

# Alejandro Cruz Osorio

Instituto de Astronomía, Universidad Nacional Autónoma de México  
Ciudad de México – México

✉ [aosorio@astro.unam.mx](mailto:aosorio@astro.unam.mx) • 🌐 <https://itp.uni-frankfurt.de/~osorio/index.html>  
🐦 [@ACruz\\_Osorio](https://twitter.com/ACruz_Osorio) • Nationality: Mexican Date of birth: April 17 of 1984

## Research Interests

Relativistic Astrophysics : Extragalactic Relativistic Jets – Shadows – Multiwavelength Emission – Accretion onto Compact Objects – General Relativistic Magnetohydrodynamics. General Relativity: Gravitational waves – Neutron and Quark Stars. Nonthermal Particle Acceleration.

## Experience

### Postdoctoral Fellow in Relativistic Astrophysics

2019–2023

*Institut für Theoretische Physik, Goethe Universität Frankfurt, Germany. MENTOR: Luciano Rezzolla*

- General Relativistic Radiation (shadow) calculations;
- General Relativistic Magnetohydrodynamics simulation;
- Mentoring graduate students
- Member of the collaboration Event Horizon Telescope (Nov.2019–now).
- Member of the collaboration "Black Hole Cam" (Ago.2019 now).

### Postdoctoral Fellow in Numerical Relativity

2017–2019

*Departament d'Astronomia i Astrofísica, Universitat de València, Spain. MENTOR: José A. Font Roda.*

- Numerical relativity simulations of tilted disks with Einstein Toolkit;
- Accretion of magnetized disks around compact objects;
- Convolutional Neural Networks to analyse the gravitational wave signals, using TensorFlow.

### Postdoctoral Fellow in Relativistic Astrophysics

2016–2017

*Institut Für Theoretische Physik, Goethe Universität Frankfurt, Germany. MENTOR: Luciano Rezzolla*

- Developer of the new exa-scale numerical relativity code: ExaHype;

### Postdoctoral Fellow in Astronomy

2015–2016

*Instituto de Astronomía, Universidad Nacional Autónoma de México, México. MENTOR: F. Sánchez.*

- Relativistic hydrodynamics simulations of wind accretion in presence of clumps around black holes.

### Full time interim professor

Aug.2014–Feb.2015

*Dep. of Computational Systems, Instituto Tecnológico Superior de los Ríos, México*

## Education

### Ph.D. in Physics

2010–2014

*Institute of Physics and Mathematics, UMSNH, México*

*Supervisor: F. S. Guzmán*

*Numerical implementation of the relativistic magnetohydrodynamics*

### M.Sc. in Physics

2008–2010

*Institute of Physics and Mathematics, UMSNH, México*

*Supervisor: F. S. Guzmán*

*Numerical solution of the wave equation in Minkowski and Schwarzschild space-times in a domain containing the future infinite null*

### B.Sc in Physics-Mathematics

2002–2008

*Faculty of Physical-Mathematical Sciences, UMSNH, México*

*Supervisor: F. S. Guzmán*

*Tracking null radial geodesics of spherically symmetric space-times.*

## Languages

---

**Nahuatl:** Native

**English:** Full professional proficiency

**Spanish:** Native

**German:** Basic

## Awards and Recognitions

---

**EHT Early Career Award 2022:** For the outstanding contribution of Theoretical Modeling of Sagittarius A\*. The Event Horizon Telescope collaboration. Dec. 2022

**Wissenschaftspris der Frankfurter Physik 2022 (Science Award of Frankfurt Physics 2022):** Department of Physics Goethe University Frankfurt and Walter Greiner Gesellschaft zur Förderung der physikalischen Grundlagenforschung, Frankfurt, Germany. Jul. 2022

**2016–2022 SNI I:** National Researchers System Recognition by the National Council of Science and Technology (CONACYT <sup>1</sup>), México. First period: Jan 2016 – Dec 2018. Second period: Jan 2019 – Dec 2022. Third period: Jan 2023 –

## Research Grants

---

**2022–2025 Marie Curie Horizon Europe Staff Exchange action 2022 (NewFunFiCO):** Fundamental Fields and Compact Objects: new opportunities, funding 276 000 Euros, **co-PI of Germany branch.**

**2021–now JETSET-ERC Fellowship:** Institut Für Theoretische Physik, Goethe Universität.

**2019–2021 Black Hole Cam-EHT Fellowship:** Institut Für Theoretische Physik, Goethe Universität.

**2017–2019 CONACYT Postdoc abroad Fellowship:** at Universitat de València.

**2016–2017 ExaHyPE-Horizon 2020 EU Fellowship:** Institut Für Theoretische Physik, Goethe Universität.

**2015–2017 DGAPA postdoc Fellowship:** at Institute of Astronomy, UNAM

**2008–2010 Fellowship for Ph.D. studies:** at the Institute of Physics and Mathematics, UMSNH <sup>2</sup>, granted by the Mexican Council of Science CONACyT.

**2010–2014 Fellowship for M.Sc studies:** at the Institute of Physics and Mathematics, UMSNH, granted by the Mexican Council of Science CONACyT.

## Grants of computational time allocation

---

**PI** of the project **Long-term simulations of magnetized disks and jets around supermassive black-hole binaries in General Relativity-2023** HAWK cluster, High-Performance Computing Center Stuttgart, Stuttgart, Germany. **100 Millions CPU-hours**.

**PI** of the project **Large-scale numerical-relativity simulations of tilted black hole-torus system**, project ID: FI-2019-2-0043, **3 Millions CPU-hours**, Estimated cost: 2959 euros, Cluster: Barcelona Supercomputing center-MareNostrum 4.

