science Bulletin,** https://doi.org/10.48550/arXiv.2306.00641
- E. Aakvaag, **N. Fomin**, A. Lipniacka, S. Pokorski, J. Rosiek, D. Sahoo "Exploring CP violation in H→τ+τ−γ", **Eur. Phys. J. C,** https://doi.org/10.1140/epjc/s10052-024-12691-z

Aurora Grefsrud - GRIEG project

PhD candidate, Western Norway University of Applied Sciences

As part of the GRIEG collaboration I wrote a paper with colleagues from the Western Norway University of Applied Sciences, University of Warsaw and the University of Bergen. Our paper is titled "Machine learning classification of sphalerons and black holes at the LHC" and was published in the EPJC 30th April 2024. Our research showcased the usefulness of different machine learning (ML) methods in the classification of particle collision events at the LHC.

Western Norway University of Applied Sciences

Machine learning classification of sphalerons and black holes at the LHC

Regular Article – Theoretical Physics | Open access | Published: 30 April 2024

Volume 84, article number 442, (2024)   Cite this article

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Aurora Singstad Grefsrud, Trygve Buanes, Fotis Koutroulis, Anna Lipniacka, Rafał Masełek, Andreas Papaefstathiou, Kazuki Sakurai ✉, Therese B. Sjursen & Igor Slazyk

ⓘ A preprint version of the article is available at arXiv.

Abstract

In models with large extra dimensions, "miniature" black holes (BHs) might be produced in high-energy proton–proton collisions at the Large Hadron Collider (LHC). In the semi-classical regime, those BHs thermally decay, giving rise to large-multiplicity final states with jets and leptons. On the other hand, similar final states are also expected in the

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I am pursuing a PhD in Computer Science, with the aim of investigating the use of ML techniques in the search for new physics at the LHC. Through the GRIEG project collaboration I have been able to get invaluable hands-on experience as well as guidance and inspiration from established scientists outside of my own university.

The paper inspired me to further investigate how best to use ML in physics analyses, and this is going to be the focus of my research now.

Presentations:

- "Using computer-vision inspired techniques for end-to-end event classification on ATLAS data", The 27th Nordic Conference on particle physics, Vinstra 5. Jan 2023
- "Separating black hole and sphaleron events using machine learning techniques", HVL PhD Seminar Poster Presentation, 8. Mai 2023
- "Why we are making microscopic black holes and dark matter on our computers", outreach to high school students in Bergen 28th April 2023.

Ayuki Kamada

My research

- theoretical study of dark matter phenomenology

    - Unitarity

- dark matter searches in astrophysical/cosmological observations

    - self-interacting dark matter, multi-component dark matter

List of publications

- A. Kamada, H. J. Kim, J. C. Park and S. Shin, "Manifesting hidden dynamics of a sub-component dark matter," JCAP 10, 052 (2022) doi:10.1088/1475- 7516/2022/10/052 [arXiv:2111.06808 [hep-ph]]

- A. Kamada and T. Kuwahara, "LHC lifetime frontier and visible decay searches in composite asymmetric dark matter models," JHEP 03, 176 (2022) doi:10.1007/JHEP03(2022)176 [arXiv:2112.01202 [hep-ph]]

- A. Kamada, S. Kobayashi and T. Kuwahara, "Perturbative unitarity of strongly interacting massive particle models," JHEP 02, 217 (2023) doi:10.1007/JHEP02(2023)217 [arXiv:2210.01393 [hep-ph]]

- A. Kamada, T. Kuwahara and A. Patel, "Quantum theory of dark matter scattering," JHEP 11, 105 (2023) doi:10.1007/JHEP11(2023)105 [arXiv:2303.17961 [hep-ph]]

- A. Kamada and H. J. Kim, "Evolution of resonant self-interacting dark matter halos," Phys. Rev. D 109, no.6, 063535 (2024) doi:10.1103/PhysRevD.109.063535 [arXiv:2304.12621 [astro-ph.CO]]

- H. Kawai, A. Kamada, K. Kamada and N. Yoshida, "Modeling the core- halo mass relation in FDM halos," [arXiv:2312.10744 [astro-ph.CO]]

