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Mining the kinematics of discs to hunt for planets in formation

Izquierdo Cartagena, A.F.

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Publications

First-author publications

Refereed

The Disc Miner. II. Revealing gas substructures and kinematic signatures from planet-disc interaction through line profile analysis
Izquierdo, A. F., Testi, L., Facchini, S., Rosotti, G. P., van Dishoeck, E. F., Wölfer, L. and Paneque-Carreño, T., 2023, A&A, 674, A113.

A new planet candidate detected in a dust gap of the disk around HD 163296 through localized kinematic signatures: An observational validation of the DISCMINER
Izquierdo, A. F., Facchini, S., Rosotti, G. P., van Dishoeck, E. F. and Testi, L., 2022, ApJ, 928, 2.

The Disc Miner. I. A statistical framework to detect and quantify kinematical perturbations driven by young planets in discs
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The Cloud Factory II: gravoturbulent kinematics of resolved molecular clouds in a galactic potential
Izquierdo, A. F., Smith, R. J., Glover, S. C. O., Klessen, R. S., Treß, R. G., Sormani, M. C., Clark, P. C., Duarte-Cabral, A., Zucker, C., 2021, MNRAS, 500, 4.

Radiative transfer modelling of W33A MM1: 3D structure and dynamics of a complex massive star-forming region
Izquierdo, A. F., Galván-Madrid, R., Maud, L. T., Hoare, M. G., Johnston, K., Keto, E. R., Zhang, Q., de Wit, W. J., 2018, MNRAS, 478, 2.

To be submitted

exoALMA III. Line profile tomography of protoplanetary discs
Izquierdo, A. F. and the exoALMA collaboration, in preparation.

Co-author publications

High turbulence in the IM Lup protoplanetary disk. Direct observational constraints from CN and C_2H emission
Paneque-Carreño, T., **Izquierdo, A. F.**, Teague, R., Miotello, A., Bergin, E., Loomis, R. and van Dishoeck, E. F., 2023, A&A, in press.

MagAO-X and HST High-contrast imaging of the AS 209 Disk at Hα
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Kinematics and brightness temperatures of transition discs. A survey of gas substructures as seen with ALMA
Wölfer, L., Facchini, S., van der Marel, N., van Dishoeck, E. F., Benisty, M., Bohn, A. J., Francis, L., **Izquierdo, A. F.** and Teague, R. D., 2023, A&A, 670, A154.

Directly tracing the vertical stratification of molecules in protoplanetary disks
Paneque-Carreño, T., Miotello, A., van Dishoeck, E., Tabone, B., **Izquierdo, A. F.** and Facchini, S., 2023, A&A, 669, A126.

Vertically extended and asymmetric CN emission in the Elias 2-27 protoplanetary disk
Paneque-Carreño, T., Miotello, A., van Dishoeck, E. F., Pérez, L. M., Facchini, S., **Izquierdo, A. F.**, Tychoniec, L. and Testi, L., 2022, A&A, 666, A168.

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Zooming into the collimation zone in a massive protostellar jet
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The Cloud Factory I: Generating resolved filamentary molecular clouds from galactic-scale forces
Smith, R. J., Treß, R. G., Sormani, M. C., Glover, S. C. O., Klessen, R. S., Clark, P. C., **Izquierdo, A. F.**, Duarte-Cabral, A. and Zucker, C., 2020, MNRAS, 492, 2.

On the effects of self-obscuration in the (sub)millimeter spectral indices and the appearance of protostellar disks
Galván-Madrid, R., Liu, H. B., **Izquierdo, A. F.**, Miotello, A., Zhao, B., Carrasco-González, C., Lizano, S. and Rodríguez, L. F., 2018, ApJ, 868, 39.

Curriculum Vitae

I was born on January 19th in Palmira, an agricultural city near the Pacific coast in western Colombia, to Carlos Izquierdo and Damaris Cartagena, and raised alongside my younger sister, Camila. Most of my early education took place at the all-through school *Colegio Agustiniano* in the same city, where I developed a passion for maths and problem-solving. This love for numbers led me to participate in regional math Olympiads, earning me local government scholarships to enroll in foundational math courses at the University of Valle in the neighboring city of Cali. During that period, I believed my future would revolve around the study of mathematics as a pure discipline. However, due to enlightening conversations with friends involved in science, my interest began to lean towards something more applied, and I would thus aim my college applications at programs in physics and astronomy at various national universities.

At the age of 16, I accepted one of the college offers and embarked on my bachelor's studies in Astronomy at the University of Antioquia in Medellin. It was clear that the mathematical aspect I had initially yearned for was prominently incorporated into the curriculum of the program, but I anyway quickly developed a fascination for the study of celestial bodies and the physical theories behind the functioning of galaxies, stars, and planets. This newfound interest was largely thanks to the guidance of wonderful professors and mentors who introduced me to the pleasure of grasping the complexities of the natural world, or at least a small fraction of it. In this phase I also discovered an immense passion for coding in my programming courses. Bridging the theoretical knowledge acquired in other classes for the sake of analysing physical and astronomical data with numerical methods made me particularly excited. In parallel, I also explored more empirical work as a research associate on a project focused on developing an optical vortex coronagraph within the university's Optics and Photonics group, but it was computational science where my heart and brain would truly rejoice.