Microphysical aspects of binary neutron star mergers (BNSMIC), HAWK cluster, High-Performance Computing Center Stuttgart, Stuttgart, Germany. **100 Millions CPU-hours**. PI Luciano Rezzolla.

## Publications

---

[1] **Cruz-Osorio**, A., Gonzalez-Juarez, A., Guzman, F. S., & Lora-Clavijo, F. D. Numerical solution of the wave equation on particular space-times using CMC slices and scri-fixing conformal compactification. *Rev. Mex. Fis.*, 56:456–468, pages 456–468. 2010

[2] **Cruz-Osorio**, A., Lora-Clavijo, F. D., & Guzmán, F. S., Jul. 2010, in *American Institute of Physics Conference Series*, Vol. 1256, *Gravitational Physics: Testing Gravity from Submillimeter to Cosmic*, ed. H. A.

CONACYT: Consejo Nacional de Ciencia y Tecnología

UMSNH: Universidad Michoacana de San Nicolás de Hidalgo

Morales-Tecotl, L. A. Urena-Lopez, R. Linares-Romero, & H. H. Garcia-Compean, pages 311–317

- [3] Lora-Clavijo, F. D., **Cruz-Osorio**, A., & Guzmán, F. S. Evolution of a massless test scalar field on boson star space-times. *Phys. Rev. D*, **82**(2):023005, page 023005. Jul. 2010
- [4] **Cruz-Osorio**, A., Guzmán, F. S., & Lora-Clavijo, F. D. Scalar field dark matter: behavior around black holes. *Journal of Cosmology and Astroparticle Physics*, **2011**(6):029, page 029. Jun. 2011
- [5] **Cruz-Osorio**, A., Lora-Clavijo, F. D., & Guzmán, F. S. Is the flip-flop behaviour of accretion shock cones on to black holes an effect of coordinates? *Mon. Not. R. Astron. Soc.*, **426**(1):732–738, pages 732–738. Oct. 2012
- [6] **Cruz-Osorio**, A., Lora-Clavijo, F. D., & Guzmán, F. S., Jul. 2013, in American Institute of Physics Conference Series, Vol. 1548, IX Mexican School on Gravitation and Mathematical Physics: Cosmology for the XXIst Century: Gravitation and Mathematical Physics Division of the Mexican Physical Society DGFM-SMF, ed. L. A. Uren-López, R. Becerril-Bárcenas, & R. Linares-Romero, pages 323–327
- [7] Lora-Clavijo, F. D., Guzmán, F. S., & **Cruz-Osorio**, A. PBH mass growth through radial accretion during the radiation dominated era. *Journal of Cosmology and Astroparticle Physics*, **2013**(12):015, page 015. Dec. 2013
- [8] Lora-Clavijo, F. D., **Cruz-Osorio**, A., & Guzmán, F. S. CAFE: A New Relativistic MHD Code. *Astrophys. J., Supp.*, **218**(2):24, page 24. Jun. 2015
- [9] Lora-Clavijo, F. D., **Cruz-Osorio**, A., & Moreno Méndez, E. Relativistic Bondi-Hoyle-Lyttleton Accretion onto a Rotating Black Hole: Density Gradients. *Astrophys. J., Supp.*, **219**(2):30, page 30. Aug. 2015
- [10] González-Avilés, J. J., **Cruz-Osorio**, A., Lora-Clavijo, F. D., & Guzmán, F. S. Newtonian CAFE: a new ideal MHD code to study the solar atmosphere. *Mon. Not. R. Astron. Soc.*, **454**(2):1871–1885, pages 1871–1885. Dec. 2015
- [11] **Cruz-Osorio**, A., & Lora-Clavijo, F. D. Non-axisymmetric relativistic wind accretion with velocity gradients on to a rotating black hole. *Mon. Not. R. Astron. Soc.*, **460**(3):3193–3201, pages 3193–3201. Aug. 2016
- [12] **Cruz-Osorio**, A., Sánchez-Salcedo, F. J., & Lora-Clavijo, F. D. Relativistic Bondi-Hoyle-Lyttleton accretion in the presence of small rigid bodies around a black hole. *Mon. Not. R. Astron. Soc.*, **471**(3):3127–3134, pages 3127–3134. Nov. 2017
- [13] Becerra-Vergara, E. A., Mojica, S., Lora-Clavijo, F. D., & **Cruz-Osorio**, A. Anisotropic quark stars with an interacting quark equation of state. *Phys. Rev. D*, **100**(10):103006, page 103006. Nov. 2019
- [14] Arroyo-Chávez, G., **Cruz-Osorio**, A., Lora-Clavijo, F. D., Campuzano Vargas, C., & García Mora, L. A. Neutron and quark stars: constraining the parameters for simple EoS using the GW170817. *Astrophys Space Sci.*, **365**(2):43, page 43. Feb. 2020
- [15] **Cruz-Osorio**, A., Gimeno-Soler, S., & Font, J. A. Non-linear evolutions of magnetized thick discs around black holes: dependence on the initial data. *Mon. Not. R. Astron. Soc.*, **492**(4):5730–5742, pages 5730–5742. Mar. 2020
- [16] **Cruz-Osorio**, A., & Rezzolla, L. Common-envelope Dynamics of a Stellar-mass Black Hole: General Relativistic Simulations. *Astrophys. J.*, **894**(2):147, page 147. May 2020
- [17] Event Horizon Telescope Collaboration, Akiyama, K., Algaba, J. C., et al. First M87 Event Horizon Telescope Results. VII. Polarization of the Ring. *Astrophys. J. Lett.*, **910**(1):L12, page L12. Mar. 2021

