

# Jesús M. Rueda-Becerril — Ph.D.

Astrophysicist – Data Scientist – ML Engineer

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## Education

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### Ph.D. in Physics

Oct. 2011 – Jul. 2017

*Universitat de València, Spain*

Excellent *cum laude*.

ADVISOR: Prof. Miguel A. Aloy & Dr. Petar Mimica.

THESIS: *Numerical treatment of radiation processes in the internal shocks of magnetized relativistic outflows*

### M.Sc. in Physics

Aug. 2009 – Sep. 2011

*Universidad Michoacana de San Nicolás de Hidalgo, Mexico*

ADVISOR: Prof. José A. Cervera

THESIS: *Study of TOV stars with the SPH method*

### B.Sc. in Physics

Aug. 2004 – Dec. 2008

*Universidad Autónoma del Estado de México, Mexico*

“Dr. Juan Josafat Pichardo” Award

ADVISOR: Prof. Francisco S. Guzmán

THESIS: *Numerical solution of null geodesics for the generation of gravitational lenses produced by spherically-symmetric and static spacetimes*

## Experience

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### Software Engineer (Remote)

Apr 2022 – Jan 2024

*Paychex, Rochester NY, USA; based in Seattle, WA, USA*

- Conducted data preparation, validation, and analysis in SQL from Oracle EBS datasets.
- Developed Java Kafka consumers for the streamlined transfer of large volumes of client data across databases. Developed high quality code using Java, Spring Boot, Kafka, PL/SQL, and deployed into production using Jenkins and OpenShift, following software development best practices.
- Collaborated with stakeholders, other software developers and engineers, and senior leadership to assess product needs and meet code standards for continuous integration model.
- Created Splunk dashboards and alerts for analysis of production data.
- Developed and deployed Python tests to ensure software quality and continuous integration.

### Postdoctoral Research Associate

Feb 2021 – Apr 2022

*Rochester Institute of Technology, Rochester, NY, USA*

- Led a team of specialists on a NSF-sponsored project to upgrade the C code **PatchworkMHD** to perform HPC simulations using state-of-the-art numerical techniques to model supermassive black hole binaries.
- Implemented a new feature (black hole spin) to **PatchworkMHD**, making more realistic binary black hole simulations without impacting runtime.
- Designed the experiments and evaluated state-of-the-art mathematic and numerical algorithms implemented in **PatchworkMHD** by running simulations at *Frontera* supercomputer (TACC, UT at Austin).
- Worked in a detail-oriented manner to successfully benchmark and identify performance optimization opportunities of the scientific code.
- Mentored and collaborated with a graduate student to apply the machine learning algorithm *gradient descent* to adjust the parameters of the open-source code, **Paramo**, to classify observations of blazars (extra-galactic objects) from Fermi-LAT telescope.
- Participated in a multi-institutional collaboration to study binary Neutron Star mergers through HPC simulations, resulting in 2 publications that provided critical breakthrough insights of the physics underlying these events.
- Published 3 co-authored papers and mentored graduate students (2 Ph.D.).

### Postdoctoral Research Fellow

Oct 2018 – Nov 2020

*Purdue University, West Lafayette, IN, USA*

- Developed the open-source code, **Paramo**, a numerical code in Fortran 95 optimized with OpenMP to perform radiative transfer simulations in relativistic astrophysics scenarios.
- Obtained and led a NASA grant to explain the origin and nature of radiation from active galaxies (blazars) using numerical and statistical models for objects observed with NASA Fermi-LAT space telescope. This research helped to unify our understanding of the two main types of blazars, identifying that important physical constraints applied to both objects.
- Developed Python tools to calculate the loss of energy due of high-energy particles due to interactions spectrum and evolution in the context of gamma-ray burst afterglows by developing sophisticated numerical integration, and OpenMP optimized features to **Paramo**.
- Collaborated with a group of multidisciplinary scientists to develop Python scripts for statistically modeling the COVID-19 outbreak in Mexico and helped create scientific infographics and blogposts for Spanish-speaking populations to reduce the spread of misinformation.
- Published 1 first-author and 1 co-authored paper and mentored three graduate students (1 M.S. and 2 Ph.D.).

## Postdoctoral Research Fellow

Jan – Sep 2018

*Universidad Michoacana de San Nicolás de Hidalgo, Morelia, Michoacan, Mexico*

- Developed a Python script that would process images of spinning black holes simulations from the numerical code **GRTrans** to provide an SVM with training data that would later predict radio images of actual black holes.
- Developed an open-source data analysis and visualization tool in Python to provide any user with accessible tools to calculate radiative transfer phenomena (spectra and light-curves) in relativistic astrophysics.
- Organized a workshop to train graduate students in the use of the high-volume data storage tool HDF5.