Another significant aspect that shaped my career from an early stage was international collaboration. My first experience abroad took me to a summer school in 2015 at the Institute of Radioastronomy and Astrophysics (IRyA) in Mexico. During this program, I engaged in a project led by Dr. Roberto Galván-Madrid, with the goal of revealing the three-dimensional structure and dynamics of a massive star-forming region, observed with ALMA, through radiative transfer modelling,

marking the beginning of a long-lasting scientific network and friendship which endures to this day. Following that, in 2016, I had the privilege of participating in the LEAPS summer school program at the Leiden Observatory, where I continued my work on radiative transfer modelling under the guidance of Dr. Luke Maud. Both of these experiences further fueled my passion for astronomical research and ultimately led to the publication of my first scientific article while I was completing my bachelor's studies.

My journey in astronomy continued with a one-year master's degree at the University of Manchester, under the wise supervision of Dr. Rowan Smith. It was an intense year, far from home and filled with mixed emotions, but it was also a period of huge personal growth and excitement as I embarked on full-time research for the first time. During this phase, I shifted my focus to studying much larger celestial objects, although still closely related to the process of star formation. The aim of this project was to determine the relative influence of supernovae and gravitational forces in shaping the dynamics and evolution of the dense and cold regions of the interstellar medium where stars are born. I achieved this by performing statistical analyses of the observable kinematic structure of molecular clouds extracted from numerical simulations of our Galaxy.

Moving forward to my Ph.D. studies, in the fall of 2019, I was exceptionally fortunate to have been accepted for a position jointly offered by Prof. dr. Leonardo Testi and Prof. dr. Ewine van Dishoeck, to work at both the European Southern Observatory in Germany and the Leiden Observatory. Initially, my main project consisted of modelling the radiation transport of protoplanetary discs based on hydrodynamical simulations, but the focus gradually shifted to exploring the kinematics of these discs and developing the methodologies for young-planet detection presented in this thesis. All of this became possible thanks to the inspiring guidance of Leonardo and Ewine, along with close collaboration with Dr. Stefano Facchini and Dr. Giovanni Rosotti.

My next stop is Gainesville in the United States, where I will assume a position as a NASA Sagan Fellow at the University of Florida. My goal there is to enhance and streamline the identification of crucial observables resulting from planet-disc interaction and the influence of non-planetary mechanisms on disc structure and dynamics, setting the stage for a significant shift in the way we study the impact and presence of planets in their formation environment.

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These four years have marked one of the most thrilling stages of my life, filled with wonderful people who have inspired my entire being. The list is ample, and so are my feelings, but space is limited, so this is just a brief note to acknowledge some of them in a few lines.

Leonardo, you carefully guided me on a topic that was broadly new to me, you were patient, and from a certain point, you pushed me when necessary. Thank you for tirelessly trying to bring out the best in me and for being an endless source of ideas; none of this would have been possible without your vast vision. Ewine, you always managed to carve out quality time to help me improve – I can't thank you enough. I could even feel renewed every time we met to discuss about science and life-related matters; you always seemed to have the right words at precisely the right moments. Thanks for pushing me to always aim high.

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My time in Garching was largely framed by a historical pandemic that continues to leave its mark to this day. I extend my gratitude to Anna, Carlo, my fellow students, and the ESO staff for their persistence in keeping all kinds of discussions alive and for collectively making the situation more manageable. Pietro and Cristiano, collaborating with you and enjoying your friendship has been a fantastic experience. I'm thankful for your warmth and kindness every time we met. Dominika, thanks for your continuous transfer of positive energy; you always had time to talk, despite paper and proposal deadlines. Teresa, Lisa, and Joe, thanks for your lovely friendship and for being the first to play with DISCMINER when it was anything but user-friendly; I'm not sure if it's reached that point yet, but it's certainly improved a lot thanks to your input. To all those who joined later – Aashish, Alice, Enrique, Giulio, Luca, Łukasz, Nicolás, Rik, Sierra, Victor – thank you for also being part of this journey.

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Big thanks also to all external colleagues who have contributed in multiple ways to broadening my scientific horizon during this stage of my career: Roberto, Rowan, Myriam, Daniele, Andrew, Jaehan, Maria, Richard, Marcelo, Christophe, Daniel, Tom, Giuseppe, Elena, Luna, and to the exoALMA collaboration in general.

To my dear families Izquierdo Coronado and Cartagena Guerrero, thank you immensely for all the love that you have given me in so many ways and flavours. Madre, your tenacity and courage have helped me conquer many fears, for which I'm filled with gratitude. Padre, thanks for instilling in me the idea that regardless of the size of the task, I should always give it my all and a bit more. Thank you both for unwaveringly supporting our dreams despite adversity. Hermanita, thank you for bringing smiles to my face so easily and for sharing your knowledge and care about society with me; it helps me stay grounded.

Laila, you have witnessed my ups and downs more closely than anyone else during these years, and you have always extended your hand. You have been my greatest support and companion through both the sweetest and most arduous of adventures. Thank you! I am incredibly fortunate to have you!

Every second of this journey has been worth it, including the sleepless nights spent grappling with the challenges of doing science, or at least attempting to. In fact, I feel privileged and humbled that these were the type of challenges that kept me busy during this time. I come from a part of the world where, alas, as in several others, the puzzles that a great many people try to solve have more to do with surviving day-to-day life than with deciphering how a tiny part of the universe works. I carry you all in my thoughts, and I hope that my life can one day be an inspiration for all who dream of and strive for a better future.