- [18] Event Horizon Telescope Collaboration, Akiyama, K., Algaba, J. C., et al. First M87 Event Horizon Telescope Results. VIII. Magnetic Field Structure near The Event Horizon. *Astrophys. J. Lett.*, **910**(1):L13, page L13. Mar. 2021
- [19] Goddi, C., Martí-Vidal, I., Messias, H., et al. Polarimetric Properties of Event Horizon Telescope Targets from ALMA. *Astrophys. J. Lett.*, **910**(1):L14, page L14. Mar. 2021
- [20] EHT MWL Science Working Group, Algaba, J. C., Anczarski, J., et al. Broadband Multi-wavelength Properties of M87 during the 2017 Event Horizon Telescope Campaign. *Astrophys. J. Lett.*, **911**(1):L11, page L11. Apr. 2021
- [21] Narayan, R., Palumbo, D. C. M., Johnson, M. D., et al. The Polarized Image of a Synchrotron-emitting Ring of Gas Orbiting a Black Hole. *Astrophys. J.*, **912**(1):35, page 35. May 2021
- [22] Kocherlakota, P., Rezzolla, L., Falcke, H., et al. Constraints on black-hole charges with the 2017 EHT observations of M87\*. *Phys. Rev. D*, **103**(10):104047, page 104047. May 2021
- [23] **Cruz-Osorio**, A., Gimeno-Soler, S., Font, J. A., De Laurentis, M., & Mendoza, S. Magnetized discs and photon rings around yukawa-like black holes. *Phys. Rev. D*, **103**(12):124009, page 124009. Jun. 2021
- [24] **Cruz-Osorio**, A., Lora-Clavijo, F. D., & Herdeiro, C. GW190521 formation scenarios via relativistic accretion. *Journal of Cosmology and Astroparticle Physics*, **2021**(07):032, page 032. Jul. 2021
- [25] Janssen, M., Falcke, H., Kadler, M., et al. Event Horizon Telescope observations of the jet launching and collimation in Centaurus A. *Nature Astronomy*, **5**:1017–1028, pages 1017–1028. Jul. 2021
- [26] **Cruz-Osorio**, A., Fromm, C. M., Mizuno, Y., et al. State-of-the-art energetic and morphological modelling of the launching site of the M87 jet. *Nature Astronomy*, **6**:103–108, pages 103–108. Jan. 2022
- [27] Satapathy, K., Psaltis, D., Özel, F., et al. The Variability of the Black Hole Image in M87 at the Dynamical Timescale. *Astrophys. J.*, **925**(1):13, page 13. Jan. 2022
- [28] Fromm, C. M., **Cruz-Osorio**, A., Mizuno, Y., et al. Impact of non-thermal particles on the spectral and structural properties of M87. *Astronomy and Astrophysics*, **660**:A107, page A107. Apr. 2022
- [29] Event Horizon Telescope Collaboration, Akiyama, K., Algaba, J. C., Alberdi, A., & Alef, W. First Sagittarius A\* Event Horizon Telescope Results. I. The Shadow of the Supermassive Black Hole in the Center of the Milky Way. *Astrophys. J. Lett.*, **930**(2):L12, page L12. May 2022
- [30] Event Horizon Telescope Collaboration, Akiyama, K., Algaba, J. C., Alberdi, A., & Alef, W. First Sagittarius A\* Event Horizon Telescope Results. II. EHT and Multiwavelength Observations, Data Processing, and Calibration. *Astrophys. J. Lett.*, **930**(2):L13, page L13. May 2022
- [31] Event Horizon Telescope Collaboration, Akiyama, K., Algaba, J. C., Alberdi, A., & Alef, W. First Sagittarius A\* Event Horizon Telescope Results. III. Imaging of the Galactic Center Supermassive Black Hole. *Astrophys. J. Lett.*, **930**(2):L14, page L14. May 2022
- [32] Event Horizon Telescope Collaboration, Akiyama, K., Algaba, J. C., Alberdi, A., & Alef, W. First Sagittarius A\* Event Horizon Telescope Results. IV. Variability, Morphology, and Black Hole Mass. *Astrophys. J. Lett.*, **930**(2):L15, page L15. May 2022
- [33] Event Horizon Telescope Collaboration, Akiyama, K., Algaba, J. C., Alberdi, A., & Alef, W. First Sagittarius A\* Event Horizon Telescope Results. V. Testing Astrophysical Models of the Galactic Center Black Hole. *Astrophys. J. Lett.*, **930**(2):L16, page L16. May 2022
- [34] Event Horizon Telescope Collaboration, Akiyama, K., Algaba, J. C., Alberdi, A., & Alef, W. First Sagittarius A\* Event Horizon Telescope Results. VI. Testing the Black Hole Metric. *Astrophys. J. Lett.*, **930**(2):L17, page L17. May 2022

