Les Lumières: probing the cosmic Epoch of Reionization with high-redshift quasars

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Publications

First Author

- *First constraints on the local ionization topology in front of two quasars at $z \sim 7.5$*
  Timo Kist, Joseph F. Hennawi, Frederick B. Davies, Eduardo Bañados, Sarah E. I. Bosman, Zheng Cai, Anna-Christina Eilers, Xiaohui Fan, Zoltán Haiman, Hyunsung D. Jun, Yichen Liu, Jinyi Yang and Feige Wang
  Monthly Notices of the Royal Astronomical Society, Volume 545, Issue 3, January 2026, staf2219.
  doi.org/10.1093/mnras/staf2219

- *Inferring local quasar IGM damping wing constraints*
  Timo Kist, Joseph F. Hennawi and Frederick B. Davies
  submitted to Monthly Notices of the Royal Astronomical Society.
  doi.org/10.48550/arXiv.2508.21812

- *A local, topology-independent parameterization of quasar IGM damping wings*
  Timo Kist, Joseph F. Hennawi and Frederick B. Davies
  Monthly Notices of the Royal Astronomical Society, Volume 544, Issue 2, December 2025, Pages 2316-2339.
  doi.org/10.1093/mnras/staf1762

- *Quantifying the precision of IGM damping wing measurements towards quasars*
  Timo Kist, Joseph F. Hennawi and Frederick B. Davies
  Monthly Notices of the Royal Astronomical Society, Volume 538, Issue 4, April 2025, Pages 2704-2728.
  doi.org/10.1093/mnras/staf460

Unrelated to the topics of this thesis:

- *The robustness of slow contraction and the shape of the scalar field potential*
  Timo Kist and Anna Ijjas
  Journal of Cosmology and Astroparticle Physics, Volume 2022, Issue 08, August 2022, 046.
  doi.org/10.1088/1475-7516/2022/08/046

- *Lee-Yang theory of criticality in interacting quantum many-body systems*
  Timo Kist, Jose L. Lado and Christian Flindt
  Physical Review Research, Volume 3, Issue 3, September 2021, 033206.
  doi.org/10.1103/PhysRevResearch.3.033206

Contributing Author

- *Precisely measuring the cosmic reionization history from IGM damping wings towards quasars*
  Joseph F. Hennawi, **Timo Kist**, Frederick B. Davies and John Tamanas
  Monthly Notices of the Royal Astronomical Society, Volume 539, Issue 3, May 2025, Pages 2621-2653.
  doi.org/10.1093/mnras/staf643

Curriculum Vitae

Born on the 15th of December 1997, I spent the first 18 years of my life in the small town of Zeven in Northern Germany. I managed to do well in school at the Grundschule Klostergang and later the St.-Viti-Gymnasium because I could compensate my shyness with an insatiable thirst for knowledge, although I cannot claim that the skies have always been my one and only passion. Especially mathematics came naturally to me early on and I enjoyed solving all kinds of mathematical tasks and riddles, but nonetheless, I was similarly excited about the natural sciences – physics in particular – but also history or Latin once they would finally be added to my timetable.

Probably one of the most important events that brought me to the point where I am today is the Mathematical Olympiad. It was in fifth grade that I was finally old enough to attend the central state-level finals at the venerable Mathematical Institute of the University of Göttingen. The event, hosted in an actual city, three hours away from my small home town, was an entirely new experience for me, and also the first time I set foot into a university. But most importantly, I was suddenly surrounded by other students that enjoyed mathematics just as much as I did. Not only was I lucky enough to get back home with a silver medal, but also to return to Göttingen (almost) every year until the end of school, and being invited to several training seminars, a foretaste of future summer schools during my PhD.

As I approached my final years of school, it was rather clear to me that I would want to pursue studies at a university, but I still had to figure out the subject and the place. In essence, I decided to tread the predetermined path and settle on the city that I had already come to know over the past eight years. Subject-wise, it naturally came down to the choice between physics and mathematics. What ultimately turned the balance was the fact that physics would still heavily involve mathematics as a tool to describe the fundamental laws of nature – and maybe also two great teachers, Mr. Dietz and Ms. Wagner, that I had the luck to learn from in secondary school.

