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Rodrigo Carvajal

Last-year PhD student in Astronomy and Astrophysics at the Instituto de Astrofísica e Ciencias do Espaço (IA), in the University of Lisbon (FCUL). Working on the identification and characterisation of Radio Galaxies and on the implementation of Machine Learning tools to detect and study them in large-area radio surveys.

▬▬▬ Education

Instruction

2019 – 2024   **PhD in Astronomy and Astrophysics**, *Faculdade de Ciências, Universidade de Lisboa*, Lisbon, Portugal
Project: The First Radio Galaxies in the Universe. Supervisors: J. Afonso, I. Matute, H. Messias.

2016 – 2019   **MSc in Astrophysics**, *Pontificia Universidad Católica de Chile*, Santiago, Chile
Thesis: Stacking UV-selected Lyman-Break Galaxies in the ALMA Frontier Fields[1](Maximum distinction).
Supervisor: F. E. Bauer.

2007 – 2014   **Licenciado en Ciencias (BSc equivalent)**, *Universidad de Chile*, Santiago, Chile, *Astronomy (Distinction, no thesis required)*

Prizes and Awards

2019   **PhD::SPACE Fellowship**, *Instituto de Astrofísica e Ciências do Espaço*, Lisbon, Portugal
The Doctoral Network in Space Sciences (PhD::SPACE) is a program funded by the Fundação para a Ciência e a Tecnologia (MEC, Portugal) to support PhD Fellowships in Space Sciences.

2017   **Teaching Assistant Scholarship**, *Pontificia Universidad Católica de Chile*, Santiago, Chile
This scholarship, awarded by the Pontificia Universidad Católica de Chile, grants students full exemption from payment of tuition fees and provides subsistence allowance to students.

2007 – 2010   **Beca Universidad de Chile**, *Universidad de Chile*, Santiago, Chile
Beca Universidad de Chile covers tuition and fee of undergraduate programs for the duration of studies.

▬▬▬ Research Experience

Jan 2019 – Oct 2019   **Research Assistant**, *Institute of Astrophysics, Pontificia Universidad Católica de Chile*, Santiago, Chile
Imaged and analysed ALMA data for project "Hunting for redshifts of faint DSFGs in A2744".

Aug 2015 – Mar 2019   **Research Assistant**, *Institute of Astrophysics, Pontificia Universidad Católica de Chile*, Santiago, Chile
Used image enhancement techniques to improve quality of ALMA observations and study objects with low signal-to-noise ratio. Supervised by Prof. Franz Bauer and Dr. Jorge González.

Jan 2014 – Mar 2015   **Research Assistant**, *Joint ALMA Observatory (JAO)*, Santiago, Chile
Studied Mars' atmosphere and produce profiles for temperature, and wind speed using ALMA observations. Supervised by Dr. Rüdiger Kneissl and Dr. David Rabanus, from JAO.

Aug 2013 – Oct 2013   **Research Assistant**, *Departament of Astronomy, Universidad de Chile*, Santiago, Chile
Studied differences from outer structures of lensing galaxies through absorbed light of far quasars. Supervised by Prof. Sebastián López.

Mar 2013 – May 2013   **Research Assistant**, *Departament of Astronomy, Universidad de Chile*, Santiago, Chile
Searched quasars pairs at small distances over catalogue of more than 100 000 objects (SDSS-DR9 Quasar Catalog. Pâris et al. 2012). Supervised by Dr. Isabelle Pâris.

Mar 2012 – Jul 2012   **Research Assistant**, *Departament of Astronomy, Universidad de Chile*, Santiago, Chile
Confirmed influence of thermal-broadening Doppler parameter in turbulent broadening in Intergalactic Medium. Supervised by Prof. Sebastián López.

May 2012 – Jul 2012   **Research Assistant**, *Departament of Astronomy, Universidad de Chile*, Santiago, Chile
Measured correlation for results of Voigt curve-fitting procedures in metallic species absorption lines from far quasar emission. Supervised by Prof. Sebastián López.

Aug 2011 – Dec 2011   **Research Assistant**, *Departament of Astronomy, Universidad de Chile*, Santiago, Chile
Determined influence of thermal-broadening Doppler parameter in turbulent broadening in Intergalactic Medium. Supervised by Prof. Sebastián López.

