

PEDRO E. RIVERA-CARDONA

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EDUCATION

- University of Illinois at Urbana-Champaign (UIUC)** *August 2022 - Present*
Graduate Program, Physics *Doctoral Student*
Advisors: Professors Jessie Shelton, Yonatan Kahn
SURGE and Graduate College Fellow | Sloan UCEM Scholar
- Massachusetts Institute of Technology (MIT)** *August 2021 - May 2022*
MIT Center for Theoretical Physics *Visiting Student*
Advisor: Professor Jesse Thaler
- University of Puerto Rico Mayagüez (UPRM), Mayagüez** *August 2017 - May 2022*
Bachelors of Science, Physics *Magna Cum Laude*
Awarded Most Distinguished Physics Student

RESEARCH

- Axial Freeze-in** *Spring 2023 - Present*
Illinois Center for Advanced Studies of the Universe, UIUC
Mentors: Professors Jessie Shelton, Yonatan Kahn
- Infalling Relativistic Particle Orbits At Event Horizon Boundaries**
Astrophysics Science Division, NASA Goddard Space Flight Center *June 2022 - August 2022*
NASA MUREP/ GEM Fellowship *(Competitiveness/Selected)*
Mentor: Dr. Ronald Gamble

An introductory description of quantum field theory in high-energy astrophysical environments. With an interest on general relativistic effects of particle orbits around black holes, this work will explore the implications of infalling relativistic particles onto the event horizons of black holes with varying spin parameters. Beginning with a mathematical introduction to the mechanics of black holes, and ending with a model of the innermost stable circular orbits of relativistic particles at high Lorentz factors.

- Implementation of $U(1)$ Group Symmetry on Energy Flow Networks**
Center for Theoretical Physics, Massachusetts Institute of Technology *June 2021 - August 2022*
Massachusetts Institute of Technology Summer Research Program *(Competitiveness/Selected)*
Mentors: Professor Jesse Thaler, Rikab Gambhir

Using $U(1)$ cylindrical symmetry, I implemented periodicity onto Energy Flow Networks, machine learning models that analyze collider events. $U(1)$ cylindrical symmetry allows for full event analysis which manifest periodicity. This was achieved by implementing a new initial layer Φ_0 , which avoids altering the dataset. After the implementation, we deploy CMS Open Data for further analysis, such as quark/gluon discrimination and top jet tagging.

UPRM CMS High Energy Physics Group
UPRM, Department of Physics, Mayagüez, Puerto Rico
Mentor: Professor Sudhir Malik

2020 - 2022

University of Puerto Rico, Mayagüez's Compact Muon Solenoid Research Group has strong ties to Fermilab as it is the host lab for 50 US institutions on CMS. We work on Beyond Standard Model analysis with LHC Physics Center (LPC) based physicists and test beam characterization of pixel sensors for CMS upgrade at Fermilab Test Beam Facility. I successfully completed the required software skills that are pre-requisite to CMS Physics Data School hosted annually at the LPC, Fermilab.

Viability of Post-Emission Collimation of Photoemitted Electron Beam

Intern researcher (Remote)

June 8 - August 14, 2020

Cornell Laboratory for Accelerator-based Sciences and Education

(Competitiveness/Selected)

Mentors: William H. Li, Professor Jared Maxson

Worked on improving single-shot ultrafast electron diffraction experiments by lowering non-linear spacecharge effects on electron bunch. Using Python and General Particle Tracer (GPT) simulations, I added excess charge at the start of the beam and clipped it to a desired bunch charge right before the target. Clipping occurred at the ends of the beam, where non-linear spacecharge is present. As a result, lower transverse emittance was achieved at the screen, while not violating Liouville's theorem.

High-Power Picosecond Fiber Laser for High-Current Electron Photo-Injectors

Intern researcher

May 27 - August 2, 2019

Thomas Jefferson National Accelerator Facility, Newport, Virginia

(Competitiveness/Selected)

Mentor: Dr. Shukui Zhang

Developed a high-power drive laser for photocathode-based electron guns and accelerators at Jefferson Lab's Low Energy Recirculator Facility (LERF). The second part of my research was focused on simulating laser systems with fiber optics software. Several simulations were performed on laser amplification to analyze and optimize fiber length and output power, while maintaining minimum spatial, temporal and spectral distortion; high output power and excellent beam quality. The laser system is effectively operating and being used by the LERF for other research projects.

PRESENTATIONS

Oral Presentations

46th GEM Annual Conference & Board Meeting

Fall 2022

Infalling Relativistic Particle Orbits At Event Horizon Boundaries

MIT Lightning Talk MSRPx '21

August 9, 2021

Implementation of $U(1)$ Group Symmetry on Energy Flow Networks

<https://bit.ly/3C3NCFhu>

UPRM Physics Department's Symposium:

October 29, 2020

Viability of Post-Emission Collimation of Photoemitted Electron Beam

Cornell Laboratory for Accelerator-Based Sciences and Education
Viability of Post-Emission Collimation of Photoemitted Electron Beam

August 14, 2020

The Center for Bright Beams: Beam Dynamics and Control, Cornell University
Viability of Post-Emission Collimation of Photoemitted Electron Beam

