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Extreme Astrophysics Group
Steward Observatory
University of Arizona
Tucson, Arizona, USA

January 2, 2018

To whom it may concern,

I recently found the announcement at the AAS job listing of a Postdoctoral Research Fellow at the University of Arizona and I would like to apply for that position.

I have recently finished my PhD at the University of Valencia (SPAIN), under the supervision of Prof. Miguel Ángel Aloy and Dr. Petar Mimica. My PhD research focused on the nature of blazars, particularly on connecting their measured spectral features and lightcurves to the physics of the underlying plasma. I worked within the *internal shocks* paradigm. According to this model, shocks inside a heterogeneous beam of relativistic plasma accelerate charged particles, such as leptons and/or hadrons, to higher energies. Since the plasma is threaded by both randomly-oriented small-scale and ordered large-scale magnetic fields, magnetobremsstrahlung (MBS) emission is naturally produced. For simplicty, this radiation is considered as synchrotron for high frequencies and relativistic electrons. The radiation formalism I appied in my thesis is more general and deals with the cyclotron emission as well. My work consisted initially in performing and analyzing numerical simulations based on the internal shocks model, followed by an improvement and extension of the existing numerical tools available in my research group at the Universitat de València. The spectral shape of blazars at high frequencies in the working model is determined by inverse-Compton upscattered photons from an external radiation field or those produced by MBS. Due to the non-linear and complex character of the plasma dynamics, governed by the equations of relativistic magneto-hydrodynamics, as well as the processes of particle acceleration and MBS emission, a fully numerical modeling was accomplished. I performed a systematic parameter coverage of the physical properties of the radiation emitting plasma, with special emphasis on the plasma magnetization. The kind of numerical simulations I performed during my PhD involved solving the kinetic and radiative transfer equations in a magnetized medium. What was found with this study were the fingerprints of the magnetic field in the underlying plasma left in the shape of the spectra detectected by a distant observer.

I am currently a member of the Computational Physics Group at the Institute of Physics and Mathematics at the Universidad Michoacana de San Nicolás de Hidalgo in Mexico. My purpose here is to support state of the art simulations of relativistic radiation hydrodynamics to model long GRBs performed by members of the group, contributing with astrophysical insight given the expertise I gained during my doctoral studies. Simultaneously, I am following up on two promising research projects derived from my PhD thesis. One of the projects consist on the construction of numerical code which consistently computes the synchrotron-self Compton cooling term out of a hybrid thermal–nonthermal distribution of accelerated particles, injected into a magnetized medium.

My undergraduate work on Numerical Relativity and my ensuing involvement in Numerical Astrophysics have helped me to develop advanced programming skills and intuition in the performance of numerical codes, as well as great interest and knowledge about general relativity and (magneto)hydrodynamics. Nowadays I am mostly interested in high energy physics in astrophysical scenarios, specifically those in the vicinity of compact objects, for instance stellar and supermassive black holes, and neutron stars. Since the first observations by the Event Horizon Telescope, I have been closely following the results from Sgr A* and M87. I am eager to investigate the physics in the surroundings of those objects, with a major interest on the high energy processes.

I am convinced that the experience and knowledge I have will prove highly useful and benefitial to your research program if I should be selected. I can provide more details about any aspect of my work/resume you are interested in. I am available for videoconference interview any weekday.

I look forward to hearing from you soon.

Best regards,

Jesús M. Rueda-Becerril

Attached: curriculum vitae & research statement

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Jesús M. Rueda-Becerril

CV

Last Updated: January 2, 2018

Profile

Doctor in Astrophysics with high expertise in programming, data analysis and problem solving. I am creative, innovative, analyst and hard worker.

During my PhD studies I developed high programming skills in several languages such as Python, R, Fortran 95, C, Shell and version control tools like Git using platforms such as GitHub and Bitbucket. I worked on developing sophisticated numerical tools which were implemented to simulate blazar flares (prompt high energy radiation from relativistic jets of active galactic nuclei). This has shown my fast learning skill of new programming languages and develop efficient codes to solve the problem posed.

I am coauthor of three articles in peer reviewed scientific journals and author of a doctoral thesis, qualified as innovative, in which several numerical and programming issues were overcome, reason why it received the distinction of excellent. In addition, I have good English skills which makes me capable of discussing and interact fluently in both Spanish and English.

