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Ingredients of the planet-formation puzzle: Gas substructures and kinematics in transition discs

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Publications

First-author publications

Refereed

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., Teague, R., 2023, *Astronomy & Astrophysics*, 670, A154.

A highly non-Keplerian protoplanetary disc. Spiral structure in the gas disc of CQ Tau.

Wölfer, L., Facchini, S., Kurtovic, N. T., Teague, R., van Dishoeck, E. F., Benisty, M., Ercolano, B., Lodato, G., Miotello, A., Rosotti, G., Testi, L., Ubeira Gabellini, M. G., 2021, *Astronomy & Astrophysics*, 648, A19.

Radiation-hydrodynamical models of X-ray photoevaporation in carbon-depleted circumstellar discs

Wölfer, L., Picogna, G., Ercolano, B., van Dishoeck, E. F., 2019, *Monthly Notices of the Royal Astronomical Society*, 490, 5596.

Submitted

Spirals and meridional flows in the planet-forming disc around HD 100546. A multi-line study of its gas kinematics.

Wölfer, L., Izquierdo, A. F., Booth, A., Facchini, S., van Dishoeck, E. F., Paneque-Carreño, T., Dent, B., submitted to *Astronomy & Astrophysics*.

Co-author publications

Refereed

Probing inner and outer disk misalignments in transition disks. Constraints from VLTI/GRAVITY and ALMA observations.

Bohn, A. J., Benisty, M., Perraut, K., van der Marel, N., **Wölfer, L.**, van Dishoeck, E. F., Facchini, S., Manara, C. F., Teague, R., Francis, L., Berger, J. P., Garcia-Lopez, R., Ginski, C., Henning, T., Kenworthy, M., Kraus, S., Ménard, F., Mérand, A., Pérez, L. M., 2022, *Astronomy & Astrophysics*, 658, A183.

Submitted

The Disc Miner II: Revealing gas substructure and kinematic signatures of planet-disc interaction through line profile analysis.

Izquierdo, A. F., Testi, L., Facchini, S., Rosotti, G. P., van Dishoeck, E. F., **Wölfer, L.**, Paneque-Carreño, T., submitted to *Astronomy & Astrophysics*.

It is our choices, that show what we truly are, far more than our abilities.

Dumbledore, Harry Potter and the Chamber of Secrets

Curriculum Vitae

I was born on August 1st 1993 to Annette Schneider and Wilhelm Wölfer in Münster, a city located deep in the west of Germany and known for both its rainy weather and an immense amount of bicycles. While indeed 1.7 bikes come per person, Münster does not live up to its reputation of being particularly rainy⁴ but in fact represents a rather average German city in that regard. Being born on a Sunday, I was told that I was a child of good fortune and I can say that I was at least lucky enough to grow up with two wonderful sisters: Helen, who is two years younger and Anne who is eight years younger than me. As the oldest sibling, I learned from a young age to take responsibility, but coupled with my already well-developed perfectionism and love for detail, I would sometimes drive both my sisters and parents crazy. However, these characteristics were very useful for my interest in creative activities (such as creative writing, drawing, and handcrafting) and triggered my desire to understand things in their entirety. I grew a particular passion for two topics, dinosaurs and the universe, and the latter eventually developed into my profession.

But first, I attended the Thomas-Morus-Schule, an elementary school close to my home, and later the Annette-von-Droste Hülshoff Gymnasium, a high school only a 20-minute bike ride away. While I already had a tendency towards natural sciences and mathematics at that time, I must admit that I was one of those weird students who liked most subjects, perhaps not entirely surprising with both of my parents being teachers. In my senior years it was therefore particularly difficult for me to drop some of my classes and when I had to choose what to focus on – linguistic, scientific or social science subjects – I decided to go with all of them at first. In the end, however, I decided to keep physics and chose math and chemistry as my majors, while I had to give up two of the foreign languages and art with a heavy heart. But of course there were also subjects I wasn't really keen on. In geography, my poor sense of orientation could be quite inconvenient and most of the time I didn't enjoy the gym classes (which unfortunately I was forced to keep until the end): I hated running, was too small for basketball, and fouled too much for football.

