

# Carlos Alberto Gomez Gonzalez

Research chair in Data Science for Earth, Space and Environmental Sciences

I am a research data scientist with a background in Computer Vision and Astrophysical image processing. During my thesis, I developed novel algorithms for the task of exoplanet direct detection, pioneering the application deep learning to the field of high-contrast imaging. Nowadays, my work focuses on the development of Artificial Intelligence techniques for the exploitation of multidimensional datasets, such as those found in Astrophysics and Remote Sensing for Earth observation. Following my interest in open research practices, I develop open-source scientific software for use in data-intensive science and conduct data challenges to foster multi and crossdisciplinary research. I have a profound interest in the application of Artificial Intelligence for tackling humanity's biggest challenges and developing effective solutions at the interface between academia and entrepreneurship.

## Personal details

Citizenship: Colombian  
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## Education

**PhD in Computer Vision and Astrophysics** 2013-2017  
*STAR and Montefiore Institutes, Université de Liège, Belgium*  
Supervisors: Jean Surdej, Marc Van Droogenbroeck, Olivier Absil  
Thesis: Advanced data processing for high-contrast imaging – pushing exoplanet direct detection limits with Machine Learning

**MSc in Astrophysics** 2012-2013  
Universidad Autónoma de Madrid and Universidad Complutense, Spain

**Specialization in Software Development** 2011-2012  
Universidad del Magdalena, Colombia

**BSc in Astronomy and Astrophysics** 2002-2007  
VV Sobolev Astronomical Institute, St. Petersburg State University, Russia

## Experience

**Research chair in Data Science** 2017-Present  
Grenoble Alpes Data Institute, Université Grenoble Alpes, France

**Data science consultant** March 2017  
Science to Data Science program, Pivigo Ltd

**Technician in Geographic Information Systems** 2011-2012  
IGAC – Agustín Codazzi Geographical Institute, Santa Marta, Colombia

**Scientific advisor at Planetarium of Medellín** 2009-2010  
Planetarium “Jesus Emilio Ramírez González”, Medellín, Colombia

**Junior researcher and lecturer for introductory Physics** 2009-2010  
Technological University ITM, Medellín, Colombia

## Mentoring

**Supervisor of master thesis on image processing and ML** 2019-Present  
*Institut de Planétologie et d'Astrophysique de Grenoble, Université Grenoble Alpes*

Student: Corentin Doco

**Co-supervisor of master thesis on image processing and ML** 2018-2019  
*Institut de Planétologie et d'Astrophysique de Grenoble, Université Grenoble Alpes*  
Student: Ralf Farkas

**Co-supervisor of master thesis on image processing** 2014-2015  
*Institute of Information and Communication Technologies, Catholic University of Louvain*  
Student: Benoit Pairet

## Outreach

2018 Instructor for a Software Carpentry workshop at the Université Grenoble Alpes  
2018 Co-organizer of the Python for science and data analysis in Grenoble group  
2009 Public outreach at the Planetarium of Medellín, Colombia

## Honors and awards

**1st Prize at the InvEnterPrize competition with “Amigrow” farming** March 2019  
Aberystwyth University, Wales, United Kingdom

**Grant for project “Exoplanet direct imaging meets AI” (14 k€)** 2018-2019  
Grenoble Alpes Data Institute, France

**1st Prize at the Phi-week startup bootcamp as part of the team “Amigrow”** November 2018  
European Space Agency, Earth Observation Phi-Week

**PyData Amsterdam - diversity scholarship** April 2017  
Numfocus

**PhD Scholarship under ARC grant for Concerted Research Action** 2013-2017  
Université de Liège, Belgium

**Scholarship for master studies in Astrophysics** 2012-2013  
CSIC International Campus of Excellence & Universidad Autónoma de Madrid

**Scholarship for studies in Astronomy** 2001-2007  
ICETEX (Colombia) & Government of the Russian Federation

## Skills

### Data analysis and machine learning:

- Statistics, Monte Carlo methods, data cleansing, feature selection and problem formulation.
- Computer Vision, Natural Language Processing and Deep Learning (artificial neural networks).
- Machine Learning: supervised (regression and classification) and unsupervised (clustering, density estimation, dimensionality reduction and low-rank modeling).