List of talks

- 2021

    - "Beyond-WIMP DM models and constraints from anomalous strong-lens systems," Time-Domain Cosmology with Strong Gravitational Lensing workshop, February 1, Japan (online)

    - "Composite asymmetric dark matter and galactic rotation curves," Particle Physics and Cosmology Seminar (Warsaw), March 4, Poland (online)

    - "Light feebly interacting massive particle: freeze-in production and galactic-scale structure formation," HECA Seminar (NCBJ), April 27, Poland (online)

    - "Very heavy dark matter and its late-time decay," 1st Workshop on Multimessenger Study of Heavy Dark Matter, August 2, Japan (online)

Ayuki Kamada

List of talks

- 2022

  - "Dark hadrons and intensity/lifetime frontier experiments", Particle Physics and Cosmology Seminar (Warsaw), March 10, Poland

  - "Dark hadrons and intensity/lifetime frontier experiments", HEPAP/CMA Seminar (PSU), April 12, USA (online)

  - "Maximally self-interacting dark matte", HECA Seminar (NCBJ), June 7, Poland (online)

  - "Unitarity bounds on heavy dark matter interactions," 2nd Workshop on Multimessenger Study of Heavy Dark Matter, July 11, Japan

  - "Perturbative Unitarity of dark pion dark matter", APEC Seminar (IPMU), August 2, Japan

  - "Asymmetric dark matter: signatures of dark hadrons and dark photon," DM^{3} Workshop, September 16, Japan (online)

  - "Asymmetric dark matter: signatures of dark hadrons and dark photon," 5th Symposium of the Division for Physics of Fundamental Interactions of the Polish Physical Society, October 22, Poland

- 2023

  - "Quantum theory of dark matter scattering", APEC Seminar (IPMU), February 17, Japan

  - "(sub-)GeV dark matter - asymmetric dark matter -", Joint Workshop of the Nagoya B-1 units "Heavy Flavor & Dark Matter", March 30, Japan (online)

  - "Quantum theory of dark matter scattering", Planck 2023, May 23, Poland

  - "Quantum theory of dark matter scattering", PPC 2023, June 15, Korea

  - "Manifesting hidden dynamics of a sub-component dark matter", BDM 2023, June 17, Korea

  - "Evolution of resonant self-interacting dark matter halos", Workshop on Self-Interacting Dark Matter: Models, Simulations and Signals, June 23, Italy

  - "Current status of self-interacting dark matter", PPP 2023, August 28, Japan

  - "Self-interacting dark matter: strong or resonant interaction", APEC Seminar (IPMU), September 8, Japan

  - "Quantum theory of dark matter scattering", CTPU workshop on Particle Physics and Cosmology, October 24, Korea

  - "Self-interacting dark matter: strong or resonant interaction", E-lab Seminar (Nagoya), October 31, Japan

  - "Self-interacting dark matter: strong or resonant interaction", Particle Physics and Cosmology Seminar (Warsaw), November 9, Poland

  - "(sub-)GeV dark matter - asymmetric dark matter -", NCBJ seminar, November 29, Poland

  - "Self-interacting dark matter: strong or resonant interaction", TUM HEP Seminar, November 30, Germany

Acknowledgement

- Grieg helps me to start up my new position (adjunkt) at University of Warsaw
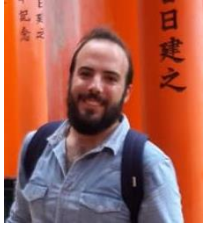
Iñaki Lara Pérez participated in the Project **"Understanding the Early Universe interplay of theory and collider experiments"** as part of *Task 1*. His research involved recasting and reinterpreting LHC searches to constrain models of Dark Matter.
Participation on the project had a great impact on his professional career. Currently is looking for his next position.

achievements as part of the project :

Talks:

Dark matter at the LHC:

- The EPS Forum. Paris. June 2022.
  "Universe and colliders"
- "The XXIX International Conference on Supersymmetry and Unification of Fundamental Interactions". University of Ioannina. June 2022
  "LHC constraints on monojet signatures from electroweakino DM and coloured-superpartner decays"
- (Re)interpretation of the LHC results for new physics". CERN December 2022.
  "LHC constraints on monojet signatures from electroweakino DM and coloured-superpartner decays
- 25th International Conference From the Planck Scale to the Electroweak Scale. Warsaw May 2023.
  "LHC constraints on electroweakino dark matter revisited"