I want to apply my mathematical knowledge, programming skills and data analysis experience to machine learning, data mining, decision making and modelling.

Interests

High energy astrophysics

- Cosmic rays
- Particles acceleration processes
- Relativistic jets: formation, composition, magnetization
- Active galactic nuclei: blazars, quasars, radio galaxies
- Tidal disruption events
- Microquasars
- Gamma-ray bursts
- Pulsars
- X-ray binaries
- Gravitational waves

Hydrodynamics	○ Newtonian and (General) Relativistic ○ Magnetic (ideal and resistive) ○ Radiative ○ Numerical methods
Numerical Astrophysics	○ Numerical solutions of the radiation transport equation ○ Plasma modeling via fully–kinetic and hybrid kinetic–fluid simulations ○ Computational hydrodynamics and magnetohydrodynamics ○ Numerical solution to the Einstein equations ○ Numerical solutions to the geodesic equation (timelike and null) ○ Black holes and neutron stars mergers ○ Performance, stability, convergence and accuracy of numerical codes
Computer Sciences	○ Decision-making optimization ○ Machine learning (supervised and unsupervised) ○ Neuronal networks ○ Text mining ○ Network analysis

Employment

2017–Present **Posdoctoral Researcher**, *Instituto de Física y Matemáticas, Universidad Michoacana de San Nicolás de Hidalgo*, Morelia, Mexico.

Education

2011–2017 **Ph.D. in Physics**, *Universitat de València*, Valencia, Spain, Distinction *Cum Laude*.
Supervisors: Prof. Miguel Ángel Aloy Torás and Dr. Petar Mimica
Thesis title: *Numerical treatment of radiation processes in the internal shocks of magnetized relativistic outflows.* Access: `http://roderic.uv.es/handle/10550/60003`

2009–2011 **M.Sc. in Physics**, *Instituto de Física y Matemáticas*, Morelia, Mexico.
Supervisor: Prof. José Antonio González Cervera
Thesis title: *Study of TOV stars with the SPH method*

2004–2009 **B.Sc. in Physics**, *Universidad Autónoma del Estado de México*, Toluca, Mexico.
Supervisor: Prof. Francisco S. Guzmán Murillo
Thesis title: *Numerical solution of null geodesics for the generation of gravitational lenses in spherically symmetric space-times*

Publications

Articles

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. *Mon. Not. R. Astron. Soc.* **468**, 1169–1182 (2017). `10.1093/mnras/stx476`.

2. **Rueda-Becerril, J. M.**, Mimica, P. & Aloy, M. A. The influence of the magnetic field on the spectral properties of blazars. *Mon. Not. R. Astron. Soc.* **438**, 1856–1869 (2014). `10.1093/mnras/stt2335`.

1. Guzmán, F. S. & **Rueda-Becerril, J. M.** Spherical boson stars as black hole mimickers. *Phys. Rev. D* **80**, 084023 (2009). 10.1103/PhysRevD.80.084023.

Proceedings

3. **Rueda-Becerril, J. M.**, Mimica, P. & Aloy, M. A. Numerical simulations of the internal shock model in magnetized relativistic jets of blazars. In *Proceedings of Swift: 10 Years of Discovery (SWIFT 10)*, 159 (Rome, Italy, 2014).

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. In *The Innermost Regions of Relativistic Jets and Their Magnetic Fields*, vol. 61 of *European Physical Journal Web of Conferences*, 02007 (2013). 10.1051/epjconf/20136102007.

1. Mimica, P., Aloy, M. A., **Rueda-Becerril, J. M.**, Tabik, S. & Aloy, C. Numerical simulations of dynamics and emission from relativistic astrophysical jets. In *24th IUPAP Conference on Computational Physics*, vol. 454 of *Journal of Physics: Conference Series*, 012001 (2013). 10.1088/1742-6596/454/1/012001.

Meetings and conferences

Oral presentations

2014 **Rueda-Becerril, J. M.**, Mimica, P., Aloy, M. A., *Numerical simulations of the internal shock model in magnetized relativistic jets of blazars*, IVICFA's Fridays: Computation in Physics, Paterna, Spain, 17 October.