## Graduate Research Assistant

Oct 2011 – Jul 2017

*Universitat de València, Burjassot, Valencia, Spain*

- Independently developed Shell and Python scripts to build pipelines to run simulation of the radiative transfer code **C-SPEV** and perform data processing of output datasets in HDFS format, ensuring data quality and integrity for downstream analysis and model fit with observations.
- Developed Python scripts to perform exploratory data analysis on datasets from NASA Fermi-LAT telescope and from the Very Large Baseline Array (VLBA) of the National Radio Astronomy Observatory (NRAO), and build non-linear regression models.
- Independently constructed models from **C-SPEV** simulations for curve fitting, pattern recognition, and prediction of data from NASA telescopes.
- Conducted multiple analyses to identify patterns in spectra and light-curves that allowed the quantification of magnetization of plasma in blazars.
- Conducted an analysis that identified the importance of including both cyclotron and synchrotron radiation from non-relativistic to ultra-relativistic charged particles in blazar simulations.
- Implemented sophisticated numerical tools and data handling to **C-SPEV** that could calculate both discrete and continuous spectra from particle distributions with arbitrary shape, without impacting simulation runtime.
- Published 2 first-author papers.

## Skills

**Programming Languages:** Python, Shell, C/C++, Fortran, Java, R, Julia, SQL (PL/SQL, PostgreSQL), Rust, HTML, Markdown, MongoDB

**Python Ecosystem:** Numpy, Pandas, Matplotlib, Scipy, Astropy, Scikit-learn, Tensorflow, PyTorch, Pytest, Jupyter

**Miscellaneous:** Git (GitHub, Bitbucket),  $\text{\LaTeX}$ , MPI, OpenMP, OpenACC, HDF5, Mathematica, Maple, Docker, Jenkins, Splunk, Jira, Kafka, Visit, Paraview, Job Scheduling (SLURM, PBS)

## Publications

### Articles.....

- [9] Davis, Z., **Rueda-Becerril, J. M.**, & Giannios, D. *Tleco: A Toolkit for Modeling Radiative Signatures from Relativistic Outflows*, **ApJ** **976**, 182, (2024), [arXiv:2405.17581](#).
- [8] Davis, Z., **Rueda-Becerril, J. M.**, & Giannios, D. *Balancing Turbulent Heating with Radiative Cooling in Blazars*, **MNRAS** **513**, 5766–5779, (2022), [arXiv:2201.07790](#).
- [7] Lopez-Armengol, F. G., Etienne, Z. B., [...], **Rueda-Becerril, J. M.**, [...] *Handing off the outcome of binary neutron star mergers for accurate and long-term postmerger simulations*, **Phys. Rev. D** **106**, 083015, (2022), [arXiv:2112.09817](#)

- [6] Murguía-Berthier, A., Noble, S., [...], **Rueda-Becerril, J. M.**, [...] *HARM3D+NUC: A New Method for Simulating the Post-merger Phase of Binary Neutron Star Mergers with GRMHD, Tabulated EOS, and Neutrino Leakage*, *ApJ* **919**, 95, (2021), [arXiv:2106.05356](#)
- [5] **Rueda-Becerril, J. M.**, Harrison, A. O. & Giannios, D. *Blazar jets launched with similar energy per baryon, independently of their power*, *MNRAS* **501**, 4092–4102, (2021), [arXiv:2009.02273](#).
- [4] Zhang, H., Christie, I., Petropoulou, M., **Rueda-Becerril, J. M.** & Giannios, D. *Inverse Compton Signatures of Gamma-Ray Burst Afterglows*, *MNRAS* **496**, 974–986, (2020), [arXiv:1910.14049](#).
- [3] **Rueda-Becerril, J. M.**, Mimica, P. & Aloy, M. A. *On the influence of a hybrid thermal–non-thermal distribution in the internal shocks model for blazars*, *MNRAS* **468**, 1169–1182, (2017), [arXiv:1612.06383](#).
- [2] **Rueda-Becerril, J. M.**, Mimica, P. & Aloy, M. A. *The influence of the magnetic field on the spectral properties of blazars*, *MNRAS* **438**, 1856–1869 (2014), [arXiv:1310.5441](#).
- [1] Guzmán, F. S. & **Rueda-Becerril, J. M.** *Spherical boson stars as black hole mimickers*, *Phys. Rev. D* **80**, 084023 (2009), [arXiv:1009.1250](#).