Others

- (Re)interpretation of the LHC results for new physics". CERN December 2022.
  "Implementation of multi-bin searches in CheckMATE".
- 2023 pyhf Users and Developers Workshop. CERN December 2023.
  "Signal region combination in CheckMATE"

Publications:

Dark matter at the LHC:

- *Monojet signatures from gluino and squark decays,* I. Lara,T. Buanes, R. Masełek, M.M.Nojiri, K. Rolbiecki, K.Sakurai, E-Print:2208.01651 [hep-ph]. *JHEP 10 (2022) 150.*
- *LHC constraints on electroweakino dark matter revisited,* I. Lara,T. Buanes, K. Rolbiecki, K.Sakurai, *E-Print: 2208.04342 [hep-ph].Phys.Rev.D 107 (2023) 9, 095021.*

Phenomenology of SUSY models with R-parity violation:

- *The new (g-2) result and the μvSSM,* S. Heinemeyer, E. Kaptcha, I. Lara, D. E. López-Fogliani, C. Muñoz,E-Print: 2104.03294 [hep-ph], Eur.Phys.J.C 81 (2021) 9, 802.
- *Searching for stop LSP at the LHC.* E. Kaptcha, I. Lara, D. E. López-Fogliani, C. Muñoz, N. Nagata, H. Otono,E-Print: 2111.13212 [hep-ph], Eur.Phys.J.C 82 (2022) 3, 261.
- *Explaining muon g−2 data in the μvSSM.* E. Kaptcha, I. Lara, D. E. López-Fogliani, C. Muñoz, N. Nagata E-Print: arXiv:1912.04163, Eur.Phys.J.C 81 (2021) 2, 154.

Others:

- *U(1)' extensions of the μvSSM,*J.A. Aguilar-Saavedra,I. Lara, D.E. López-Fogliani and C. Muñoz, E-Print: 2101.05565 [hep-ph], Eur.Phys.J.C 81 (2021).
- *Exotic diboson Z' decays in the UμvSSM,*J.A. Aguilar-Saavedra,I. Lara, D.E. López-Fogliani and C. Muñoz, E-Print: 2103.13458 [hep-ph], Eur.Phys.J.C 81 (2021) 9, 805.

GRIEG RESEARCH: A SUMMARY

- **My research activity within *Grieg Collaboration* involved in summary the following topics:**

<u>Early Universe</u>

1) *Phases of pNGBs*: A Dark Sector made by Gegenbauer pNGB potentials with non-trivial phase transitions can explain the SGWB of the PTA experiments

2) *Ising Cosmology*: A chaotic Inflationary model under dS/CFT can explain the nearly scale invariant CMB's power spectrum without slow-rolling

<u>Collider searches</u>

1) *ML and Black Holes at LHC*: Studying whether one can discriminate among Black Hole or sphaleron-like events, if observed in LHC, using Machine Learning methods

- **List of publications under the *Grieg Collaboration* acknowledgement:**

1) *Phases of pNGBs*: **F. Koutroulis**, M. McCullough, M. Merchand, S. Pokorski and K. Sakurai, *Phases of Pseudo-Nambu-Goldstone Bosons*, arXiv: 2309.15749 [hep-ph] (**under peer review in JHEP**)

2) *Ising Cosmology*: N. Irges, A. Kalogirou and **F. Koutroulis**, *Ising Cosmology*, Eur. Phys. J. C **83** (2023) 5, 431

3) *ML and Black Holes at LHC*: A. S. Grefsrud, T. Buanes, **F. Koutroulis**, A. Lipniacka, R. Maselek, A. Papaefstathiou, K. Sakurai, Th. B. Sjursen, I. Slazyk, *Machine Learning Classification of Sphalerons and Black Holes at the LHC*, arXiv: 2310.15227 [hep-ph] (**under peer review in EPJC**)

