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## Atmospheres of hot alien Worlds

Brogi, M.

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# List of publications

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## Refereed Publications

1. **Brogi, M.**; de Kok, R. J.; Birkby, J. L.; Schwarz, H.; Snellen, I. A. G. *Carbon monoxide and water vapor in the atmosphere of the non-transiting planet HD 179949 b*, A&A accepted (arXiv:1404.3769).
2. **Brogi, M.**; Snellen, I. A. G.; de Kok, R. J.; Albrecht, S.; Birkby, J. L.; de Mooij, E. J. W. *Detection of molecular absorption in the dayside of exoplanet 51 Pegasi b?* ApJ, 767, 27B (2013)
3. **Brogi, M.**; Keller, C. U.; de Juan Ovelar, M.; Kenworthy, M. A.; de Kok, R. J.; Min, M.; Snellen, I. A. G. *Evidence for the disintegration of KIC 12557548 b*. A&A, 545L, 5B (2012b)
4. **Brogi, M.**; Snellen, I. A. G.; de Kok, R. J.; Albrecht, S.; Birkby, J. L.; de Mooij, E. J. W. *The signature of orbital motion from the dayside of the planet  $\tau$  Boötis b*. Nature, 486, 502B (2012a)
5. **Brogi, M.**; Marzari, F.; Paolicchi, P. *Dynamical stability of the inner belt around  $\epsilon$  Eridani*. A&A, 499L, 13B (2009)
6. Snellen, I. A. G.; Brandl, B. R.; de Kok, R. J.; **Brogi, M.**; Birkby, J. L.; Schwarz, H. *Fast spin of the young extrasolar planet  $\beta$  Pictoris b*. Nature, 509, 63-65 (2014)
7. de Kok, R. J.; Birkby, J. L.; **Brogi, M.**; Schwarz, H.; Albrecht, S.; de Mooij, E. J. W.; Snellen, I. A. G. *Identifying new opportunities for exoplanet characterisation at high spectral resolution*. A&A, 561A, 150D (2014).
8. van Werkhoven, T. I. M.; **Brogi, M.**; Keller, C. U.; Snellen, I. A. G. *Analysis and interpretation of 15 quarters of Kepler data of the disintegrating planet KIC 12557548 b*. A&A, 561A, 3V (2014).
9. Birkby, J. L.; de Kok, R. J.; **Brogi, M.**; de Mooij, E. J. W.; Schwarz, H.; Albrecht, S.; Snellen, I. A. G. *Detection of water absorption in the dayside atmosphere of HD 189733 b using ground-based high-resolution spectroscopy at 3.2  $\mu$ m*. MNRAS, 436L, 35B (2013)
10. de Mooij, E. J. W.; **Brogi, M.**; de Kok, R. J.; Snellen, I. A. G.; Croll, B.; Jayawardhana, R.; Hoekstra, H.; Otten, G. P. P. L.; Bekkers, D. H.; Haffert, S. Y.; van Houtdt, J. J. *Search for Rayleigh scattering in the atmosphere of GJ1214 b*. ApJ, 771, 109D (2013)
11. de Kok, R. J.; **Brogi, M.**; Snellen, I. A. G.; Birkby, J. L.; Albrecht, S.; de Mooij, E. J. W. *Detection of carbon monoxide in the high-resolution day-side spectrum of the exoplanet HD 189733b*. A&A, 554A, 82D (2013)

12. Snellen, I. A. G.; de Kok, R. J.; le Poole, R.; **Brogi, M.**; Birkby, J. L. *Finding Extraterrestrial Life Using Ground-based High-dispersion Spectroscopy*. *ApJ*, 764, 182S (2013)
13. de Mooij, E. J. W.; **Brogi, M.**; de Kok, R. J.; Snellen, I. A. G.; Kenworthy, M. A.; Karjalainen, R. *The GROUSE project. III. K<sub>S</sub>-band observations of the thermal emission from WASP-33b*. *A&A*, 550A, 54D (2013)
14. de Mooij, E. J. W.; **Brogi, M.**; de Kok, R. J.; Koppenhoefer, J.; Nefs, S. V.; Snellen, I. A. G.; Greiner, J.; Hanse, J.; Heinsbroek, R. C.; Lee, C. H.; van der Werf, P. P. *Optical to near-infrared transit observations of super-Earth GJ 1214b: water-world or mini-Neptune?* *A&A*, 538A, 46D (2012)

## Conference Proceedings

1. Snellen, I.; de Kok, R. J.; de Mooij, E. J. W.; **Brogi, M.**; Nefs, S. V.; Albrecht, S. *Exoplanet atmospheres at high spectral resolution: A CRIRES survey of hot Jupiters*. *IAUS*, 276, 208 (2011)
2. de Mooij, E. J. W.; de Kok, R. J.; Nefs, S. V.; **Brogi, M.**; Snellen, I. *The GROUnd-based Secondary Eclipse project*. *IAUS*, 276, 478 (2011)

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# Curriculum Vitae

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I was born on May 12, 1983 in Grosseto, Italy, where I spent the first 19 years of my life and completed my pre-university education. In 1989 I started primary school, and in 1994 middle school. In the meanwhile, I began to be fascinated by the night sky and astronomy in general, so I decided to attend a science-oriented lyceum, from which I graduated in 2002 with the highest grade.