### Scientific computing and software development:

- Six years of software development experience with Python.
- Large experience with Python scientific libraries: Numpy, Scipy, Pandas, Jupyter(lab), Astropy, Scikit-image, OpenCV, emcee, Dask, Matplotlib, Bokeh and Seaborn.
- Experience with ML/DL libraries: Scikit-learn, Keras, Tensorflow, Pytorch, H2O and Cupy.
- Experience in open-source collaborative development and version control with Git/[GitHub](#):
  - Author and lead developer of the open-source VIP Python package for astronomical high-contrast imaging. [GitHub repository](#).
  - Author of the open-source HCIplot Python package for plotting multidimensional high-contrast imaging datacubes. [GitHub repository](#).
  - Author of the SODINN Python package for deep learning applied to supervised source detection in high-contrast imaging. [GitHub repository](#).
  - Contributor to the PyAstrOFit package for planet orbit fitting using MCMC. [GitHub repository](#).

- Documentation and tutorials generation with Sphinx, readthedocs and Jupyter notebooks.
- Continuous integration with Travis CI and automated testing with pytest.
- Experience with NLP libraries: NLTK and Spacy.
- Experience with GIS platforms: ArcGIS and QGIS.
- Large experience with bash (Unix-based systems) and  $\text{\LaTeX}$ .
- Basic knowledge of R, SQL, C, Fortran, Java, Octave/Matlab and HTML.

## Languages

Spanish	Native
English	Advanced reading (C1), speaking (C1) and writing (C1)
Russian	Advanced reading (C1), intermediate speaking (B1) and writing (B1)
French	Intermediate reading (B2), basic speaking (B1) and writing (A2)

## Conferences, workshops and summer schools

Most of my talks are showcased on my [personal website](#) and my [Speaker deck](#) profile.

### Invited talks:

- *Academic data science: reflections and lessons learned*, June 2019, Global Challenges Science Week, Grenoble, France.
- *Exoplanet imaging data challenge*, June 2019, Global Challenges Science Week, Grenoble, France.
- *A data scientist's guide to direct imaging of exoplanets*, February 2019, RADA Big data workshop, Medellin, Colombia.
- *Supervised detection of exoplanets with deep neural networks*, August 2018, Université de Liège - Colonster castle, Liège, Belgium.
- *Review of mainstream post-processing techniques for high-contrast imaging*, August 2018, Université de Liège - Colonster castle, Liège, Belgium.
- *Exoplanet direct imaging data challenge*, April 2018, Paris-Saclay center for data science, Palaiseau, France.
- *Data science in astronomical image processing: looking for exoplanets using supervised machine learning*, March 2018, Data Science in the Alps, Grenoble, France.
- *High-contrast imaging post-processing methods for exoplanet detection and characterization*, February 2018, Seminar Thoth team, INRIA Grenoble - Rhône-Alpes, France.
- *Post-processing for high-contrast imaging*, August 2016, Keck Institute for Space Studies (KISS) workshop on Direct Imaging of exoplanets, Caltech, US.
- *Applications of PCA and low-rank plus sparse decompositions in high-contrast Exoplanet imaging*, February 2016, Seminar ICTeam, Catholic University of Louvain, Belgium.

### Contributed talks:

- *Deep (learning) dive on SPHERE/IRDIS image processing*, October 2018, Centrum Wiskunde & Informatica, Amsterdam, Netherlands.
- *A la caza de exoplanetas por imagen directa con Python: De la ciencia de datos, la exoplanetología y otros demonios*, October 2018, PyconES, Málaga, Spain.
- *Exoplanet direct imaging meets data science*, June 2018, NASA ARC Space Science and Astrobiology Division Seminar Series, Silicon Valley, US.
- *Exoplanet direct imaging meets data science*, June 2018, Kavli Institute for Particle Astrophysics and Cosmology, Stanford, US.
- *Data science for direct imaging of exoplanets. Machine learning applied to high-contrast imaging*, April 2018, European Week of Astronomy and Space Science, Liverpool, UK.
- *Chasing exoplanets with Python and Machine Learning*, March 2018, PySciDataGre launch event, Grenoble, France.

- *Academic data science: conducting research at the interface of different disciplines*, February 2018, Data club seminar, Université Grenoble Alpes, France.
- *Supervised detection of exoplanets through high-contrast imaging*, August 2017, Workshop on Image processing for high-contrast imaging, Université de Liège, Belgium.
- *Deep machine learning for astronomical image processing and signal detection*, July 2017, Seminar IPAG, Université Grenoble Alpes, France.
- *Image-processing for high-contrast imaging. Beyond the black-box*, January 2017, Seminar, ETH Zurich, Switzerland.
- *Angular and reference star differential imaging post-processing with VIP*, August 2016, First Vortex international workshop, Caltech, US.
- *Beyond PCA, Low-rank plus Sparse decomposition of high-contrast ADI image sequences for exoplanet detection*, June 2015, In the Spirit of Lyot conference, Montreal, Canada.
- *Vortex Image Processing package tutorial*, May 2015, Adaptive optics data processing workshop, Laboratoire d'Astrophysique de Marseille (LAM), France.