2014 **Rueda-Becerril, J. M.**, Mimica, P., Aloy, M. A., *Influence of the magnetic field on the spectral properties of blazars in the internal shocks scenario*, Extreme-Astrophysics in an Ever-Changing Universe: Time-Domain Astronomy in the 21st Century, Ierápetra, Greece, 16–20 June.

2013 **Rueda-Becerril, J. M.**, Mimica, P., Aloy, M. A., *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, 15–19 July.

Poster presentations

2014 **Rueda-Becerril, J. M.**, Mimica, P., Aloy, M. A., *Numerical simulations of the internal shock model in magnetized relativistic jets of blazars*, Swift: 10 years of Discovery, Rome, Italy, 2–5 December.

2013 **Rueda-Becerril, J. M.**, Mimica, P., Aloy, M. A., *Numerical study of broadband spectra caused by internal shocks in magnetized relativistic jets of blazars*, The Innermost Regions of Relativistic Jets and Their Magnetic Fields, Granada, Spain, 10–14 June.

2007 **Rueda-Becerril, J. M.**, Leyte González, R., García Santibañez, F., Rosendo-Francisco, P., *Analysis of the superficial structure of graphite samples submitted to an electric arc*, L National Physics Meeting, Boca del Río, Mexico, 29 October–2 November.

2006 **Rueda-Becerril, J. M.**, Leyte González, R., García Molina, N., Rosendo-Francisco, P., *Modifications on the superficial structure of graphite samples*, XLIX National Physics Meeting, San Luis Potosí, Mexico, 16–19 October.

2005 **Rueda-Becerril, J. M.**, Gómez Díaz, A., Rosendo-Francisco, P., *Studies of microwave effects of graphite samples*, XLVIII National Physics Meeting, Guadalajara, Mexico, 17–21 October.

Attendance only

2016 CoCoNuT Meeting 2016, Burjassot, Spain, 14–16 December

2008 LI National Physics Meeting, Zacatecas, Mexico, 20–24 October

Organization

2012 Contribution to the organization of the X Scientific Meeting of the Spanish Astronomical Society, Valencia, Spain, 14–16 December

Computer skills

Proficient Unix (Linux, macOS), Fortran (fixed and free format), OpenMP, Python (2, 3), R, RStudio, Shell, Makefile, HDF5, Git, Mathematica, LaTeX, Atom (text editor), Emacs, gnuplot, grace, GitHub

Intermediate C, C++, Julia, Jupyter, MPI, SageMath, OpenOffice, Microsoft Office, iWork, Elisp, DOT, TikZ/PGF, yEd, GeoGebra

Basic HTML, Jekyll, Matlab, Maple, Java, Swift, Perl, SQL, Java

Research experience

2011–2017 **Graduate research assistant**, *Universitat de València*, Burjassot, Spain.

- Studied in depth AGNs and blazars, the blazars models, the radiation transfer equation, the kinetic equation.
- Automatized the launching of simulations, treatment of data and generation of plots for an extensive parameter space study of the internal shocks code developed by Petar Mimica and Miguel A. Aloy in order to find traces left in the spectra due to the magnetization of the shocked shells of plasma.
- Extracted and interpreted data from the simulations of the main characteristics of blazars SEDs, e.g. Compton dominance, syncrotron and Compton peaks, spectral index.
- Extracted, cleaned and processed data from the *Fermi* LAT Second AGN Catalog database for the comparison with our simulations.
- I implemented a routine for a more general distribution of particles (thermal and nonthermal) injected at the shock front to be treated in the original code.
- I calculated tables with the magnetobremsstrahlung emission of charged particles of arbitrary velocity, and the emissivity for isotropic distributions of electrons using a code that I developed from scratch.
- I implemented the magnetobremsstrahlung tables to the original code and performed simulations of the internal shocks scenario for blazars.
- Interpreted the new SEDs out of the simulations.
- Wrote and defended a thesis.
- Contributed to the writing of and coauthored two manuscript for publication in a peer-reviewed journal.

2010–2011 **Graduate research assistant**, *Instituto de Física y Matemáticas*, Morelia, Mexico.