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[1]Thesis text available at https://repositorio.uc.cl/handle/11534/22335

Jan 2011 **Research Assistant**, *Departament of Astronomy, Universidad de Chile*, Santiago, Chile
Worked in project "A study of the Molecular Properties of the Vela Molecular Ridge (Coud C)" searching possible clumps using data from Mopra Radio Telescope. Supervised by Dr. Nadia Lo.

▬▬▬ Referred Articles

Carvajal, R., Matute, I., Afonso, J., Norris, R. P., Luken, K. J., Sánchez-Sáez, P., Cunha, P., Humphrey, A., et al. "**Selection of Powerful Radio Galaxies with Machine Learning**". In: *A&A* (2023). Accepted.

Humphrey, A., Cunha, P. A. C., Paulino-Afonso, A., Amarantidis, S., **Carvajal, R.**, Gomes, J. M., Matute, I., and Papaderos, P. "**Improving machine learning-derived photometric redshifts and physical property estimates using unlabelled observations**". In: *MNRAS* 520.1 (Mar. 2023), pp. 305–313. DOI: 10.1093/mnras/stac3596.

Miranda, H., Pappalardo, C., Papaderos, P., Afonso, J., Matute, I., Lobo, C., Paulino-Afonso, A., **Carvajal, R.**, et al. "**An investigation of the star-forming main sequence considering the nebular continuum emission at low-z**". In: *A&A* 669, A16 (Jan. 2023), A16. DOI: 10.1051/0004-6361/202244390.

Carvajal, R., Matute, I., Afonso, J., Amarantidis, S., Barbosa, D., Cunha, P., and Humphrey, A. "**Exploring New Redshift Indicators for Radio-Powerful AGN**". In: *Galaxies* 9.4 (Oct. 2021), p. 86. DOI: 10.3390/galaxies9040086.

Pappalardo, C., Cardoso, L. S. M., M. Gomes, J., Papaderos, P., Afonso, J., Breda, I., Humphrey, A., Scott, T., et al. "**Self-consistent population spectral synthesis with FADO. II. Star formation history of galaxies in spectral synthesis methods**". In: *A&A* 651, A99 (July 2021), A99. DOI: 10.1051/0004-6361/202039792.

Carvajal, R., Bauer, F. E., Bouwens, R. J., Oesch, P. A., González-López, J., Anguita, T., Aravena, M., Demarco, R., et al. "**The ALMA Frontier Fields Survey. V. ALMA Stacking of Lyman-Break Galaxies in Abell 2744, Abell 370, Abell S1063, MACSJ0416.1-2403 and MACSJ1149.5+2223**". In: *A&A* 633, A160 (Jan. 2020), A160. DOI: 10.1051/0004-6361/201936260.

González-López, J., Bauer, F. E., Aravena, M., Laporte, N., Bradley, L., Carrasco, M., **Carvajal, R.**, Demarco, R., et al. "**The ALMA Frontier Fields Survey. III. 1.1 mm emission line identifications in Abell 2744, MACSJ 0416.1-2403, MACSJ 1149.5+2223, Abell 370, and Abell S1063**". In: *A&A* 608, A138 (Dec. 2017), A138. DOI: 10.1051/0004-6361/201730961.

Laporte, N., Bauer, F. E., Troncoso-Iribarren, P., Huang, X., González-López, J., Kim, S., Anguita, T., Aravena, M., et al. "**The ALMA Frontier Fields Survey. II. Multiwavelength Photometric analysis of 1.1 mm continuum sources in Abell 2744, MACSJ0416.1-2403 and MACSJ1149.5+2223**". In: *A&A* 604, A132 (Aug. 2017), A132. DOI: 10.1051/0004-6361/201730628.

González-López, J., Bauer, F. E., Romero-Cañizales, C., Kneissl, R., Villard, E., **Carvajal, R.**, Kim, S., Laporte, N., et al. "**The ALMA Frontier Fields Survey. I. 1.1 mm continuum detections in Abell 2744, MACS J0416.1-2403 and MACS J1149.5+2223**". In: *A&A* 597, A41 (Jan. 2017), A41. DOI: 10.1051/0004-6361/201628806.