### Lightning talks:

- VIP & SODINN – *Image/data processing for exoplanets direct imaging*, June 2018, SPHERE upgrades workshop, Grenoble, France.
- VIP & SODINN – *Image/data processing for exoplanets direct imaging*, May 2018, Python in Astronomy, New York, US.
- *Post-processing for high-contrast imaging*, August 2016, Keck Institute for Space Studies (KISS) workshop on direct imaging of exoplanets, Caltech, US.

### Posters:

- VIP – *Vortex Image Processing package*, October 2016, Astrominformatics IAU symposium, Italy.
- VIP – *Vortex Image Processing package*, May 2016, Resolving planet formation in the era of ALMA and extreme adaptive optics, ESO, Chile.
- *Python based pipeline for post-processing in astronomical high-contrast imaging*, July 2014, SciPy Conference 2014, Austin, US.

### Other attended events:

- ESA Living Planet Symposium, May 2019, Milan, Italy.
- ESA Earth observation Phi-week, November 2018, Frascati, Italy.
- PRAIRIE Artificial Intelligence Summer School, July 2018, Grenoble, France.
- Combining high-resolution spectroscopy and high-contrast imaging, June 2018, Pasadena, US.
- NUMEDIART Deep Learning workshop, May 2017, Mons, Belgium.
- PyData Amsterdam, April 2017, Netherlands.
- PyData Berlin, May 2016, Germany.
- ONERA high-contrast imaging workshop, January 2015, Chatillon, France.
- Sagan Exoplanet Summer Workshop, July 2014, Pasadena, US.
- 5th Subaru International Conference – Exoplanets and disks, December 2013, Hawaii, US.

## Publications

### Refereed:

- [1] **C. A. Gomez Gonzalez**, D. Mouillet, and O. Absil. SODINN framework for deep learning applied to supervised exoplanet direct detection in high-contrast imaging. *in prep.*, 2019.
- [2] G. Ruane, H. Ngo, D. Mawet, et al. Reference Star Differential Imaging of Close-in Companions and Circumstellar Disks with the NIRC2 Vortex Coronagraph at the W. M. Keck Observatory. *Astronomical Journal*, 157:118, Mar 2019.
- [3] A. M. Lagrange, A. Boccaletti, M. Langlois, et al. Post-conjunction detection of  $\beta$  Pictoris b with VLT/SPHERE. *Astronomy and Astrophysics*, 621:L8, Jan 2019.
- [4] D. Mawet, L. Hirsch, E. J. Lee, et al. Deep Exploration of  $\epsilon$  Eridani with Keck Ms-band Vortex Coronagraphy and Radial Velocities: Mass and Orbital Parameters of the Giant Exoplanet. *Astronomical Journal*, 157:33, Jan 2019.
- [5] B. Pairet, F. Cantalloube, **C. A. Gomez Gonzalez**, O. Absil, and L. Jacques. STIM map: detection map for exoplanets imaging beyond asymptotic Gaussian residual speckle noise. *ArXiv e-prints*, October 2018.
- [6] W. Jerry Xuan, Dimitri Mawet, Henry Ngo, et al. Characterizing the Performance of the NIRC2 Vortex Coronagraph at W. M. Keck Observatory. *Astronomical Journal*, 156:156, Oct 2018.
- [7] V. Christiaens, S. Casassus, O. Absil, et al. Characterization of low-mass companion HD 142527 B. *Astronomy and Astrophysics*, 617:A37, Sep 2018.
- [8] **C. A. Gomez Gonzalez**, O. Absil, and M. van Droogenbroeck. Supervised detection of exoplanets in high-contrast imaging sequences. *Astronomy and Astrophysics*, 613:A71, May 2018.
- [9] M. Reggiani, V. Christiaens, O. Absil, et al. Discovery of a point-like source and a third spiral arm in the transition disk around the Herbig Ae star MWC 758. *Astronomy and Astrophysics*, 611:A74, Mar 2018.
- [10] G. Ruane, D. Mawet, J. Kastner, et al. Deep Imaging Search for Planets Forming in the TW Hya Protoplanetary Disk with the Keck/NIRC2 Vortex Coronagraph. *Astronomical Journal*, 154:73, August 2017.
- [11] R. Jensen-Clem, D. Mawet, **C. A. Gomez Gonzalez**, et al. A New Standard for Assessing the Performance of High Contrast Imaging Systems. *Astronomical Journal*, 155:19, Jan 2018.
- [12] **C. A. Gomez Gonzalez**, O. Wertz, O. Absil, et al. VIP: Vortex Image Processing Package for High-contrast Direct Imaging. *Astronomical Journal*, 154:7, July 2017.
- [13] Z. Wahhaj, J. Milli, G. Kennedy, et al. The SHARDDS survey: First resolved image of the HD 114082 debris disk in the Lower Centaurus Crux with SPHERE. *Astronomy and Astrophysics*, 596:L4, November 2016.
- [14] É. Choquet, J. Milli, Z. Wahhaj, et al. First Scattered-light Images of the Gas-rich Debris Disk around 49 Ceti. *Astrophysical Journal, Letters*, 834:L12, January 2017.
- [15] V. Christiaens, S. Casassus, O. Absil, et al. Characterization of the low-mass companion HD 142527 B. *Under review, submitted to A&A*.
- [16] J. Milli, P. Hibon, V. Christiaens, et al. Discovery of a low-mass companion inside the debris ring surrounding the F5V star HD 206893. *Astronomy and Astrophysics*, 597:L2, January 2017.
- [17] E. Serabyn, E. Huby, K. Matthews, et al. The W. M. Keck Observatory Infrared Vortex Coronagraph and a First Image of HIP 79124 B. *Astronomical Journal*, 153:43, January 2017.
- [18] D. Mawet, É. Choquet, O. Absil, et al. Characterization of the Inner Disk around HD 141569 A from Keck/NIRC2 L-Band Vortex Coronagraphy. *Astronomical Journal*, 153:44, January 2017.
- [19] O. Wertz, O. Absil, **C. A. Gomez Gonzalez**, et al. VLT/SPHERE robust astrometry of the HR8799 planets at milliarcsecond-level accuracy. Orbital architecture analysis with PyAstrOFit. *Astronomy and Astrophysics*, 598:A83, February 2017.