With Göttingen's rich history in mathematics and theoretical physics, the boundary between the two disciplines was fluid, and being enrolled as a physics student, I could still attend the 'real' calculus and linear algebra lectures in my first semester – as well as many more advanced ones in the coming years, again blurring my decision towards physics. Attending so many lectures and learning so many new things was exciting but nonetheless intense, and even the semester breaks were often filled with additional programming courses that did not fit into the regular semester schedule.

Two and a half years later – when I had to choose a topic for my Bachelor's thesis – I knew I would want to be a theorist, but I did not know yet in which field. In the end, I had the luck that Fabian Heidrich-Meisner pitched

a project to me where I could try out different numerical methods for solving the Gross-Pitaevskii equation to model Bose-Einstein condensates. In spite of its immediate roots in quantum many body physics, the project also had an astrophysical component, with the same equation being known as the Schrödinger–Poisson equation in the context of fuzzy dark matter.

With my Bachelor's thesis just submitted, a new chapter of my life followed right away with my first Master's year that I spent, via the Erasmus programme, in Finland at the University of Helsinki. Living abroad for the first time in my life was certainly a whole new and exciting experience, and it was here that I attended my first lectures on cosmology. Certainly one of the highlights were student-run observing nights at the old observatory domes on the premises of the Metsähovi Radio Observatory.

Despite these first allusions towards astrophysics, I also kept my passion for quantum physics and got offered a summer research internship on a new method to detect criticality in quantum phase transitions with Christian Flindt and Jose Lado at the nearby Aalto University. Even though the COVID-19 pandemic hit in the middle of my second semester, I decided to stay in Finland and go through with the project – the correct decision, as it turned out, since I could not only spend a rather safe pandemic summer in sparsely populated Finland, but we also obtained interesting results that we decided to publish in what turned out to be my first scientific publication.

Upon my return to Göttingen, given the amount of mathematical credits I had accumulated over time, I was essentially only a thesis away from a second Bachelor's degree in mathematics which I then obtained with a thesis on random Schrödinger operators. Nonetheless, I was rather certain by that time that I would ultimately want to stay in physics. Although I could have continued with my summer project, I remained very curious about astrophysics and cosmology. In the end, Anna Ijjas at the Max Planck Institute for Gravitational Physics had an exciting theoretical cosmology project for me where I could explore ways of addressing the cosmic initial conditions problem with a slow contraction phase in the early Universe. Once my thesis was complete, I even had the luck to get to visit Paul Steinhardt at Princeton University and turn my thesis into a full publication.

Subsequently, the roulette of PhD positions brought me to the Netherlands where Joe Hennawi offered me an exciting PhD project at Leiden University where I could use statistical inference techniques to place better constraints on the Epoch of Reionisation. Four years later, I can certainly say that I learned a great deal the Observatory and that I got much closer from being a theoretical cosmologist to an astrophysicist. Ultimately, in my final year, I was lucky enough to win a Rubicon grant from the Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO) that will allow me to spend two years at the Institute of Astronomy at the University of Cambridge, and I can't wait to see what this new chapter of my life will entail.

Acknowledgements

I have always been wondering what it tells us that the following two pages will most likely be the most-read ones of this entire thesis. Much more than negating the relevance of our research, I hope it rather is a statement about the importance of others in the academic world – after all, four years of astrophysical research are certainly not possible alone.

As such, of course I have to start by thanking Joe for being such a great supervisor over these past four years. Thanks for believing in my potential and abilities rather than my previous research experience – after all, you hired a theoretical cosmology and/or quantum physics student for a PhD project in astrophysics and statistics! Even though I would still not go far enough to call myself a true astronomer, these past four years have certainly brought me much closer to what is considered an astrophysicist. Fred, it was a pleasure having you as a collaborator on this project and to meet and discuss at various different conferences over the past years!

Leiden University has been an outstanding research environment, and it was amazing to work and study in this place after my first two pandemic-shaped research projects that I largely had to carry out in my own room. Especially, I would like to thank Joop and Matthieu for the weekly preprint meetings, Gijs, and later Lukas and Vysakh for running the machine learning journal club, Zephyr and Mathilde for keeping the Green Committee alive, and the Lorentz Institute for hosting the Colloquia Ehrenfestii – sadly a highly under-appreciated event at the Observatory.