▬▬▬ Contributed Talks

Sep 2023 **Ensemble Machine Learning for the selection of radio AGN in multi-survey data**, *XXXIII Encontro Nacional de Astronomia e Astrofísica (ENAA)*, University of Coimbra, Coimbra, Portugal

Nov 2022 **Ensemble Machine Learning for Radio Galaxy detections**, *SPARCS XI. 2022 meeting of the SKA Pathfinders Radio Continuum Surveys (SPARCS)*, IDIA – Inter-university Institute for Data Intensive Astronomy, South Africa

Sep 2022 **Ensemble Machine Learning for the Extraction of High-Redshift Radio Galaxies**, *XXXII Encontro Nacional de Astronomia e Astrofísica (ENAA)*, University of Lisbon, Lisbon, Portugal

Jul 2022 **Searching for High-z Radio Galaxy Detections with Ensemble Machine Learning**, *EMU International Virtual Meeting*, Evolutionary Map of the Universe - Online event

Feb 2022 **Prediction of distant Radio Galaxies candidates with Machine Learning**, *Jornadas Doutorais (Doctoral Day) from the Department of Physics*, Faculty of Sciences - University of Lisbon, Lisbon, Portugal

Feb 2022 **High-redshift Radio Galaxies candidates prediction with ensemble Machine Learning.**, *SAZERAC SIPS: Learning the high-redshift Universe*, online event

Jan 2022 **Prediction of high-redshift Radio Galaxy candidates with ensemble Machine Learning.**, *XVII SOCHIAS Meeting. 2022 meeting of the Chilean Society of Astronomy*, online event, Chile

Nov 2021 **Using ensemble Machine Learning to predict high-redshift Radio Galaxy detections.**, *SPARCS X 2021. 2021 meeting of the SKA Pathfinders Radio Continuum Surveys (SPARCS)*, online event, IDIA – Inter-university Institute for Data Intensive Astronomy. South Africa

Nov 2021 **Obtaining High-redshift Radio Galaxy candidates with Machine Learning**, *Internal Workshop of the Intitute of Astrophysics and Space Sciences (IA-ON8)*, IA - University of Coimbra, Portugal

Oct 2021 **Using a series of Machine Learning Models for the detection of high-redshift Radio Galaxy candidates**, *Debating the potential of Machine Learning in astronomical surveys*, IAP Colloquium, Institut d'Astrophysique de Paris, France

Aug 2021 **Using Machine Learning to identify high-redshift Radio Galaxy candidates**, *50th Young European Radio Astronomers Conference*, online event, IRAM

Mar 2021	**Exploring new redshift indicators for radio-powerful AGNs**, *RGCW: A new window on the radio emission from galaxies, clusters and cosmic web*, online event, Italy
Oct 2020	**Searching for the earliest AGN in the radio sky**, *Internal Workshop of the Intitute of Astrophysics and Space Sciences (IA-ON7)*, online event, Porto, Portugal
Mar 2020	**The first Radio Galaxies in the Universe**, *Jornadas Doutorais (Doctoral Day) from the Department of Physics*, Faculty of Sciences - University of Lisbon, Lisbon, Portugal
Dec 2017	**Stacking in the ALMA Frontier Fields**, *Distant Galaxies from the Far South*, Bariloche, Argentina

Invited Talks or Seminars

Jun 2021	**Developing a ML pipeline to detect high-redshift Radio Galaxy candidates**, *Machine Learning in Astronomy Group – SPARCS*, Western Sydney University. Sydney, Australia
May 2021	**Explaining Machine Learning Models: SHAP**, *IA - Galaxies Machine Learning Club*, Porto, Portugal
Jul 2020	**Stacking UV-selected Lyman-Break Galaxies in the ALMA Frontier Fields**, *Instituto de Astrofísica e Ciências do Espaço*, Lisbon, Portugal
Jun 2019	**Stacking UV-selected Lyman-Break Galaxies in the ALMA Frontier Fields**, *ESO*, Santiago, Chile