After school, I decided to stay in my home town, where my family and best friends were still living, to study physics with chemistry as a minor at the West-

⁴„Entweder regnet es in Münster, oder es läuten die Glocken“ - Westfälisches Sprichwort

fälische Wilhelms-Universität. Even though I enjoyed my studies, I very quickly had to realize that the astrophysics component, which interested me most, was virtually non-existent. The only astronomy class offered included not much more than looking at pretty pictures of the universe, which were so large that it was nearly impossible to download the lecture notes, let alone print them. After finishing my Bachelor's project in nuclear physics under the supervision of Prof. Dr. Alfons Khoukaz it was therefore clear to me that I would leave for another university. In 2016, I moved to the southeast of Germany to Munich, where I started a Master of Astrophysics at the Ludwig-Maximilians Universität. Although it was hard at first to leave my friends and family behind and although everybody else in class had much more astrophysical knowledge from their Bachelor programs than me, this turned out to be one of the best decisions in my life, as I could finally study what I enjoyed most. However, an old problem of mine came back when I had to choose a Master's project because I didn't know how to decide which area interested me most. In the end, I decided on a theoretical project in planetary sciences with Prof. Dr. Barbara Ercolano. I very much enjoyed this year of research and I decided to pursue a scientific career by applying to PhD positions in astronomy.

During the PhD interviews, I got particularly excited about the projects of prof. dr. Ewine van Dishoeck and when students got offered positions from Leiden Observatory, I was very disappointed not to be among them. I wrote to Ewine to ask if there was still a chance for me, and I could not have been happier when she replied that my offer would actually come in the next few days through the Max Planck Institute for Extraterrestrial Physics rather than Leiden Observatory. Looking back, I recall that my project was supposed to be more on the theoretical side but as customary in Ewine's group, I also started to work on some observations. Not only did this research turn out to be more than the side project it was initially intended to be but also as very exciting and in the end a large part of my thesis is observational.

During my three years at MPE in Garching and my final year at Leiden Observatory, I had the privilege to meet many great people and to travel to interesting conferences. I am very grateful for the experiences I made during my PhD and although at times it could be very stressful, these experiences convinced me to continue in science. My next stop will now take me to Boston, where I will start a postdoctoral position with Dr. Richard Teague at the Massachusetts Institute of Technology.

Quand tu regarderas le ciel, la nuit,
puisque j'habiterai dans l'une d'elles,
puisque je rirai dans l'une d'elles,
alors ce sera pour toi
comme si riaient toutes les étoiles.
Tu auras, toi, des étoiles qui savent rire.

*Antoine de Saint-Exupéry, Le Petit
Prince*

Acknowledgements

Now that this adventure called PhD is coming to an end, I would like to take the time to thank the people (apologies if I have forgotten anyone!), who did not only accompany me on this journey but also gave me a great deal of support in times when my feet wouldn't carry me any further. As it lies in the nature of adventures, my path led me via several detours and was marked by many ups and downs, but these are exactly the ingredients that make a story interesting.

First of all, I would like to express my gratitude to you Ewine, for making it possible for me to start my journey in the first place. Thank you for believing in me and for the huge amount of time and support you have granted me over the past years. I find both your scientific insights and your joy for science inspiring! I also would like to thank my co-supervisors: Barbara, who always had kind words for me and found the time to help me with various issues. I admire your positive attitude and thank you for sparking my interest in planetary sciences. And Stefano, for introducing me to the world of observations and taking the time to explain even the more basic things. I really appreciate all the help you have given me!