GRIEG RESEARCH: A SUMMARY

- **List of talks given related to the *Grieg Collaboration*:**

  1) *Scalars 2023*, September 2023, Warsaw, Poland

  2) Workshop on *the Standard Model and Beyond*, held by EISA at Corfu Summer Institute, August 2023, Corfu, Greece

  3) PLANCK 2023 - *The 25th International Conference From the Planck Scale to the Electroweak Scale*, May 2023, Warsaw, Poland

  4) Kitzbühel Humboldt Kolleg, June 2022, *Clues to a mysterious universe*, Kitzbühel, Austria

- **The role of *Grieg Collaboration* on my scientific career:**

  Participating in the *Grieg Collaboration* was a uniq opportunity for me to obtain a strong scientific experience on both theoretical and experimental particle physics. Moreover I had the opportunity to take part in several important seminars and conferences through which I managed to communicate my work.
  Due to the *Grieg project* my next scientific steps are leading me to the IHEP of Chinese Academy of Science (a prestigious institution of high energy physics) in Peking as a postdoctoral researcher.

Priyanka Lamba

I work as Postdoc from 01 Oct 2023 to 31/03/2024 under Grieg project. During these six month, I worked on effect of anomaly free heavy fermion in chiral gauge theories and axion decay in global limit of such theories for both anomalous and anomaly free heavy fermion spectrum with Prof. Dudas, Prof. Pokorski and Prof. Sakurai. Under this study, We consider two or more spontaneously broken chiral $U(1)$ gauge theories with an anomaly free set of massive fermions and with the gauge couplings much smaller than the Yukawa couplings. The effective theory below the fermion mass scale is given by the kinetic terms and the Stueckelberg-Chern-Simons operators. For an anomaly free heavy fermion spectrum, their Wilson coefficients are finite and unambigously calculable in terms of the fermion gauge charges. In the effective theory, we calculate the gauge boson scattering amplitudes and show that they violate perturbative unitarity at energies of the order of the fermion masses. Secondly, in the limit of one of the gauge couplings becoming zero, the theory contains a physical axion in the spectrum. Certain subtelties of such a limit are discussed. The axion couplings to the gauge bosons include the Stueckelberg-CS term. Some phenomenological applications are discussed. The work is almost near to finish. Soon will be ready for publication.

The benefits I have obtained from working in the Grieg project in my scientific career:

It helps me work with experts in our field and learn from them, which will help me become an independent researcher in the future. Thanks to GRIEG project, I can participate in international conferences which help me talk to international research community about future research projects which help me get a new post-doc job at the University of Bologna.

Rafał Masełek

My research interests include searches for Beyond the Standard Model physics at colliders and the application of novel Machine Learning techniques to Particle Physics problems. In the GRIEG project, I was involved in utilising monojet and dijet channels for supersymmetric studies targetting squarks and gluinos. I was also taking part in another study, which investigated very exotic collider processes: production and evaporation of microscopic black holes and electroweak sphalerons. I have investigated the possibility of distinguishing between the two processes at the HL-LHC and discriminating between different extra-dimensional Black Hole models with the help of Convolutional Neural Networks. Moreover, I have actively cooperated with colleagues from the MoEDAL experiment, while working on the possibility to extend MoEDAL's physics programme to include searches for charged long-lived particles.

"Involvement in the GRIEG project allowed me to establish new academic connections and provided financial support for my research, which helped me to obtain a PhD degree and find a postdoc position."

Papers:

1) Monojet signatures from gluino and squark decays; Iñaki Lara, Trygve Buanes, Rafał Masełek, Mihoko M. Nojiri, Krzysztof Rolbiecki, Kazuki Sakurai; JHEP 10 (2022) 150; e-Print: 2208.01651 [hep-ph]; DOI: 10.1007/JHEP10(2022)150

2) Machine Learning Classification of Sphalerons and Black Holes at the LHC; Aurora Singstad Grefsrud, Trygve Buanes, Fotis Koutroulis, Anna Lipniacka, Rafał Masełek, Andreas Papaefstathiou, Kazuki Sakurai, Therese B. Sjursen, Igor Slazyk; e-Print: 2310.15227 [hep-ph]