- [20] **C. A. Gomez Gonzalez**, O. Absil, P.-A. Absil, et al. Low-rank plus sparse decomposition for exoplanet detection in direct-imaging ADI sequences. The LLSG algorithm. *Astronomy and Astrophysics*, 589:A54, April 2016.
- [21] F. Cantalloube, D. Mouillet, L. M. Mugnier, et al. Direct exoplanet detection and characterization using the ANDROMEDA method: Performance on VLT/NaCo data. *Astronomy and Astrophysics*, 582:A89, October 2015.
- [22] V. A. Hagen-Thorn, N. V. Efimova, V. M. Larionov, et al. Color variations of the blazar 3C 454.3 in 2004-2006. *Astronomy Reports*, 53:510–518, June 2009.
- [23] C. M. Raiteri, M. Villata, V. M. Larionov, et al. WEBT and XMM-Newton observations of 3C 454.3 during the post-outburst phase. Detection of the little and big blue bumps. *Astronomy and Astrophysics*, 473:819–827, October 2007.

#### Non Refereed:

- [1] O. Absil, D. Mawet, M. Karlsson, et al. Three years of harvest with the vector vortex coronagraph in the thermal infrared, in *Ground-based and Airborne Instrumentation for Astronomy VI*, vol. 9908 of *Proceedings of the International Society for Optical Engineering*, Aug. 2016, p. 99080Q.
- [2] B. Femenía Castellá, E. Serabyn, D. Mawet, et al. Commissioning and first light results of an L'-band vortex coronagraph with the Keck II adaptive optics NIRC2 science instrument, *Adaptive Optics Systems V*, 2016.
- [3] B. Pairet, L. Jacques, **C. A. Gomez Gonzalez**, et al. Low Rank and Group-Average Sparsity Driven Convex Optimization for Direct Exoplanets Imaging, in *Third international Traveling Workshop on Interactions between Sparse models and Technology*, 2016.
- [4] D. Defrère, O. Absil, P. Hinz, et al. L'-band AGPM vector vortex coronagraph's first light on LBT/LMIRCam, in *Adaptive Optics Systems IV*, vol. 9148 of *Proceedings of the International Society for Optical Engineering*, July 2014, p. 91483X.