- [35] Farah, J., & Event Horizon Telescope Collaboration. Selective Dynamical Imaging of Interferometric Data. *Astrophys. J. Lett.*, **930**(2):L18, page L18. May 2022
- [36] Wielgus, M., & Event Horizon Telescope Collaboration. Millimeter Light Curves of Sagittarius A\* Observed during the 2017 Event Horizon Telescope Campaign. *Astrophys. J. Lett.*, **930**(2):L19, page L19. May 2022
- [37] Georgiev, B., & Event Horizon Telescope Collaboration. A Universal Power-law Prescription for Variability from Synthetic Images of Black Hole Accretion Flows. *Astrophys. J. Lett.*, **930**(2):L20, page L20. May 2022
- [38] Broderick, A., & Event Horizon Telescope Collaboration. Characterizing and Mitigating Intraday Variability: Reconstructing Source Structure in Accreting Black Holes with mm-VLBI. *Astrophys. J. Lett.*, **930**(2):L21, page L21. May 2022
- [39] Röder, J., **Cruz-Osorio**, A., Fromm, C. M., et al., Jan. 2022, in *European VLBI Network Mini-Symposium and Users' Meeting 2021*, page 24
- [40] Issaoun, S., Wielgus, M., & Event Horizon Telescope Collaboration. Resolving the inner parsec of the blazar J1924–2914 with the Event Horizon Telescope. *Astrophys. J.*, **934**(2):21, page 21. Jul. 2022
- [41] Broderick, A., Pesce, D., Gold, R., et al. The Photon Ring in M87\*. *Astrophys. J.*, **935**(1):61, page 61. Aug. 2022
- [42] Meringolo, C., **Cruz-Osorio**, A., Rezzolla, L., & Servidio, S. Microphysical Plasma Relations from Special-relativistic Turbulence. *Astrophys. J.*, **944**(2):122, page 122. Feb. 2023
- [43] Jorstad, S., Wielgus, M., Lico, R., et al. The Event Horizon Telescope Image of the Quasar NRAO 530. *Astrophys. J.*, **943**(2):170, page 170. Feb. 2023
- [44] Röder, J., **Cruz-Osorio**, A., Fromm, C. M., et al. Probing the spacetime and accretion model for the Galactic Center: Comparison of Kerr and dilaton black hole shadows. *Astronomy and Astrophysics*, **671**:A143, page A143. Mar. 2023
- [45] Prather, B. S., Dexter, J., Moscibrodzka, M., et al. Comparison of Polarized Radiative Transfer Codes Used by the EHT Collaboration. *Astrophys. J.*, **950**(1):35, page 35. Jun. 2023
- [46] Torne, P., Liu, K., Eatough, R. P., et al. A search for pulsars around sgr a\* in the first event horizon telescope data set. *The Astrophysical Journal*, **959**(1):14, page 14. nov 2023
- [47] **Cruz-Osorio**, A., Rezzolla, L., Lora-Clavijo, F. D., et al. Bondi-Hoyle-Lyttleton accretion onto a rotating black hole with ultralight scalar hair. *Journal of Cosmology and Astroparticle Physics*, **2023**(8):057, page 057. Aug. 2023
- [48] Kocherlakota, P., Narayan, R., Chatterjee, K., **Cruz-Osorio**, A., & Mizuno, Y. Toward General Relativistic Magnetohydrodynamics Simulations in Stationary Nonvacuum Spacetimes. *Astrophys. J. Lett.*, **956**(1):L11, page L11. Oct. 2023
- [49] Event Horizon Telescope Collaboration, Akiyama, K., Alberdi, A., et al. First M87 Event Horizon Telescope Results. IX. Detection of Near-horizon Circular Polarization. *Astrophys. J. Lett.*, **957**(2):L20, page L20. Nov. 2023
- [50] Roelofs, F., Johnson, M. D., Chael, A., et al. Polarimetric Geometric Modeling for mm-VLBI Observations of Black Holes. *Astrophys. J. Lett.*, **957**(2):L21, page L21. Nov. 2023
- [51] Mpisketzis, V., Duqué, R., Nathanail, A., **Cruz-Osorio**, A., & Rezzolla, L. Impact of anisotropic ejecta on jet dynamics and afterglow emission in binary neutron-star mergers. *Mon. Not. R. Astron. Soc.*, **527**(3):9159–9175, pages 9159–9175. Jan. 2024

- [52] Moriyama, K., Cruz-Osorio, A., Mizuno, Y., et al. Future Prospects for Constraining Black Hole Spacetime: Horizon-scale Variability of Astrophysical Jets. *Astrophys. J.*, **960**(2):106, page 106. Jan. 2024
- [53] Event Horizon Telescope Collaboration, Akiyama, K., Alberdi, A., et al. The persistent shadow of the supermassive black hole of M 87. I. Observations, calibration, imaging, and analysis. *Astronomy and Astrophysics*, **681**:A79, page A79. Jan. 2024
- [54] Paraschos, G. F., Kim, J. Y., Wielgus, M., et al. Ordered magnetic fields around the 3C 84 central black hole. *Astronomy and Astrophysics*, **682**:L3, page L3. Feb. 2024

## Teaching and Mentoring

---

### Graduated students.....

<b>Giuseppe Riveccio (M.Sc. in Physics)</b>	<b>17.11.2023</b>
<i>Università degli Studi di Napoli Federico II, Italy</i>	
Tracking hotspots around Sgr A*	<i>co-supervisor: Mariafelicia De Laurentis</i>
<b>Mauricio Ortiz (M.Sc. in Astrophysics) with Summa cum laude</b>	<b>04.09.2023</b>
<i>Institut für Theoretische Physik, University of Cologne, Germany</i>	<i>co-supervisor: Claus Kiefer</i>
General Relativistic Magnetohydrodynamic Simulations of Relativistic Jets Interacting with Stellar Winds	
<b>Jan Röder (M.Sc. in Astrophysics) with Summa cum laude</b>	<b>14.04.2020</b>
<i>Institut für Theoretische Physik, Goethe Universität Frankfurt, Germany</i>	<i>co-supervisor: Luciano Rezzolla</i>
Comparison of Kerr and dilaton black hole shadows: Impact of non-thermal emission	
<b>Luis García (B.Sc. in Physic)[14]</b>	<b>12.03.2019</b>
<i>Faculty of Physics, UNAM, México</i>	
Quark star using MIT bag model	
<b>Griselda Arroyo Chávez (B.Sc. in Physic) with "Mención Honorífica" [14]</b>	<b>26.01.2018</b>
<i>Faculty of Physics, Universidad Veracruzana, México</i>	<i>co-supervisor: C. Campuzano</i>
Observational and numerical comparability of neutron stars models using a polytropic EoS	