I subsequently moved to Pisa and enrolled in the Science Faculty for the Bachelor courses (laurea triennale) in General Physics. At that time, I was already determined to eventually study Astrophysics. In 2006, under the guidance of Prof. Paolo Paolicchi, I got my Bachelor Degree with the highest grade, presenting a research project on the analytical formalism for predicting the effects of secular resonances in dynamical evolution of celestial bodies.

After obtaining my Bachelor Degree, I started the Master courses in Astrophysics. Approximately one year thereafter, I decided to base my Master Thesis on the dynamical stability of the Habitable Zones of known exoplanets, in collaboration with Prof. Paolo Paolicchi and Prof. Francesco Marzari. A spin-off project of this work resulted in a publication in *Astronomy & Astrophysics* (Brogi et al. 2009). At the end of the project, I graduated *Cum Laude* and started to look for a PhD project.

In the Fall of 2009, I won a PhD position in Pisa, although not in Astrophysics. I decided to resign and search for a project in exoplanet science, intrigued by the subject in general, but in particular by observations of exoplanet atmospheres and the quest for an Earth-twin. As a result, I started my research as a PhD at Leiden Observatory, in the Netherlands, under the guidance of Prof. Ignas Snellen. As a main project, I developed a novel observational technique to probe the atmospheres of exoplanets, and I was the first to apply it to non-transiting planets, obtaining their masses and orbital inclinations (Brogi et al. 2012b, 2013, 2014). In addition, I analyzed data from the *Kepler* spacecraft in collaboration with Prof. Christoph Keller, which led to the first quantitative evidence for the evaporation of one of the *Kepler* planet candidates (Brogi et al., 2012b).

In early 2014 I have been awarded with a NASA Hubble Fellowship, which I will take at University of Colorado, Boulder, starting from September 2014. In the context of the Fellowship, I will work in collaboration with Jean-Michel Désert on the ideas presented in the final chapter of this thesis.



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Being able to defend my PhD thesis is the result of a long path that started when I was still a child. I am grateful to many people for their support throughout this journey.

First of all, none of my achievements would have been possible without my parents, so they deserve a special thanks in my mother tongue. Mamma e babbo, avete sempre creduto in me e sostenuto i miei sogni. Vi siete resi conto di quanto il cielo stellato mi ispirasse fin dall'adolescenza, e avete fatto in modo che potessi completare gli studi scientifici. So bene quanti sacrifici abbiate fatto, date le condizioni economiche della nostra famiglia. Per questo, per essere genitori meravigliosi e per il vostro amore incondizionato, vi sarò sempre grato.

I grew up in a small rural town, where attachment to the land and to practical and tangible things is still strong. This does not encourage the choice of science and research as a job. I am grateful to all the people who believed in me at the right moment and were supportive throughout my journey. First of all to my relatives, and in particular to my uncle Paolo and my cousins Francesca, Ilaria, and Luca. Secondly, to some of my teachers. With his unconventional methods, Enzo Flaminio boosted my interest for science during middle school. Grazia Stilli, my high-school literature teacher, significantly helped me to develop a critical view of life.

I have shared a large part of my life with two special friends. Sara and Giuliano, we have experienced so many things together! Not only have we shared an apartment in Pisa during university, but also our adolescence, weekends, parties, achievements and failures. So many good memories include you two, and you never judged me for my ideas or my behavior. When I needed your help you were there, and I still feel you very close even though we seldom meet anymore. Not by chance, you will sit at my side during the defense!

I shared memorable moments, the heights and the lowest points of my university years with a very special group of friends: Ale (and by that I mean il Bocco, il Cilla and DJ pacco), Ali, Damiano, il Mancio, il Leo, il Petro, Rosa, Vera. We are now all scattered across Italy and Europe, but certainly my life today partly depends on the good times that we had together, on our mutual support during troublesome times, and even on our many arguments.

My journey towards the doctorate has not been always easy. In the darkest moments, music has given me the right inspiration to go on. To my uncle Cristiano, wherever he is now, goes the highest merit, as he taught me everything I know, with endless patience. Thanks to my amazing friends and musicians Edoardo, Francesco, and Luca, for making the dream of performing live the music of Pink Floyd possible.