Posters

Jul 2023	**Ensemble Machine Learning for the prediction of Radio AGN in multi-survey data**, *Encontro Ciência '23: Encontro com a Ciência e Tecnologia em Portugal*, Aveiro, Portugal
Feb 2023	**Radio Galaxy prediction with multi-survey data and ensemble Machine Learning**, *Coordinated Surveys of the Southern Sky*, ESO, Garching, Germany
Sep 2022	**Searching for Radio Galaxy detections with ensemble Machine Learning**, *VLA Sky Survey in the Multiwavelength Spotlight*, NRAO, Socorro, NM. U.S.A.
May 2022	**Radio Galaxy detection prediction with ensemble Machine Learning**, *International Conference on Machine Learning for Astrophysics - ML4Astro*, Catania, Italy
May 2022	**Finding high-redshift Radio Galaxies with Machine Learning**, *Encontro Ciência '22: Encontro com a Ciência e Tecnologia em Portugal*, Lisbon, Portugal
Sep 2021	**Detection of high-redshift Radio Galaxies using Machine Learning models**, *Encontro Nacional de Astronomia e Astrofísica*, online event, Portugal
Jun 2021	**Using Machine Learning to look for high-redshift Radio Galaxies**, *Encontro Ciência '21: Encontro com a Ciência e Tecnologia em Portugal*, Lisbon, Portugal
Mar 2021	**Exploring new redshift indicators for radio-powerful AGNs**, *A precursor view of the SKA Sky*, online event, The SKA Observatory
Nov 2020	**Mining the radio sky toward the earliest AGN**, *Encontro Ciência '20: Encontro com a Ciência e Tecnologia em Portugal*, Lisbon, Portugal
Sep 2020	**Mining the radio sky toward the earliest AGN**, *Encontro Nacional de Astronomia e Astrofísica*, online event, Portugal
Mar 2015	**Mapping the winds on Mars. Test study (master project) for planetary atmospheric monitoring with ALMA**, *Ground and space observatories: a joint venture to planetary science*, Santiago, Chile

Observation Experience

Nov 2022	**NIKA2 and EMIR instruments**, *30m Pico Veleta Radio Telescope*, IRAM, Spain, One-week observation run under pooled observations scheme.
Feb 2013	**MagE instrument**, *6.5m Magellan-Clay Telescope*, LCO, Chile, One-night observation run under the supervision of Dr. Isabelle Pâris.

Teaching Experience

Mar 2013 – Jul 2013	**Universidad de Chile**, *Teaching Assistant FI1001. Introduction to Newtonian Physics*, Department of Physics, Santiago, Chile. Professor: Sebastián López
Mar 2013 – Jul 2013	**Universidad de Chile**, *Teaching Assistant EI2001. Project Workshop*, School of Engineering, Santiago, Chile. Professor: S. López. Practical course to teach students how to characterize a CCD at the University Observatory.
Mar 2012 – Jul 2012	**Universidad de Chile**, *Teaching Assistant AS3004–AS758. Intergalactic Medium*, Department of Astronomy, Santiago, Chile. Professor: S. López

Student Supervision

Jul 2023 **Instituto de Astrofísica e Ciências do Espaço**, *Co-supervision of Bsc and MSc students' Summer Internships*, Faculdade de Ciências - Universidade de Lisboa, Lisbon, Portugal
With main supervisors (B. Arsioli and I. Matute) we guided five students (L. Rodrigues, G. Monteiro, A. Correia, D. Barreta, and T. Melo) on project "Multifrequency Analysis and Machine Learning for the most powerful quasars in the Universe".

Sep 2022 – **Universidade de Lisboa**, *Co-supervision of BSc student*, Faculdade de Ciências, Lisbon, Portugal
Feb 2023 Helped main supervisor (I. Matute) guiding J. Bagagem on project "Connecting galaxies photometry with Super-Massive Black Hole (SMBH) properties: A machine learning approach".

Sep 2021 – **Universidade de Lisboa**, *Co-supervision of BSc student*, Faculdade de Ciências, Lisbon, Portugal
Feb 2022 Helped main supervisor (I. Matute) guiding J. Lopes on project "Modelling Active Galactic Nuclei with Machine Learning".

Sep 2021 – **Universidade de Lisboa**, *Co-supervision of BSc student*, Faculdade de Ciências, Lisbon, Portugal
Jan 2022 Helped main supervisor (I. Matute) guiding B. Resendes on project "Identifying and characterizing AGN in next-generation radio surveys with machine learning".

Jul 2021 **Instituto de Astrofísica e Ciências do Espaço**, *Co-supervision of students' Summer Internships*, Faculdade de Ciências - Universidade de Lisboa, Lisbon, Portugal
Helped main supervisor (I. Matute) guiding four students (J. Sandrin, P. Ferreira, P. Rodrigues, and A. Monteiro) on project "Identifying and characterizing AGN in next-generation radio surveys using machine and deep learning".

Jul 2021 **Instituto de Astrofísica e Ciências do Espaço**, *Co-supervision of students' Summer Internships*, Faculdade de Ciências - Universidade de Lisboa, Lisbon, Portugal
Helped supervisor (J. Afonso) guiding four students (A. Labib, M. E. Pimentel, L. Barroso, and J. Rato) on project "The 200: exploring the most active supermassive black holes in the first Gyr of the Universe".