### Teaching.....

- 2023 Quantum Mechanics, M. Sc. in Astrophysics program, Institute of Astronomy-UNAM, México.
- 2022 Hydrodynamics and Magnetohydrodynamics, M. Sc. in Physics program, summer semester, Institute of Theoretical Physics, Goethe-Universität Frankfurt, Germany. [Notes here](#)
- 2016 Relativity, Science Faculty (Physic), UNAM, México.
- 2015 Electrodynamics, M. Sc. in Astrophysics program, Institute of Astronomy-UNAM, México.
- 2015 Hydrodynamics in general relativity, M. Sc. in Astrophysics program, Institute of Astronomy-UNAM, México.
- 2014 General Physics, Department of Computer Systems Engineering, Instituto Tecnológico Superior de los Ríos, México.
- 2014 Fluid mechanics, Environmental Engineering, Instituto Tecnológico Superior de los Ríos, Tabasco, México.
- 2014 Transport phenomena, Environmental Engineering, Instituto Tecnológico Superior de los Ríos, México.
- 2014 Graduation Seminar. Master in Nutritional, Universidad de Morelia, Michoacán, México.
- 2014 Statistics II. Masters in Nutritional, Universidad de Morelia, Michoacán, México.
- 10-13 Mathematics I, Faculty of Biology, Universidad Michoacana de San Nicolás de Hidalgo, Michoacán, México.
- 10-13 Physics, Faculty of Biology, Universidad Michoacana de San Nicolás de Hidalgo, Michoacán, México.
- 2010 Thermodynamics, Faculty of Electrical Engineering, Universidad Michoacana de San Nicolás de Hidalgo, Michoacán, México.

### Tutoring.....

- 2022 General Relativity, Winter semester, Professor: Dr. Luciano Rezzolla, Goethe-Universität Frankfurt, Germany.
- 2021 Proseminar on Astrophysics, summer semester, Professor: Dr. Laura Sagunski and Dr. Jürgen Schaffner Bielich, Goethe-Universität Frankfurt, Germany.
- 2021 Einführung in die Programmierung für Physiker (Introduction to programming for physicists), winter semester, Professor of the course: Dr. Eberhard Engel, Goethe-Universität Frankfurt, Germany.

## Talks

---

### Invited talks – Conferences

#### **Using ngVLA to probe gravity, plasma properties and particle acceleration**

*Invited Talk, First Mexican meeting in route to the Next Generation VLA, Morelia, México. Sep. 25-27 2023*

#### **Interpretando la imagen de la sombra de Sagitario A\* utilizando relatividad general**

*Plenary Talk, LXV Congreso Nacional de Física, Zacatecas, México. Oct 4 2022*

#### **Shadow of the supermassive black hole in M87**

*Review Talk, Growing Black Holes: Accretion & Mergers In memory of Sergio Colafrancesco Kathmandu, Nepal, May 15-20, 2022*

#### **GW190521 formation scenarios via relativistic accretion**

*Engineering Week, Faculty of Higher Studies "Aragón" -UNAM, Mexico City, México. October 28th 2021.*

### Invited talks – Seminars

#### **Relativistic Jets as laboratory to test gravity, particle acceleration and plasma properties**

*Seminario "Jesús Reyes Corona", Instituto de Física, Benemérita Universidad Autónoma de Puebla, Puebla, México. Feb 23, 2024.*

#### **Modelando la sombra de un agujero negro supermasivo: M87\* y SgrA\***

*Seminario del departamento de Física, Facultad de Ciencias, UNAM, México. Feb 09, 2024.*

#### **An update on the supermassive black hole shadow M87\***

*Coloquio del Instituto de Astronomía, UNAM, México. Jan 24, 2024.*

#### **Jets relativistas bajo el microscopio: Efectos de la microfísica en la emisión electromagnética**

*Seminar group DAEC, Institute of Astronomy-UNAM, Mexico City, México. Nov 23th 2023.*

#### **Acceleration of non-thermal particles from turbulent plasmas**

*Coloquio del Instituto de Ciencias Físicas, UNAM, Cuernavaca, Morelos, Mexico. Jan 27, 2023.*

#### **Interpretando la imagen de la sombra de Sagitario A\* utilizando relatividad general**

*Seminario del Dep. de Física, Universidad Autónoma Metropolitana Iztapalapa, México. Oct 7 del 2022*

#### **Interpretación teórica de la sombra del agujero negro supermasivo Sagitario A\***

*Coloquio del Instituto de Astronomía, UNAM, Mexico. Oct 6, 2022.*

#### **SgrA\*: Our own black hole at the heart of the Milky Way**

*Seminario del Instituto de Física y Matemáticas/Facultad de Ciencias Físico-Matemáticas de la UMSNH Morelia, Michoacán, México. May 27 2022*

#### **Jets relativistas:**

*Mecanismo de generación, aceleración de partículas y emisión electromagnética en multi-frecuencias*  
*Coloquio del Instituto de Astronomía, UNAM, Mexico. May 11, 2022.*

#### **Electromagnetic emission from relativistic jets:**

*Modeling the launching and high energy emission using GRMHD simulations*  
*Seminar, Instituto Avanzado de Cosmología, Mexico. April 1, 2022.*