## Proceedings.....

- 5. **Rueda-Becerril, J. M.** *A numerical approach for radiative cooling in relativistic outflows*, *Astron. Nachr.*, **9th International Workshop on Astronomy and Relativistic Astrophysics: from Quarks to Cosmos** **342**, 277–282, (2021), [arXiv:2011.13797](#).
- 4. **Rueda-Becerril, J. M.**, Harrison, A. O. & Giannios, D. *The blazar sequence revised*, *Astron. Nachr.*, **9th International Workshop on Astronomy and Relativistic Astrophysics: from Quarks to Cosmos** **342**, 147–152, (2021), [arXiv:2011.13805](#).
- 3. **Rueda-Becerril, J. M.**, Mimica, P. & Aloy, M. A. *Numerical simulations of the internal shock model in magnetized relativistic jets of blazars*, *PoS(SWIFT 10)* **233**, 159 (2014), [arXiv:1502.07882](#).
- 2. **Rueda-Becerril, J. M.**, Mimica, P., Aloy, M. A. & Aloy, C. *Numerical study of broadband spectra caused by internal shocks in magnetized relativistic jets of blazars*, *EPJ Web Conf.* **61**, 02007 (2013), [arXiv:1309.4612](#).
- 1. Mimica, P., Aloy, M. A., **Rueda-Becerril, J. M.**, Tabik, S. & Aloy, C. *Numerical simulations of dynamics and emission from relativistic astrophysical jets*, *J. Phys.: Conf. Ser* **42**, 012001 (2013), [arXiv:1211.1794](#).

## Research Grants

### NASA Fermi Cycle-12 Guest Investigator Program

Grant #121077

*A simple model to understand the blazar sequence*, PI: Giannios, D., Co-I: **Rueda-Becerril, J. M.**

2019

## Grants and Fellowships

**Oct. 2018 – Nov. 2020: Fellowship** from the Mexican Federal Government for international postdoctoral studies awarded by the National Council of Science and Technology (CONACyT).

**Jan. – Sep. 2018: Fellowship** from the Mexican Federal Government under the *Program for the Professional Development of Higher Education Institutions*, awarded by the Secretariat of Public Education.

**Sep. 2014 – Aug. 2016: Fellowship** from the Mexican Federal Government to study abroad awarded by the National Council of Science and Technology (CONACyT).

**Oct. 2011 – Jun. 2014: Fellowship** *Santiago Grisolia* awarded by the Council of Education, Research, Culture and Sport of the Valencian Community, Spain.

**Sep. 2009 – Aug. 2011: Fellowship** for MSc studies at the Institute of Physics and Mathematics, Universidad Michoacana de San Nicolás de Hidalgo, granted by the Mexican Council of Science and Technology (CONACyT).

**Jun. – Aug. 2007: Fellowship** for a temporary stay (3 months) in a national research center under the *XVII summer of scientific investigation program* awarded by the Mexican Academia of Science.

## Projects

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### Wind and Spores

Aug 2024 – Present

*Open Source Code for Dispersion of Spores in Hilly Terrains*

[GitHub](#)

- Simulate the dispersion of spores in hilly terrains in R and C++.

### Tleco

Jan 2024 – Sep 2024

*Open Source Code for Simulation of Relativistic Particles Radiation*

[GitHub](#)

- Tleco stands for both *in the fire* and *rise* in the nahuatl language.
- Numerical code that simulates particles in relativistic plasma, and the rise of radiation from accelerating particles.
- Consists of both Rust functions and Python functions previously built in the Fortran code *Paramo*.

### Paramo

Oct 2018 – Apr 2022

*Open Source Code for Radiative Transfer Simulations in Relativistic Astrophysics*

[GitHub](#)

- Independently developed this code for distributed settings to perform HPC simulations of radiative transfer in relativistic astrophysics.
- Optimized the code with OpenMP to reduce simulation time from 2 minutes to 5 seconds.
- Researched and applied mathematical concepts of machine learning (gradient descent) to adjust the parameters of the code to classify observations from NASA telescopes.
- This code has been used for at least 5 scientific publications and also for graduate pedagogical purposes.
- Developed data analysis and data visualization tools in Python.

### Co-Founder, Mexican Scientists Abroad

Aug 2019 – Feb 2021

*Group of Mexican Scientists narrowing the gap between science and common knowledge*

[Homepage](#)

- Collaborated with a group of multidisciplinary scientists to develop Python scripts for [statistically modeling and forecasting the COVID-19 outbreak](#) in Mexico.
- Wrote [blogposts](#) and [infographics](#) for non-technical Spanish-speaking populations to reduce the spread of misinformation.

## Awards

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**Marcos Moshinsky Award:** for *Best Poster* presented at the IWARA 2020 Video Conference, Mexico City, 6 – 12 September 2020.