August 6, 2020

Old Dominion University, Norfolk, Virginia
High-Power Picosecond Fiber Laser for High-Current Electron Photo-Injectors

July 26, 2019

Poster Presentations

8th Annual Illinois Sloan UCEM Conference
Axial Freeze-in: A Model for Dark Matter Production

April 15, 2023

Massachusetts Institute of Technology, Cambridge, MA
Implementation of $U(1)$ Group Symmetry on Energy Flow Networks

August 5, 2021

Jefferson Laboratory, Newport News, Virginia
High-Power Picosecond Fiber Laser for High-Current Electron Photo-Injectors

August 2, 2019

RELEVANT ADVANCED COURSEWORK

Physics:	Quantum Mechanics, Electromagnetism, Special Relativity, Quantum Field Theory, General Relativity, Particle Physics
Mathematics:	Abstract Algebra, Linear Algebra, Calculus, Differential Equations, Mathematical Methods for Physics
Programming:	Computational Physics, Modeling and Simulation in Python

SKILLS

Programming	Python, Keras/Tensorflow, Mathematica, Git Bash
Modeling	Visual Python, General Particle Tracer, RP Fiber Power, Energy Flow
Software & Tools	Microsoft Office, L ^A T _E X, Simplify3D
Languages	English, Spanish

ACHIEVEMENTS AND MERITS

GEM Fellowship	Summer 2022 - Present
Alfred P. Sloan UCEM Scholarship	August 2022 - Present
UIUC Graduate College Fellowship	August 2022 - Present
UIUC SURGE Fellowship	August 2022 - Present
UPRM Honor Student Scholarship	Fall 2018 - Graduation
Physics Department Honor Roll	Fall 2017 - Graduation
Puerto Rico Louis Stokes Alliance for Minority Participation Scholarship	August 2021- May 2022
UPRM: ACJ Scholarship	August 2021- May 2022
HSF Scholarship Finalist	2021-2022
SPS Emergency Scholarship	2020
Society of Physics Students: UPRM Student Scholarship	Fall 2017 - Spring 2018
SPS: UPRM Most Outstanding Member	Fall 2017 - Spring 2018

WORKSHOPS & SUMMER SCHOOLS

Tri-Institute Summer School on Elementary Particles (TRISEP) *June 19-30, 2023*
Perimeter Institute for Theoretical Physics, Waterloo, ON, Canada

TRISEP is an international summer school organized jointly by the Perimeter Institute for Theoretical Physics, SNOLAB, and TRIUMF Canada's laboratory for particle and nuclear physics. Topics covered include: Dark Matter Theory, BSM Theory, Amplitude Techniques and EFT Methods, ALPs, Gravitational Waves Theory, EFT Methods for Gravity, and Cosmology.

Princeton University's Prospective PhD Preview (P3) *October 8-9, 2020*
2020 P3 Scholar | The Graduate School, Princeton University *(Competitiveness/Selected)*

The Prospective Ph.D. Preview (P3) is designed for prospective students selected from a highly competitive pool of applicants to gather information on graduate education at Princeton University.

Inverted CERN School of Computing 2020 *September 28 - October 2, 2020*
School of Computing, CERN

The 13th Inverted CERN School of Computing (iCSC 2020) consists of classes (lectures, exercises, demonstration and consultations) given by former CERN School of Computing students. Topics covered include: Programming Paradigms and Design Patterns, Modern C++ features, Computational Fluid Dynamic

Undergraduate Workshop in Plasma Physics *July 11-15, 2019*
Princeton Plasma Physics Laboratory, Princeton, New Jersey *(Competitiveness/Selected)*
Coordinator: Dr. Arturo Dominguez

This four-day workshop includes lectures and experimental sessions covering topics in calculus, electromagnetism, computational physics, and plasma physics and fusion.

Introduction to Using the Arecibo Observatory *September 11, 2018*
Arecibo Observatory, Arecibo, Puerto Rico
Coordinator: Prof. Abel Méndez, Director

This is an intensive 6-hour introductory workshop for undergraduate and graduate students of physics on using the Arecibo Observatory for scientific observations.

EXTRACURRICULAR ACTIVITIES AND OUTREACH

Society of Physics Students (SPS) *2017 - 2022*
Secretary at UPRM Chapter *Fall 2018 - Spring 2019*

Responsible of: the chapter's office space, obtaining the appropriate facilities to carry out the various activities of the society; keeping a record of all members, documents, meetings and events, and overseeing all events and education activities with schools and communities.

QuarkNet Masterclass

March 2018, April 2019

Physics Department, University of Puerto Rico at Mayagüez

Coordinator: Professor Héctor Méndez

A yearly workshop for high school students and teachers. We teach them about elementary particles and the Standard Model of particle physics. The workshop is conducted through presentations and hands-on work in HYPATIA and Arachne with CMS and MINERvA data from Fermilab. **I have participated as both student attendee and presenter/organizer.**

3D Printing Mathematical Objects with Mathematica 11.0

Fall 2018

Department of Mathematics, University of Puerto Rico at Mayagüez

Mentor: Professor Freddie Santiago

Using Mathematica 11.0 and Simplify3D, I plotted Cylinders and Quadric Surfaces in three dimensions and printed them using 3D printers. The Mathematics Department is using these surfaces in its Multivariable Calculus courses.