3) Search for Highly-Ionizing Particles in pp Collisions During LHC Run-2 Using the Full MoEDAL Detector; MoEDAL Collaboration (inc. Rafał Masełek); e-Print: 2311.06509 [hep-ex]

4) Prospects for detecting long-lived particles at the Large Hadron Collider, Rafał Masełek; PhD Thesis at the University of Warsaw; e-Print: 2310.13748 [hep-ph]

5) Search for highly-ionizing particles in pp collisions at the LHC's Run-1 using the prototype MoEDAL detector; MoEDAL Collaboration (inc. Rafał Masełek); Eur.Phys.J.C 82 (2022) 8, 694; e-Print: 2112.05806 [hep-ex]

Talks:

1) *Enhancing DM searches in LHC with ML*, IRN Terascale Meeting, 25.10.2023, Marseille

2) *Searching for Dark Matter in the LHC with the help of Machine Learning*, 23rd Hellenic School and Workshops on Elementary Particle Physics and Gravity, Workshop on the Standard Model and Beyond, 31.08.2023, Kerkira

3) *Enhancing LHC searches for Dark Matter with Machine Learning*, Rencontres du Vietnam, 09.08.2023, Quy Nhon

4) *Prospects for detecting long-lived particles at the LHC*, Seminar at KEK, 28.03.2023, Tsukuba

Marco Merchand

Postdoc at KTH Royal Institue of Technology
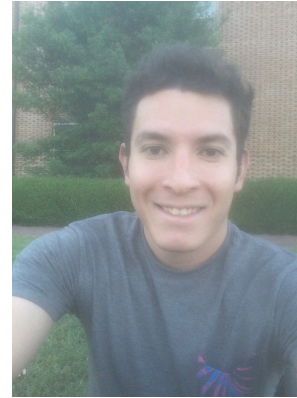
During my participation in the Grieg Financial Mechanism project I investigated theoretical aspects about pseudo-Nambu-Goldstone bosons (pnGBs) in the early universe. Together with collaborators we estimated the experimental consequences that pnGBs systems might have at future gavitational wave experiments finding promising signals. We also developed robust theoretical constraints on the parameters of the model. The outcome of this project is containted in

https://arxiv.org/abs/2309.15749   Under peer review in JHEP

Participating in Grieg has been a positive experience for my career as it has opened up opportunities for networking and learning. Greig has been an excellent platform to build and mantain connections, share knowledge and contribute to our theoretical understanding of the early universe. The activities carried out in Grieg were clearly aligned with my career goals and this specialization has proven to be a perfect fit for my current position.

1. **GRIEG Task 4: Probing new sources of CP violation in the Higgs-fermion sector**
   Proposed a new complementary approach to search for CP violation in $H\tau\tau$ Yukawa interaction via forward-backward asymmetry in $H \to \tau^+\tau^-\gamma$ using the Lorentz invariant Dalitz plot distribution of events.

2. **Publication:** E. Aakvaag, N. Fomin, A. Lipniacka, S. Pokorski, J. Rosiek and D. Sahoo, "Exploring CP violation in $H \to \tau^+\tau^-\gamma$," [arXiv:2311.16211 [hep-ph]]. (Accepted for publication in The European Physical Journal C)

Dibyakrupa Sahoo

Presentations

1. "CP violation in Higgs sector (A phenomenological and first principle overview)," Particle Physics and Cosmology Seminar, Faculty of Physics, University of Warsaw, Warsaw, Poland   (29 Feb 2024)

2. "Probing CP violation in $H \to \tau^+ \tau^- \gamma$," (online) WG2 WG3 joint meeting on CP violation in extended Higgs sector, 304/1-001 CERN.   (26 Sep 2023)

3. "Probing CP violation in $H \to \tau^+ \tau^- \gamma$," Matter To The Deepest (MTTD) 2023, Ustroń, Katowice, Poland.   (20 Sep 2023)

4. "Probing CP violation in $H \to \tau^+ \tau^- \gamma$," Scalars 2023, University of Warsaw, Warsaw, Poland.   (15 Sep 2023)

5. "CP violation in $H \to \tau^+ \tau^- \gamma$ (With a phenomenological overview)," Workshop on the Standard Model and Beyond, Corfu, Greece.   (29 Aug 2023)