Sep 2020 – **Universidade de Lisboa**, *Co-supervision of BSc student*, Faculdade de Ciências, Lisbon, Portugal
Feb 2021 Helped main supervisor (I. Matute) guiding I. Tiago on project "Understanding triggering Radio emission from AGNs (Machine Learning)".

Jul 2020 **Universidade de Lisboa**, *Co-supervision of BSc student*, Faculdade de Ciências, Lisbon, Portugal
Helped the main supervisor (J. Afonso) guiding L. Piscarreta on studying radio and X-ray emission of high-redshift AGN.

Outreach

Aug 2023 **IX Escuela Ecuatoriana de Astronomía y Astrofísica**, *(IX Ecuadorian School of Astronomy and Astrophysics)*, Quito, Ecuador
Prepare and present one of the lectures, titled "Looking for galaxies in a Universe of data".

Oct 2021 **Festival Internacional de Ciência (FICA)**, Oeiras, Lisbon, Portugal
Answer questions about observatories in the stand of the Instituto de Astrofísica e Ciencias do Espaço.

Working Experience

2013 – **Tourist guide**, *Observatorio Astronómico Andino (OAA)*, Santiago, Chile
2019 Guide visitors through observatory. Showing them main features of night sky and answering questions on Astronomy and Astrophysics. Work done in Spanish and English.

Attendance to Meetings, Conferences, Schools, or Workshops

May 2022 **18th Synthesis Imaging Workshop**, National Radio Astronomy Observatory. Socorro, NM. U.S.A.

Apr-May **SKilled, Innovative & Entrepreneurial Scientists**, Instituto de Astrofísica e Ciências do Espaço. Coimbra,
2022 Portugal

Feb 2022 **SKA regional centre training event. Hands-on Containerization**, Science User Engagement (SUE) group of the SKA Regional Centre Steering Commitee

Dec 2021 **Cosmology in the Radio Sky: Prospects and Challenges in the Square Kilometre Array Observatory era**, Instituto de Astrofísica e Ciências do Espaço

Dec 2020 **Machine Learning in Science & Engineering**, Columbia University - Data Science Institute

Dec 2020 **SOCHIAS (Chilean Society of Astronomy) annual meeting**, Pucón, Chile

Nov 2020 **Exploiting Archives for Radio Astronomy in the SKA-era**, Lisbon, Portugal

Jun 2020 **European Astronomical Society Annual Meeting**, Leiden, Netherlands

Mar 2019 **ALMA Community Day (Cycle 7 Proposing Workshop)**, *ALMA Joint Observatory (JAO)*, Santiago, Chile

Jan 2011 **SOCHIAS (Chilean Society of Astronomy) annual meeting**, Santiago, Chile

Participation in Projects

Jan 2022 – Jun 2023 **Finding Lyman-alpha emitters through machine learning (Encontrando emissores de Lyman-alpha através de aprendizagem máquina)**, *PTCRIS: EXPL/FIS-AST/1085/2021*, Funding: Fundação para a Ciência e a Tecnologia, Portugal, P.I. A. Paulino-Afonso

Memberships

Evolutionary Map of the Universe (EMU)

Square Kilometre Array Observatory (SKAO), *Extragalactic Continuum Science Working Group*

SKA Pathfinders Radio Continuum Surveys Working Group (SPARCS)

Service

Jul 2022 **Chair of KS8 session**, *EMU International Virtual Meeting*, Evolutionary Map of the Universe - Online event

Sep 2022 – Jul 2023 **Co-organiser Journal Club discussions**, *Galaxies Research Group*, Instituto de Astrofísica e Ciencias do Espaço, Weekly meetings to discuss relevant articles and topics.

Languages

Spanish Native speaker.

Portuguese Basic knowledge.

English IELTS Academic 7.5 (Good User).

Programming Languages

Python – Intermediate level

C – Intermediate level

Java – Intermediate level.

Matlab – Intermediate level

LaTeX – Intermediate level

Mathematica – Basic level

Bash – Basic level

Software Skills

- Common Astronomy Software Application (CASA)
- Tool for operations on catalogues and tables (TOPCAT)
- Gnuplot
- ESO-MIDAS
- Image Reduction and Analysis Facility (IRAF)
- The Atmospheric Radiative Transfer Simulator (ARTS)
- SAOImage DS9
- EsoRex

Last update: September, 2023.