#### **Multiwavelenght emission of M87 jet from GRMHD simulations**

*Seminario "Dr. Jesús Reyes Corona", Instituto de Física—UAP, Mexico. February 4th 2022.*

#### **Understanding multi-wavelength emission of M87 jet using general relativistic MHD simulations**

*AstroLunch, The Netherlands Institute for Radio Astronomy, Netherlands. January 26th 2022.*

#### **Modeling Radiation Emission of M87 Jet with GRMHD Simulations**

*Dep. of Gravitation and Field theory seminar, Institute of Nuclear Physic-UNAM, México. Sep. 30th 2021.*

#### **General relativistic simulations of the common-envelope evolution**

*Physics Department Seminar, Universidad de la Sapienza Roma, Roma, Italy. March 17th, 2021.*

#### **Electromagnetic emissions from relativistic jets and magnetized disks**

*Multidisciplinary seminar, Facultad de ciencias,*  
*Universidad Autónoma del Estado de México, Toluca, México. November 26th 2020*

#### **Relativistic Fluid Accretion Around a Black Hole**

*AstroCoffee seminar, Institute for Theoretical Physics, Goethe University,*

Frankfurt, Germany. May 9th 2017

**Fix Mesh Refinement in Cartesian coordinates**

*Institute of Astronomy-UNAM, Mexico City, México. June 14th 2016.*

**"Newton (Siglo XVII)-Diplomado en Astrofísica"**

*Institute of Astronomy-UNAM, Mexico City, México. May 12th 2016.*

**"Relativistic Bondi-Hoyle accretion onto rotating black holes using CAFE code**

*Seminar of National Institute of Astrophysics, Optics and Electronics(INAOE)*

Tonantzintla, Puebla, México. March 4th 2016.

**Primordial black holes as seeds of supermassive black holes**

*Seminar of the Faculty of Physics, Universidad Veracruzana, Veracruz, México. February 4th 2016.*

**Relativistic accretion of supersonic winds around rotating black holes**

*Seminar group DATA, Institute of Astronomy-UNAM, Mexico City, México. January 19th 2016.*

**Contributed Talks.....**

**Multi-wavelength emission of M87 jet using self-consistent electron-to-proton temperature**

*Workshop on Kinetic Models of Relativistic Plasmas, Trinity College, Dublin, Ireland, Feb. 27 – March.2, 2023.*

**Non-thermal emission at event horizon and jet launching scales**

*New Generation Event Horizon Telescope Meeting 2022. June 22-25 2022.*

**Modeling the limb brightening of M87 jet: Effects of electron temperature and magnetic energy**

*Event Horizon Telescope Meeting 2022. June 19-22 2022.*

**Modeling MWL emission with GRMHD and GRRT simulations**

*Event Horizon Telescope Meeting 2021. December 6-10 2021.*

**Non-thermal emission in SANE and MAD GRMHD simulations**

*Event Horizon Telescope SgrA\* Theory Symposium 2020. September 4th 2020.*

**Non-linear evolution of magnetized-torus-BH: Comparison between magnetic field approaches**

*689. WE-Heraeus-Seminar on Accretion in strong gravity, Bad Honnef, Germany. February 4-8 2019.*

**Evolution of a Magnetized Thick disk around a highly rotating black hole**

*The European Einstein Toolkit meeting 2018, Lisbon, Portugal. September 13th 2018.*

**Consistent construction of a magnetised accretion disc around a highly rotating black hole**

*Spanish-Portuguese Relativity Meeting 2018, Palencia, Spain. September 4th 2018.*

**Special and General relativistic magnetohydrodynamics in ExaHyPE**

*ExaHyPE council Meeting, Garching, Germany. April 3th 2017.*

**CAFE a new relativistic MHD code**

*28th Texas Symposium on Relativistic Astrophysics, Geneva, Switzerland. December 2015.*

**Relativistic Bondi-Hoyle Accretion onto a Rotating Black Hole: Density Gradients**

*X Mexican School on Gravitation and Mathematical Physics, Playa del Carmen, México. December 2014.*

**Morelia, a new special relativistic MHD code**

*X workshop of the DGFM, Hidalgo, México. December 2013.*

**Morelia, a new special relativistic MHD code**

*XXV National Congress of Astronomy, Mexico city, México. November 2013.*

**Flip-flop instability of the shock cone in Bondi-Hoyle accretion**

*IX Mexican School on Gravitation and Mathematical Physics, Guadalajara, México. December 2012.*

**Flip-flop instability in the wind accretion around a rotating black hole**

*LV National Congress of Physics, Morelia, México. October 2012.*

**Bondi-Hoyle accretion onto Schwarzschild and Kerr black holes**

*XXIV National Congress of Astronomy, Guadalajara, México. September 2011.*

**Solution of a scalar field on a background of Schwarzschild containing the null infinity future**

*LIII Congress of Physics, Veracruz, México. October 2010.*

**Numerical solution of the wave equation on space-times with scri-fixing conformal compactifications**

*VIII Mexican School on Gravitation and Mathematical Physics of the DGFM-SMF,*

*Playa del Carmen, México. December 10th 2009*

## **Poster Sessions**

### **Gravitational Waves From Long-Time Evolution Of Tilted Thick Disc Around A Rotating Black Hole**

*22nd International Conference on General Relativity and*

Gravitation-13th Edoardo Amaldi Conference on Gravitational Waves, València, Spain. July 7th-12th 2019.