I was lucky enough to be part of a big research group, with very cool and unique characters both on the Garching and Leiden side. Paolo, Yao, Andrés, Teresa, Sierra, and Giulio, all of you have been great colleagues in Garching! I always enjoyed chatting with you about both science and life in general. Alex, I am glad that we had some overlap in Garching, it was cool to see your excitement in scientific discussions! Margot, thank you for the joint online lunches during the pandemic, for helping me with dutch bureaucracy, and for being there for me when I was struggling. You are a very sweet and considerate person! Alice, you have been the best office mate! Thank you for taking care of me and cheering me up, I could not have made it through the last year without you. I love your fun and down-to-earth personality. See you in Boston! Pooneh, thank you for finding the kindest words for me when I was doubting myself. Your cheerful and enthusiastic nature is contagious! Martijn, I really like your relaxed and humorous way of approaching things! Thanks for all your help with the formalities, including travel forms and thesis formats, and with the nederlandse samenvatting. Lucas and Ardjan, you have been great colleagues! Nienke, I got a lot of good advice from you. Pranjali, talking to you was always very interesting, especially during stressful times. Merel, Arthur, Sierk, Leon, Łukasz, Giovanni, Benoît, Jeroen, and

Michał, most of the time you were on the other side of the screen, but I always enjoyed our meetings and valued your input a lot! Yuan, Katie, Marissa, Milou, Nashanty, Danny, and Logan, it was really great meeting you!

I also would like to thank my friends outside the observatory. First, my best friends Hilke and Sandra: Hilke, you have been like family to me for almost 30 years. You are a warm and welcoming and overall just lovely person, and the only one who is allowed to call me “Lieschen”. Ever since we were little, you took care of me and I know that I can always rely on you. Sandra, we could not be more different but you have always accepted me for who I am and defended me against all odds. You believed in me when I didn’t and were never afraid to tell me the truth. Sophia, there is no one else I enjoy taking a walk with as much as with you. I love engaging in hour-long and very unique conversations with you and I appreciate that you showed so much interest in my work. Answering your question was sometimes challenging but helped me to understand my research better. Sebi, you have been a great friend (and dancing partner!) and I especially like looking back at our fun times during the Bachelor. Camilla, Lukas, and Geray, you are what made my move to Munich and my Master studies most enjoyable. And even though our PhDs brought us to different corners of the world, you stayed amazing and supporting friends. Katja, our regular gatherings kept me going during my PhD in Garching and I was thrilled to hear that you and Dominik would also move to Leiden. I think the four of us make a good team! You are not only an impressive scientist but also a genuine and caring person.

I also would like to thank my family, we are a bit of a chaotic bunch, but I would not be where I am today without them. Papa, you claim that it was you who sparked my interest in astronomy when you showed me the full moon as a baby. I appreciate that you tried to answer my many, sometimes weird and difficult questions, and maybe one day I will learn: “Il faut cultiver notre jardin”. Mama, thank you for all your support and love, which I did not always appreciate as much as I should have. Helen, growing up with you, my days were often filled with adventures, magic, and fantasy. You are my fellow dinosaur lover, my fashion advisor and my fellow “Die Drei Fragezeichen”-listener. Thanks for staying calm during times I panicked. Anne, when you were very little you once told me that growing up you would like to be like me. But it was actually me who learned a great deal of things from you! You are a wonderful and most kind person and I am grateful that you were always there for me when I felt lonely. Oma, ich weiß dir ist nicht ganz klar, was genau ich eigentlich mache, aber deine Liebe und Unterstützung haben mich stets begleitet! Elias, I love that you share my interest in science, one day Wölfer & Wölfer will come!

And my biggest thanks goes to you David, for being my rock, making me laugh every day and convincing me that it was worth it. I have always admired your optimism and I never would have made it to the finish line without you. I appreciate you accompanying me to different places and I know that with you by my side nothing can really go wrong. Our adventure has just begun!



Don't adventures ever have an end?
I suppose not. Someone else
always has to carry on the story.

*J.R.R. Tolkien, The Lord of the
Rings*

