Pushing the characterization of exoplanet atmospheres down to temperate rocky planets in the era of JWST

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Publications

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Transiting exocomets detected in broadband light by TESS in the β Pictoris system.
S. Zieba, K. Zwintz, M. Kenworthy, et al., 2019, A&A, 625, L13.

K2 and Spitzer phase curves of the rocky ultra-short-period planet K2-141 b hint at a tenuous rock vapor atmosphere.
S. Zieba, M. Zilinskas, L. Kreidberg, et al., 2022, A&A, 664, A79.

PACMAN: A pipeline to reduce and analyze Hubble Wide Field Camera 3 IR Grism data.
S. Zieba, L. Kreidberg, 2022, JOSS, 7, 4838.

No thick carbon dioxide atmosphere on the rocky exoplanet TRAPPIST-1 c.
S. Zieba, L. Kreidberg, E. Ducrot, et al., 2023, Nature, 620, 746.

The β Pictoris b Hill Sphere Transit Campaign sphere transit campaign II. Searching for the signatures of the β Pictoris exoplanets through time delay analysis of the δ Scuti pulsations.
S. Zieba, K. Zwintz, M. Kenworthy, et al., 2024, accepted in A&A.

Contributor

Revisiting the pulsational characteristics of the exoplanet host star β Pictoris.
K. Zwintz, D. Reese, C. Neiner, et al. [including **S. Zieba**], 2019, A&A, 627, A28.

An unusually large gaseous transit in a debris disc.
D. Iglesias, J. Olofsson, A. Bayo, et al. [including **S. Zieba**], 2019, MNRAS, 490, 5218.

The First Habitable-zone Earth-sized Planet from TESS. I. Validation of the TOI-700 System.
E. Gilbert, T. Barclay, J. Schlieder, et al. [including **S. Zieba**], 2020, AJ, 160, 116.

The First Habitable-zone Earth-sized Planet from TESS. II. Spitzer Confirms TOI-700 d.
J. Rodriguez, A. Vanderburg, **S. Zieba**, et al., 2020, AJ, 160, 117.

Exocomets from a Solar System Perspective.
P. Strøm, D. Bodewits, M. Knight, et al. [including **S. Zieba**], 2020, PASP, 132, 101001.

Observability of evaporating lava worlds.
M. Zilinskas, C. van Buchem, Y. Miguel, et al. [including **S. Zieba**], 2022, A&A, 661, A126.

A Transmission Spectrum of the Sub-Earth Planet L98-59 b in 1.1-1.7 μm.
M. Damiano, R. Hu, T. Barclay, et al. [including **S. Zieba**], 2022, AJ, 164, 225.

Eureka!: An End-to-End Pipeline for JWST Time-Series Observations.
T. Bell, E. Ahrer, J. Brande, et al. [including **S. Zieba**], 2022, JOSS, 7, 4503.

Identification of carbon dioxide in an exoplanet atmosphere.
JWST Transiting Exoplanet Community Early Release Science Team, E. Ahrer, L. Alderson, et al. [including **S. Zieba**], 2023, Nature, 614, 649.

Early Release Science of the exoplanet WASP-39b with JWST NIRCam.
E. Ahrer, K. Stevenson, M. Mansfield, et al. [including **S. Zieba**], 2023, Nature, 614, 653.

Early Release Science of the exoplanet WASP-39b with JWST NIRSpec PRISM.
Z. Rustamkulov, D. Sing, S. Mukherjee, et al. [including **S. Zieba**], 2023, Nature, 614, 659.

Photochemical Hazes Dramatically Alter Temperature Structure and Atmospheric Circulation in 3D Simulations of Hot Jupiters.
M. Steinrueck, T. Koskinen, P. Lavvas, et al. [including **S. Zieba**], 2023, ApJ, 951, 117.

CHEOPS's hunt for exocomets: photometric observations of 5 Vul.
I. Rebollido, **S. Zieba**, D. Iglesias, et al., 2023, MNRAS, 523, 1441.

A reflective, metal-rich atmosphere for GJ 1214b from its JWST phase curve.
E. Kempton, M. Zhang, J. Bean, et al. [including **S. Zieba**], 2023, Nature, 620, 67.

Potential Atmospheric Compositions of TRAPPIST-1 c Constrained by JWST/MIRI Observations at 15 μm.
A. Lincowski, V. Meadows, **S. Zieba**, et al., 2023, ApJL, 955, L7.

Characterization of K2-167 b and CALM, a new stellar activity mitigation method.
Z. de Beurs, A. Vanderburg, E. Thygesen, et al. [including **S. Zieba**], 2024, MNRAS, 529, 1047.