### **Stellar winds effect in Bondi-Hoyle accretion around Schwarzschild black hole**

*3rd Karl Schwarzschild Meeting - Gravity and the Gauge/Gravity Correspondence,*

Frankfurt, Germany. July 24th-28th 2017.

### **Wind accretion on a Schwarzschild black hole in slab symmetry**

*LIV National Congress of Physics 2011, Yucatán, México. October 2011*

### **Basic tests of general relativity hydrodynamics codes**

*VII School of the Gravitation and Mathematical Physics Division of the Mexican Physical Society,*

Playa del Carmen, México. December 2006.

## **Lectures at Workshops**

### **Numerical methods for the study of relativistic astrophysics**

*Workshop on Numerical Relativity, Faculty of Physics, University of Veracruz,*

Xalapa, Veracruz. November 18th-20th 2015.

### **Introduction to programming in Fortran 90**

*18 anniversary of the Instituto Tecnológico Superior de los Ríos,*

Tabasco, México. November 26th & 27th 2014.

### **The science of science fiction**

*First Multidisciplinary Academic Week of the Instituto Tecnológico Superior de los Ríos,*

Tabasco, México. November 17th & 18th 2014.

## **Outreach**

### **¡Agujeros Negros fantásticos y Como Encontrarlos!**

Talk

*Night of Stars, Institute of Astronomy-UNAM, Mexico city, México. November 25th 2023.*

### **La primera imagen de la sombra del agujero negro en el centro de nuestra galaxia**

Talk

*Conversatorio en el Museo de Arte e Historia de Guanajuato,*

Leon, Guanajuato, México. Oct 14th 2023.

### **Agujeros negros y como encontrarlos sin morir en el intento**

Talk

*Seminario de Estudiantes del Posgrado en Astrofísica.,*

UNAM, Ciudad de México, México. February 22th 2022.

### **Siluetas en la oscuridad: El agujero negro en el corazón de la Vía Láctea**

Talk

*Seminario del Club de Ciencias "Johann Carl Friedrich Gauss",*

Facultad de Ingeniería Universidad Autónoma de Chihuahua. Chihuahua, México. November 10th 2022.

### **Telescopio del Horizonte de Eventos - El centro de la Vía Láctea**

Interview

*CONACYT, Mexico. August 2022.*

### **Physik an der Goethe-Universität: Auszeichnung für herausragende Forschung**

Post

*(Physics at the Goethe University: Award for outstanding research)*

Goethe Universität, Frankfurt am Main, Germany. July 08th 2022.

### **Congratulations to Dr. Cruz-Osorio, laureate of the 2022 Frankfurt Physics Prize!**

Post

*Goethe Universität, Frankfurt am Main, Germany. July 08th 2022.*

### **Astronomers reveal first image of the black hole at the heart of our galaxy**

Press Conference

*Event Horizon Telescope-Mexico, May 12th 2022.*

*Panelist of EHT Conference(Mexico) – YouTube*

### **Simulando los chorros del agujero negro de M87, Minute 1:55:00**

Podcast

*Coffee Break: Señal y Ruido, November 12th 2021, Spain.*

*Coffee Break (YouTube) Ep341: Gravitondas; Monopolos; Fluidos en Roca Porosa; Agua en Galaxias; Agujeros Negros, Minute 2:08:35*

### **Wie Schwarze Löcher ihren Jet zünden**

Press

*UniReport Nr.6, Goethe Universität, Frankfurt am Main, Germany. December 9th 2021.*

**Jet from giant galaxy M87: Computer modelling explains black hole observations**

Press Release

Goethe Universität, Frankfurt am Main, Germany. November 04th 2021.

Nature Astronomy Press Release has 119 replicas in 36 countries.

**Der Astrophysiker Alejandro Cruz Osorio im Porträt**

Press

UniReport Nr.5, Goethe Universität, Frankfurt am Main, Germany. October 12th 2017.

**The first image of a supermassive hole**

Talk

"Jornadas de Ciencia y Matemáticas", Center for research and teaching of mathematics,

Morelia, México. October 13th 2020.

**A supermassive black hole as the engine of our galaxy**

Talk

Astronomical Society of Mexico, Mexico city, México. March 30th 2016.

**A supermassive black hole at the center of our galaxy!**

Talk

Night of Stars, Institute of Astronomy-UNAM, Mexico city, México. November 28th 2015.

**Talking with Astronomers**

Talk

Night of Stars, Institute of Astronomy-UNAM, Mexico city, México. November 28th 2015.

**What is a black hole?**

Talk

Feast of Sciences and Humanities, UNAM UNIVERSUM-Museum,

Mexico city, México. October 17th 2015.

**LIGHT: our eyes throughout the universe**

Talk

22 National Week of Science and Technology, International Year of Light,  
Instituto Tecnológico Superior Huichapan, Hidalgo, México. October 12th 2015.**Nota sobre magnetohidrodinámica**

Radio

Radio UNAM 96.1 FM, Programa: Primer Movimiento min:1:54,  
Mexico city, México. June 28th 2016. <http://goo.gl/S6YzX7>**UNAM estudia el universo con el uso de códigos numéricos**

Press

El Universal, Mexico city, México. June 20th 2016. <http://goo.gl/CcGB6x>**Códigos numéricos para la Astrofísica**

Press

Agencia informativa CONACYT, Mexico city, México. May 16th 2016.