**Lic. Juan Josafat Pichardo Cruz Award:** for finishing and defending a licentiate thesis within a year after completing the undergraduate credits, granted by the Universidad Autónoma del Estado de México, 2009.

## Invited Talks

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### Morphology of the spectra from numerical simulations of the internal shocks model for blazars

*Astrophysics Seminar, Purdue University, West Lafayette, IN, USA, February 4, 2019*

### Numerical simulations of the internal shocks model in magnetized relativistic jets of blazars

*DATA group weakly Seminar, Instituto de Astronomía, UNAM, Mexico City, Mexico, June 19, 2018*

### Numerical treatment of non-thermal radiation in the internal shocks model for blazars

*Weekly Seminar, Instituto de Física y Matemáticas, Morelia, Mexico, March 2, 2018*

### Numerical simulations of the internal shock model in magnetized relativistic jets of blazars

*IVICFA's Fridays: Computation in Physics, IFIC, Paterna, Spain, October 17, 2014*

## Meetings and conferences

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### Contributed Talks

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#### Simulations of supermassive binary black holes accretion dynamics in the spinning case

*APS April Meeting 2022, New York City, NY, April 9–12, 2022*

#### A numerical approach to the Klein-Nishina corrections of radiative cooling in relativistic outflows

*APS April Meeting 2021, April 17–20, 2021*

#### The blazar sequence revised

*9th International Workshop on Astronomy and Relativistic Astrophysics, Video Conference, September 6–12, 2020*

<https://www.youtube.com/watch?v=BAZNWLNT69M>

## **Influence of the magnetic field on the spectral properties of blazars in the internal shocks scenario**

*Extreme-Astrophysics in an Ever-Changing Universe, Ierápetra, Greece, June 16–20, 2014*

## **Numerical study of broadband spectra caused by internal shocks in magnetized relativistic jets**

*XXXIV Biennial meeting of the Royal Spanish Society of Physics, Valencia, Spain, July 15–19, 2013*

## **Poster Sessions.....**

### **A numerical approach for radiative cooling in relativistic outflows**

*9th International Workshop on Astronomy and Relativistic Astrophysics, Video Conference, September 6–12, 2020*

Marcos Moshinsky Award for Best Poster. <https://www.youtube.com/watch?v=0TJiKg7k0PI>

### **Numerical simulations of the internal shock model in magnetized relativistic jets of blazars**

*Swift: 10 years of Discovery, Rome, Italy, December 2–5, 2014*

### **Numerical study of broadband spectra caused by internal shocks in magnetized relativistic jets**

*The Innermost Regions of Relativistic Jets and Their Magnetic Fields, Granada, Spain, June 10–14, 2013*

## **Teaching & Mentoring Experience**

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### **Zachary Davis [8, 9]**

*Graduate student, Department of Physics and Astronomy, Purdue University*

**Mentoring**

*2018 – 2022*

### **Amanda O. Harrison [5]**

*Graduate student, Department of Physics and Astronomy, Purdue University*

**Mentoring**

*2018 – 2020*

### **Hao Zhang [4]**

*Graduate student, Department of Physics and Astronomy, Purdue University*

**Mentoring**

*2018 – 2019*

### **Thermodynamics (Graduate Level)**

*Instituto de Física y Matemáticas, Universidad Michoacana de San Nicolás de Hidalgo*

**Guest Lecturer**

*Jun 2018*

## **Professional Development**

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### **High Performance Computing on Frontera**

*Jason Allison et al., TACC, Austin, TX, USA, May 20, 27 and June 3, 2021*

*Lecture*

### **Writing Winning Grants**

*Dr. Lauren Broyles, Purdue University, West Lafayette, IN, USA, November 7, 2019*

*Lecture*

### **XSEDE HPC Workshop: Summer Boot Camp**

*John Urbanic, Purdue University, West Lafayette, IN, USA, June 3 – 6, 2019*

*Workshop*

### **Data Analysis and Machine Learning with Python**

*Dr. Alejandro Torres, Universitat de València, Burjassot, Spain, February 7 – 16, 2017*

*Workshop*

### **Numerical Relativity Simulations of BBH Coalescence Using the Einstein Toolkit**

*Dr. Vassilios Mewes, Universitat de València, Burjassot, Spain, July 6 – 7, 2016*

*Workshop*

No. of hours: 8

### **The Universe in the Light of PLANCK and BICEP2**

*Prof. Nick Mavromatos, Universitat de València, Burjassot, Spain, May 23 – 16, 2014*