Nightside clouds and disequilibrium chemistry on the hot Jupiter WASP-43b.
T. Bell, N. Crouzet, P. Cubillos, et al. [including **S. Zieba**], 2024, Nat Astron.

Curriculum Vitae

I was born in Grödig, a suburb of Salzburg city, Austria, in June 1995. The town rests at the foot of the Berchtesgaden Alps, with the majestic Untersberg straddling the border between Salzburg and Bavaria. It's also home to the Mozartkugel confection manufacturer, Mirabell. Even now, after all these years, both the mountains and Mozartkugeln still bring me joy. At the age of six, my family relocated from Grödig to Plainfeld, a small town 12 kilometers east of Salzburg city. There, I attended the "Volkschule Plainfeld" as my primary school. Later, at ten, I embarked on the path of grammar school at the "Privatgymnasium Herz-Jesu-Missionare" in Salzburg. It was here that I translated Latin and Greek texts into German and developed a keen interest in astronomy. During this period, I also fondly recall giving outreach talks on exoplanets.

After turning 18, I left Salzburg and moved to Innsbruck to study physics there. I was truly spoiled, moving from one picturesque city to the next one. After making my way through lectures on for example classical mechanics, optics, and quantum theory, I completed my bachelor project under the supervision of Professor Norbert Przybilla in 2017. I didn't hesitate and immediately continued my academic journey also at the University of Innsbruck with a Master's degree. Having to make a decision on my specialization within physics, I decided on the "in-depth study" of astro- and particle physics. Ultimately, I worked together with Professor Konstanze Zwintz and was co-supervised by Professor Matthew Kenworthy. During this time, with the help of my co-authors, I ended up discovering comets around a different star. Before working on that paper, I didn't even know that "exocomets" were a thing in the first place.

I then started my PhD in January 2020, with the joint Max Planck Institute for Astronomy and Leiden University affiliation, under the supervision of Professor Laura Kreidberg and my Leiden supervisor, Professor Ignas Snellen. Before moving to Heidelberg in August 2020, I spent the first 2 months of my PhD in Leiden, then 3 months in Boston, and finally 2 additional months in Innsbruck. What followed were 4 years of analyzing Spitzer, Kepler, Hubble, and JWST data to learn more about the atmospheres and surfaces of exoplanets. During this time I was privileged to attend many conferences at various places around the world, including Las Vegas, New Zealand, Oxford, Zürich, and Los Angeles. At every one of these conferences, I got to meet new friends and see old ones again.

During my PhD in 2023, I got two JWST observational programs accepted as principal investigator (PI) to further investigate rocky exoplanet atmospheres and study the transition between small planets and larger ones that have signif-

icant envelopes. In 2023, I had the opportunity to work with JWST data when one of Laura's programs was accepted in Cycle 1 to observe the rocky exoplanet TRAPPIST-1 c. We ended up publishing our results in the journal Nature in June of 2024. This was followed by an intense time of finishing my thesis and applying for postdoc positions. Ultimately, I was awarded the prestigious Hubble Fellowship to continue my research at the Center for Astrophysics (CfA) in Boston. Later in 2024, I will be relocating to Boston to begin this position there.

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Here, I would like to express my deep gratitude to the many people whose unwavering support and encouragement have been so important throughout my journey to receiving my doctorate degree.

I have to start my acknowledgments with my math and astronomy teacher from grammar school, Herbert. Even though I already had a big interest in astronomy at this age, I might not have gotten that interested in exoplanets if it weren't for you, suggesting I prepare a presentation on these distant worlds. The field has for sure moved on a lot since the discovery of the "Earth-like" planets like Gliese 581 c, and I still remember preparing PowerPoint presentations on that planet for the group. Astronomy ended up being "my thing back in school, and your support was surely a big part of that. Thank you.

After finishing school in Salzburg, I studied in Innsbruck. I highly appreciate the supervision of my master's thesis supervisor, Konstanze, who guided me throughout this first scientific journey. My interest in trying to get as much information as possible from simple measurements of light over time has surely come from the work with you in your group. I also wanna acknowledge Matt who was a great co-supervisor on this Master's thesis project. The exocomet discovery in the TESS data was surely an incredibly exciting time in my Master's and also came with some sleepless nights. I'm glad I could work together with you both and that I had your guidance during my project. Also, thank you, Matt, for the continued motivation you gave me to finish the Master thesis paper which is now a chapter in this thesis. After the exocomet discovery, I was able to travel to Leiden for a workshop. There, I finally met Matt in person, and also Ignas, who ultimately ended up being my PhD promotor. I enjoyed every conversation we had, Ignas, especially important to me was the first one, which ultimately led to me getting in touch with Laura.