- I developed a newtonian and relativistic smoothed-particle hydrodynamics (SPH) codes.
- I solved the TOV field equations numerically using my RK4 solver.
- I wrote a routine with the simple predictor-corrector method: Euler method with the trapezoidal rule.
- I simulated a TOV star using the numerical solution of the TOV field equations as initial conditions of the SPH code and evolved the system using the predictor-corrector routine.
- Wrote and presented a master thesis with the results obtained.

2008–2009 **Graduate research assistant**, *Universidad Autónoma del Estado de México*, Toluca, Mexico.

- Wrote and characterized a fourth-order Runge-Kutta (RK4) solver for analytic and numeric input functions for each stage.
- I solved the null geodesic equation for two spherically symmetric and static space-times using the RK4 solver: black holes (analytic Christoffel symbols) and boson stars (numeric Christoffel symbols).
- I simulated and interpreted light trajectories due to curved space-times and characterized such trajectories for gravitational lenses.
- Wrote and presented a thesis with the results obtained.
- Contributed to the writing of and coauthored a manuscript for publication in a peer reviewed journal.

2007–2008 **Undergraduate research assistant**, *Universidad Autónoma del Estado de México*, Toluca, Mexico.

Internship service project, supervised by Prof. Jorge Orozco Velasco.

- Writing the elliptic equations in finite differences form
- Characterization of the typical kinds of boundary conditions:
  - Dirichlet
  - Neumann
- Writing of a code which solves the two-dimensional Laplace equation in Cartesian coordinates with Dirichlet and Neumann boundary conditions.

25 Jun–24 Aug 2007 **Undergraduate research assistant**, *Mexican Academia of Science*, Morelia, Mexico.

National program for temporary stays at national research centers for undergraduate science students.

Supervisor: Prof. Francisco S. Guzmán Murillo.

- Numerical solution of the wave equation with finite differences.
- Numerical solution of Burgers' equation with finite differences.
- Numerical solution of the general relativistic one-dimensional wave equation in the 3+1 formalism with finite differences.

2005–2008 **Undergraduate researcher assistant**, *Universidad Autónoma del Estado de México*, Toluca, Mexico.

Volunteer work in a faculty research project
Supervisor: Prof. Porfirio D. Rosendo-Francisco

- Exposure of graphite samples to microwaves
  - Ultrasonic cleaning of graphite samples.
  - Systematic exposure graphite samples to microwaves (2.45 GHz).
  - Observation of the superficial effects using a metallographic microscope.
  - Characterization of the structures observed.
- Exposure of graphite samples to elecric arcs
  - Ultrasonic cleaning of graphite samples.
  - Characterization of a Tesla coil.
    - Input current.
    - Output flux of electrons.
  - Controlled handling of a Tesla coil.
  - Systematic exposure of the surface of graphite samples to a perpendicular and tangential electric arc.
  - Observation of surface effects with a metallographic microscope.
  - Characterization of the zones around the contact region.
  - Characterization of the temperature around the contact region.
  - Characterization of the structures which appeared after the exposure.
  - Analysis of X-rays spectra of the samples.
  - Identification of induced families of lattice planes.

Awards and Scholarships

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

2011–2014 **Fellowship** *Santiago Grisolía* awarded by the Council of Education, Research, Culture and Sport of the Valencian Comunity.

2009–2011 **Fellowship** for academic training for MSc studies granted by the Mexican Council of Science and Technology (CONACyT).

2009 **Award** *Lic. Juan Josafat Pichardo Cruz*, granted by the UAEMex, for finishing the BSc thesis and graduating within a year after completing the undergraduate credits.

25 Jun–24 Aug 2007 **Fellowship** for a temporary stay in a national research center under the XVII summer of scientific investigation program awarded by the Mexican Academia of Science.

Outreach

2009 **Rueda-Becerril, J. M.**, *¿Decía Einstein la verdad? (Was Einstein saying the truth?)*, oral presentation at the weekly colloquium of Physics students: *Café Ciencias*, Toluca, Mexico, 11 March.

Other activities

Aug 2007–May 2009 Physics students representative at the Governing Council of the Faculty of Sciences of the UAEMex

Languages

Spanish	Mother tongue	
English	Proficient	*TOEFL certified.*
Catalan	Basic	
French	Basic	
German	Basic	

References

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