*Lecture series*

No. of credits: 2

### **Dark Matter**

*Prof. Alejandro Ibarra, Universitat de València, Burjassot, Spain, September 23 – 27, 2013*

*Lecture series*

No. of credits: 2

### **International Cargèse School on Cosmic Accelerators**

*Institut d'Études Scientifiques de Cargèse, Cargèse, France, April 23 – May 8, 2013*

*Summer school*

### **Introduction to C++ Programming**

*Dr. Jacek Generowicz, Universitat de València, Burjassot, Spain, April 9 – 12, 2012*

*Workshop*

No. of credits: 6

### **Numerical Relativistic Astrophysics**

*Prof. Luciano Rezzolla, Universitat de València, Burjassot, Spain, March 27 – April 4, 2012*

*Lecture series*

No. of hours: 9



## Fortran for Scientific Computing

HLRS, University of Stuttgart, Stuttgart, Germany, Mar. 5 – 9, 2012

Workshop

No. of hours: 33

## Certifications and Credentials

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### Data Analyst with Python

**Complete**

*Data Manipulation, Data Visualization, Importing & Cleaning Data*

*DataCamp*

Exploratory Data Analysis, Statistics, Sampling, Hypothesis Testing, Python, Pandas, Matplotlib, Seaborn

### Data Scientist Professional with Python

*Python Programming, Data Science, Data Communication, Machine Learning*

*DataCamp*

Data Analysis, EDA, Supervised Learning, Unsupervised Learning, SQL, Python, Pandas, Matplotlib, Seaborn, Scikit-Learn

### Machine Learning Scientist with Python

*Machine Learning, NLP, Deep Learning, Image Processing, Big Data*

*DataCamp*

### Mathematical Foundations of Machine Learning

Udemy, [Credential ID: UC-605df108-ae80-4297-8c8f-6bc15b967511](#)

### Python for Statistical Analysis

Udemy, [Credential ID: UC-e8557ac8-13f9-41bf-ab46-f196a041b725](#)

## Outreach

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### Los más rápidos y los más furiosos (*The Fastest and the Most Furious*)

**Online talk**

*Community of Undergraduate Physics Students, Juárez Autonomous University of Tabasco*  
Tabasco, Mexico

*September 4, 2020*

### Una simulación de la física y la astrofísica (*A Simulation of Physics and Astrophysics*)

**Online talk**

*Community of Undergraduate Physics Students, Juárez Autonomous University of Tabasco*  
Tabasco, Mexico

*August 14, 2020*

### ANITA y la teoría de los universos paralelos (*ANITA and the Theory of Parallel Universes*)

**Blog post**

*Científicos Mexicanos en el Extranjero, [mexiciencia.github.io/post/anita](https://mexiciencia.github.io/post/anita)*

*May 29, 2020*

### ¿Qué es el modelo SIR? (*What is the SIR Model?*)

**Blog post**

*Científicos Mexicanos en el Extranjero, [mexiciencia.github.io/post/modelo-sir](https://mexiciencia.github.io/post/modelo-sir)*

*May 25, 2020*

### Evolución del brote epidémico de COVID-19 (*Evolution of the COVID-19 Epidemic Outbreak?*)

**Blog post**

*Científicos Mexicanos en el Extranjero, [mexiciencia.github.io/post/covid19](https://mexiciencia.github.io/post/covid19)*

*April 5, 2020*

Collaborator with the data analysis/modeling

### Annual Department of Physics and Astronomy Poster Event

**Posters (3) presentation**

*Department of Physics and Astronomy, Purdue University*  
West Lafayette, IN, USA

*November 13, 2019*

### Post-Doc Panel Q&A: What Happens When we Complete our PhDs?

**Panelist**

*Department of Physics and Astronomy, Purdue University*  
West Lafayette, IN, USA

*April 10, 2019*

### Annual Department of Physics and Astronomy Poster Event

**Poster presentation**

*Department of Physics and Astronomy, Purdue University*  
West Lafayette, IN, USA

*November 14, 2018*

### ¿Decía Einstein la verdad? (*Was Einstein Telling the Truth?*)

**Talk**

*Facultad de Ciencias, Universidad Autónoma del Estado de México*  
Toluca, Mexico

*March 11, 2009*

## Synergetic Activities

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### X Scientific Meeting of the Spanish Astronomical Society

**Valencia, Spain**

*Organizing contributor, 14–16 December, 2012*

## Other activities

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**Aug 2007– May 2009: Representative** of the Physics students community at the Governing Council of the Faculty of Sciences of the Universidad Autónoma del Estado de México.

## Languages

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**Spanish:** Native proficiency

**English:** Full professional proficiency

**Catalan:** Intermediate