When friends or collaborators ask me how Laura is as a supervisor, I can only talk about her in the best way possible. Laura, you've been incredibly supportive in every way during my journey as a PhD student. You are kind, humble, and you are able to communicate complicated topics really well. Whoever I met at conferences could only confirm that you've been the nicest to everyone. You also always had lots of time for me throughout my whole PhD to discuss the progress I have made over the past few days or the setbacks I had. I appreciate the time you invested in me, and I hope we get to continue working together in the future.

My time as a student at the MPIA started out rough with lockdowns, but I really enjoyed every time I was able to be together with my generation of MPIA

students, especially Eric, Evert, Verena, and Nico. Our skiing trips and other outdoor adventures were surely lots of fun! The Austrian apres-ski music was obviously another highlight of these trips! I am really glad I eventually ended up in an office at the MPIA with a really nice atmosphere. One of my main motivations to go to work every day was being back in this office and getting to talk with my besties, Marten and Molly. I surely enjoyed the pool games we had in our default place, Metropol, with the usual drink, Bananenweizen. Also, I will surely miss banana juice abroad. Marten, I indeed enjoyed the Stargate-related discussions we had. We should still give that presentation on the inner workings of the Stargate system! The chess ark we had was also a highlight, but I just cannot keep up with your Elo. Molly, I think there's still enough space on the office walls for us to do dozens more Taylor Swift quizzes. It's getting so hard, though; Taylor is too productive. I'm really lucky to have had someone in the office I could always chat with about Taylor-related updates. And boy there were a lot during my PhD. Talking about Taylor, I obviously want to say how much fun it is to be part of her fandom and enjoy the great music she makes. I also loved our trip to Minehead, where I realized that the UK is not exclusively grey and rainy. Also loved that apple juice I had there! Finally, I also really enjoyed my encounters with any of the other students or postdocs in Heidelberg who I got to meet during my PhD like Max, Selina, Lucian, Glen, Liang, Alex, Callie, Steve, Jonas, and Paul.

Despite my Leiden affiliation, I did not get to be in Leiden that often. But my PhD started off with working together with the Leiden-based Lava planet expert Yamila and her student Mantas. I really appreciate your kindness, Yamila, and your scientific input on the various papers and proposals we have worked on. It was always nice to meet you whenever I was in Leiden or we attended the same conference. Mantas, every time we got to get together in person was a blast! I also wanna acknowledge the rest of the Leiden core gang, Amy and Chris. I think there has been no conference in the past few years without at least one of you guys, Amy, Chris, and Mantas. Amy, the skiing trip was lots of fun, and thanks for proofreading some Dutch stuff for me. After all these Duolingo lessons, I still don't know much more than "boterham." We should also visit our friend Prune again in Copenhagen! Chris, thanks for borrowing me your colorful jacket after I lost mine in Zürich. I can't wait to sing Angels by the late great Robbie Williams again with you. I think we get better every time. I also got to briefly meet some other Leiden folks like Lucie, Thijs, Louis, Dario, and Chloe. Every encounter with you guys was also really nice.

My time in my mid-twenties was made so much better by my girlfriend, Brianna. It's funny how we first met in Boston the first time I visited the US and now I'm going back to start my fellowship there. I still remember it all too well when we could finally meet up again in Toronto after some pandemic-related restrictions were lifted. That city was surely barren cold with all that wind and I still remember the first fall of snow, and how it glistened as it fell. What followed was just a great time with your support in every single way. You've made me a better person over the past few years, and I am looking forward to being less long-distance in the next few years. You mean so much to me. Hope you know that. It was also nice to get to meet everyone else in the Zawadzki Family, namingly Craig, Lori, Chelsea,

Poe, and Piper. It was delightful to get to know all of you over the past years. I also enjoyed getting to know Brianna's friends, like Michael, Arvind, Steve, and Josie, every time I visited central Pennsylvania.

Last but certainly not least, I want to express my heartfelt gratitude to my family—my mom, Margo, my dad, Georg, and my brother, Peter — who have supported me my whole life. It's undeniable that my passion for astronomy and science fiction was ignited by my mom, who introduced me to TV shows like Star Trek TNG, DS9, Voyager, and Stargate. My mom was always there to help me, like when she supported me in translating ancient Greek texts for my homework. I also owe my love for skiing to my parents, and I cherish the hope of continuing our mountain adventures together in the future! Thanks, Dad, for driving so far every once in a while just to get us some perogies and other foods all the way from Poland. Thanks, Peter, for being there in Innsbruck with me. I'm still impressed by some of these long bike rides you did in Tyrol. Thanks to everyone in my family. I cannot express how much you mean to me.

Everyone I've listed here has supported me in one way or another. For that, I want to say a deep thank you from my heart — or, as we would say where I'm from, dankschee fia ois!