Elena, Marijn and Sjoert, it was a pleasure to be a teaching assistant in your courses where I think I learned at least as much as all the other students. Benjamin and Vinay, thanks for all the hard work on helium reionisation, I hope could pass on to you at least a little bit of what I learned in these past years! I certainly don't want to forget to thank the secretaries, the computerworkers, the caretakers, the cleaning staff and all the other less visible professions at the University that kept everything running so smoothly every day, although I have to leave the University while still eagerly awaiting the Universitair Facilitair Bedrijf (UFB) to establish a warm, healthy and diverse lunch menu.

Thanking my group in fact already brings me beyond the bounds of Leiden University. Despite its practical challenges, being part of a group that extends across two continents truly was an enriching experience. Ben, Diego, Jiamu, Kathlynn, Koki, Linda, Molly, Shane, Suk Sien, Teng, Vikram and Yi, after seeing you week by week on the screen in group meeting, it was great to finally meet most of you in person on Corsica, in Boston, Heidelberg, Helsingør, and, most importantly, even at the University of Santa Barbara!

And of course the Leiden branch: Ben, Caitlin, Da-Ming, Elia, JT, Lars, Riccardo and Silvia, it was great to see at least half the group on a daily basis and to even share offices with some of you – which of course also holds for Beth, Elina, Kira, Lukas, Mulan, Pengyu, Piyush, Richelle, Tram and Yannick! Most especially Elia and Silvia, not only were you two amazing office mates (only in combination with Beth and Piyush of course!), but also great friends outside of the university in conference airbnbs, ski chalets, the climbing gym or even on the mountain! The latter of course is also true for all the other climbers, Darío, Erik, Joey, Manuel, Thijs, Yuze and everyone else who occasionally joined for the countless bouldering and climbing sessions!

Thanks to Amy, Christiaan, Joey, Roi, Chloe, Lucy, Ivana, Verónica, Darío, Louis, Thomas, Zeynab, Casper, Celine, Esther, Manuel and Yuze for organising four amazing ski trips, and of course to everyone who joined and made each trip an unforgettable experience! I still can't believe I got introduced to this activity by moving to a country whose spacetime structure is the textbook example of a (2+1) Minkowski metric.

And of course Aaron, Alessia, Alfred, Andrew, Andrés, Aniruddh, Anniek, Anselmo, Arielle, Beth, Bianca, Billy, Brigitte, Christian, Cecilie, Cheng-Lin, Ciarán, Colin, Dag, Dennis, Elena, Emily, Evgenii, Femke, Fraser, Frits, Gimena, Greta, Hylke, Jay, Jeger, Jelle, Jeroen, Jessica, Jinyi, Josh, Joshiwa, Jurjen, Karin, Keqin, Kevin, Kutay, Leoni, Logan, Luna, Mantas, Mariia, Markus, Marta, Martje, Matus, Michiel, Naadiyah, Niccolò, Nicole, Orestis, Osmar, Paola, Pato, Pranjal, Rico, Rob, Roland, Ryan, Sai, Sam, Scott, Sid, Sill, Tobias, Tommy, Vanesa, Victor, Victorine, Will, Willeke, Wout, Zhenlin, Zorry and anyone I might have missed, thanks for all the countless coffee breaks, lunches, borrels, defence parties and so many other things!

Thanks to all my friends from Göttingen for staying in touch even though I did not just leave behind the city but even the entire country for my PhD. Most especially, thanks to Sarah and Sonja for all the visits and the climbing trips, to the entire APAH crew, especially to Annika, Julien and Heiko for the yearly refuge from the Dutch new year celebrations, and most of all to Annika for all the cows!

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Zu guter Letzt fehlt natürlich noch meine Familie, ohne die ich ganz sicher nicht da wäre wo ich heute bin. Mama, Papa, danke dass ihr mich immer unterstützt und mir immer den Raum gegeben habt, meinen eigenen Interessen zu folgen, und vor allem danke für ein Zuhause, an das ich seit jeher jederzeit zurückkehren kann und konnte!