I feel privileged to have spent the last four years as a PhD student in the Netherlands. Living in such a welcoming country, working in a vibrant department, and meeting so many people from all over the world, truly opened my mind. Not all of these people were or are astronomers. Olmo, thanks for trying to teach me thai-chi. I was certainly the worst student in the group, but we had great fun and I will

always remember that. I hope you will make soon your way, and my best wishes for the future. Cosma, thanks for your improvised stories full of cynicism and sarcasm. Yuval, we had a lot of fun while you were in Leiden. Thanks for starting the tradition of home-brewed beer and for passing it to Marissa! Thanks to Evelijn, Yvonne, and Jeanne. Their help with all the practical matters made my moving to the Netherlands an extremely smooth transition, and my stay an enjoyable stay.

I incredibly enjoyed working in the Leiden exoplanet group. I always felt respected and treated as a colleague, rather than as a student. All my ideas have been taken seriously and often encouraged, which acquainted me with independent research very soon during the PhD. After traveling to conferences, visiting other institutes, and chatting with many astronomers, I can say that I rarely met other research groups led with such a care and success. I want to thank Ernst for his patience during my first year, for sharing his technical knowledge with me, and for always promoting collaborations and constructive discussion. Jayne, it has been a real pleasure to work with you and share the successes of the last years, the craziness of our job-hunting, and social time during conferences. Remco, thanks for helping me to understand the theoretical background behind our observations, which gave me the key to interpret our complex measurements and reach so many exciting results. Tiffany, a long time has passed since we first met in room 101. I enjoyed every bit of it, first as a friend, and then when you started to work in exoplanets. Fortunately we will meet at many other conferences in the future! Maria and Tim, collaborating with you was a great experience. You are fantastic colleagues and even more amazing in partying mood. It's a pity that you only moved from Utrecht almost at the end of your PhD, and my best wishes with your future! Anna-Lea, Emanuele, Henriette and Julien: thanks for your enthusiasm, for all our chats, and for caring so much about the social aspects of our academic life, which are too often underrated. All the best with your projects!

To my officemates, Rafa, Eva, Elisabetta, Saskia, and Clément, thanks for making our workspace so nice and livable! Rafa, the time we have shared as friends, and the way you care about your family while being such a successful scientist inspire me incredibly. My best wishes to you, Lara and Leonardo!

I greatly appreciate the distinctive social character of the Sterrewacht. I am grateful to all the colleagues sharing their ideas about science and life with me during coffee breaks, lunch time, Friday borrel, nights out and parties. Alex, Ali, Andra, Bram, Carina, Carl, Carla, Cristobal, Daniel, Ernst, Francisco, Heather, Hendrik, Jaya, Jeanette, Jesse, Joana, Kalle, Mariam, Mher, Magnus, Monica, Nienke, Pedro, Remco, Renske, Sebastiaan, Steven, Vachail, Willem, thanks for the time spent together!

With a small group of colleagues I have a special bond. They made my life in Leiden special, and certainly their support and our friendship contributed to the positive outcome of the last four years. Marissa, we met as soon as I moved in Leiden. Thanks for guiding me through the mysteries of the English language with patience, for introducing me to everyone you knew at the time, and for sharing the secrets of home-brewed beer. Thanja, it has been a real pleasure to accompany you at the piano. Thanks for dragging me to perform live again after many years.

By now you have probably realized how much playing helps me, and I hope it is the same for you! Berenice and Jesús, you both enjoy challenges, and you have the rare gift to use them to cheer you up. Thanks for dragging me out of apathy and laziness throughout these years, for the battles playing Munchkin, and for our small competitions about best food, best weather, and about everything good that comes out of Spain and Italy. It is much better to look at our countries from this perspective! Speaking of which, my special thanks to the "Italian crew". It would have been much harder without you guys. We shared the mixed feelings of being abroad and grieved for the troubles of our homeland. Mattia, sei stato un coinquilino fantastico per più di due anni. Grazie per avermi insegnato che alcuni fatti della vita si digeriscono molto meglio con un po' di sarcasmo e umorismo. Marco, sei un integralista del beach-volley e delle torte il lunedì pomeriggio. Grazie per le nostre partite tiratissime, per le chiacchierate sulle difficoltà della vita accademica, e per le risate che ci fai sempre fare a pranzo e in Kaiser Lounge. Silvia (pron. Sylbia): tra le molte cose che abbiamo condiviso, grazie per avermi fatto rendere conto che il sessismo nel mondo accademico esiste, e tutti dobbiamo prenderne atto se vogliamo cambiare la situazione. Nicola, in questi quattro anni abbiamo brindato assieme, corso assieme per centinaia di chilometri e parlato delle cose importanti, condividendo una certa visione della vita. Dobbiamo assolutamente mantenere vive tutte queste tradizioni in futuro, ok? Sergio and Petra, thanks for the amazing moments we spent together on this and the other side of the ocean. I hope it will be soon my turn to host you during your trips to the States! Alessandra e Fabio, ci siamo conosciuti quasi alla fine di questo mio percorso, ma mi sono divertito tantissimo con voi. Grazie per le nostre cene e le nostre uscite e tantissimi auguri per il futuro!

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