## Academic Service

**Organizing committee**

- **Chair of the AstroCoffee seminar**, Institut fur Theoretische Physik, Johann Wolfgang Goethe Universität Frankfurt, Oct.2020 – Sep.2022
- **EHT Sgr A\* Theory Busy Days (2020-Q4)**, Event Horizon Telescope Collaboration, Nov 30th – Dec 4th 2021.
- **First Student Meeting 2014**, Instituto Tecnológico Superior de los Ríos, November 20th 2015, Tabasco, México.
- **Basic Electronics Conference-Workshop**, Faculty of Science Physics and Mathematics-UMSNH, April 28th & 29th 2006, Morelia, México.
- **1º Regional Meeting of Optic**, September 19th-23th 2005 , Morelia, México.

**Journal Reviewer**

- Astrophysical Journal
- American Journal of Physics <sup>3</sup>
- Revista Mexicana de Física
- MDPI-Universe <sup>4</sup>
- Referee at DiRAC-cluster England: Astronomy, Particle Physics and Nuclear Physics

**Synod & Examiner****Synod committee of Thesis Defence:**

- Bachelor thesis. Fernando Vázquez Chávez, Orbitas estelares como herramienta para estudiar la naturaleza del espacio-tiempo, (04.March.2024), Facultad de Ciencias UNAM, México.

American Journal of Physics 87, 330 (2019). <https://doi.org/10.1119/1.5096895>Universe 2021, 7(2), 22; <https://doi.org/10.3390/universe7020022>

- *Bachelor thesis.* German David Prada Méndez, Análisis del espectro de emisión proveniente de un toro magnetizado alrededor de singularidades desnudas con deformación cuadrupolar (17.February.2023), Faculty of Physics, Universidad Industrial de Santander, Colombia.
- *Bachelor thesis.* Jennyfer Camila Acevedo Munoz , Análisis numérico de la interacción del sistema agujero negro – campo escalar en un espacio-tiempo dinámico (17.February.2023), Faculty of Physics, Universidad Industrial de Santander, Colombia.
- *Master thesis.* Juan Manuel Velásquez Cadavid, Simulation of the intensity map in magnetically polarized accretion disks around Kerr black holes (13.October.2022), Master of Applied Mathematics, Faculty of Physics, Universidad Industrial de Santander, Colombia.
- *Bachelor thesis.* Cédric Jockel, Modelling of plasma accretion onto black hole mimickers (20.October.2021), Institut für Theoretische Physik, Johann Wolfgang Goethe -Universität Frankfurt am Main, Germany.
- *Bachelor thesis.* Jose Miguel Amado Dugarte, Numerical study of relativistic magnetohydrodynamic laminar currents in a magnetically polarized fluid (21.July.2021), Faculty of Physics, Universidad Industrial de Santander, Colombia.
- *Master thesis.* Jan Röder, Comparison of Kerr and dilaton black hole shadows: Impact of non-thermal emission (13.April.2021), Institut für Theoretische Physik, Johann Wolfgang Goethe -Universität Frankfurt am Main, Germany.
- *Master thesis.* Manuel Eduardo de la Cruz Hernández, Modelling of work surfaces in 1D astrophysical jets at the relativistic strong shock limit (31.June.2019), Institute of Astronomy, UNAM, México.
- *Master thesis.* Alejandro Aguayo Ortiz, A direct Primitive Variable Recovery Scheme for hyperbolic conservative equations (27.Jul.2018), Institute of Astronomy, UNAM, México.

#### **Examiner of Thesis Project:**

- *Bachelor project.* German David Prada Méndez, Análisis del espectro de emisión proveniente de un toro magnetizado alrededor de singularidades desnudas con deformación cuadrupolar (22.August.2022), Faculty of Physics, Universidad Industrial de Santander, Colombia.
- *PhD project.* Gustavo Magallanes Guijón, December 3, 2021, Statistical and computational methods in inference binary black holes, PhD on Astrophysics program of the Institute of Astronomy, UNAM, México.
- *Master project.* Juan Manuel Velásquez Cadavid, Simulation of the intensity map in magnetically polarized accretion disks around Kerr black holes (04.December.2020), Master of Applied Mathematics, Faculty of Physics, Universidad Industrial de Santander, Colombia.

#### **Tutor commettee:**

- *Master.* Donald Emilio Mora (2023), Master on Astrophysics program of the Institute of Astronomy, UNAM, México.
- *PhD.* Alejandro Aguayo Ortiz (2018 –2021), PhD on Astrophysics program of the Institute of Astronomy, UNAM, México.

## **Computer skills**

**Languages:** Fortran, Python, C/C++

**Code Development:** CAFE, BHAC, BHOSS

**High Performance:** OpenMP, MPI, AMR, FMR

**Codes:** Einstein Toolkit, ehtim

## **References**

### **Prof. Dr. Luciano Rezzolla**

✉ [rezzolla@itp.uni-frankfurt.de](mailto:rezzolla@itp.uni-frankfurt.de)

Institut für Theoretische Physik,  
Goethe Universität Frankfurt,  
Max-von-Laue-Str. 1,  
60438 Frankfurt am Main, Germany

### **Prof. Dr. José Antonio Font**

✉ [j.antonio.font@uv.es](mailto:j.antonio.font@uv.es)

Departament d'Astronomia i Astrofísica,  
Universitat de València,  
Edificio de Investigación C/ Dr. Moliner s/n  
46100 Burjassot, València, Spain

### **Prof. Dr. Sergio Mendoza**

✉ [sergio@mendozza.org](mailto:sergio@mendozza.org)

Instituto de Astronomía,  
Universidad Nacional Autónoma de México,  
AP 70-264, Ciudad de México 04510, México.

### **Prof. Dr. Carlos Herdeiro**

✉ [herdeiro@ua.pt](mailto:herdeiro@ua.pt)

Departamento de Matemática,  
Universidade de Aveiro and CIDMA,  
3810-183 Aveiro, Portugal