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Identifying the origins of galaxy formation

Matthee, J.J.A.

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Publications

First-author publications

1. *A 10 deg² Lyman- α survey at $z=8.8$ with spectroscopic follow-up: strong constraints on the LF and implications for other surveys*
J. Matthee, D. Sobral, M. Swinbank, I. Smail, P. Best, J-W. Kim, M. Franx, B. Milvang-Jensen & J. Fynbo
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2. *Identification of the brightest Ly α emitters at $z=6.6$: implications for the evolution of the luminosity function in the re-ionisation era*
J. Matthee, D. Sobral, S. Santos, H. Röttgering, B. Darvish & B. Mobasher
2015, MNRAS, 451, 400.
3. *The CALYMHA survey: Ly α escape fraction and its dependence on galaxy properties at $z = 2.23$*
J. Matthee, D. Sobral, I. Oteo, P. Best, I. Smail, H. Röttgering & A. Paulino-Afonso
2016, MNRAS, 458, 449.
4. *The origin of scatter in the stellar mass - halo mass relation of central galaxies in the EAGLE simulation*
J. Matthee, J. Schaye, R. Crain, M. Schaller, R. Bower & T. Theuns
2017, MNRAS, 465, 2381.
5. *The production and escape of Lyman-Continuum radiation from star-forming galaxies at $z \sim 2$ and their redshift evolution*
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6. *Boötes-HiZELS: an optical to near-infrared survey of emission-line galaxies at $z = 0.4 - 4.7$*
J. Matthee, D. Sobral, P. Best, I. Smail, F. Bian, B. Darvish, H. Röttgering & X. Fan
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7. *Spectroscopic properties of luminous Lyman- α emitters at $z \approx 6 - 7$ and comparison to the Lyman-break population*
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8. *ALMA reveals metals yet no dust within multiple components in CR7*
J. Matthee, Sobral, D., F. Boone, H. Röttgering, D. Schaerer, M. Girard, A. Pallottini, L. Vallini, A. Ferrara, B. Darvish & B. Mobasher
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9. *Star-forming galaxies are predicted to lie on a fundamental plane of mass, star formation rate and α -enhancement*
J. Matthee & J. Schaye
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10. *The origin of scatter in the star formation rate - stellar mass relation*
J. Matthee & J. Schaye
 submitted to MNRAS, arXiv:1805.05956.
11. *Confirmation of double peaked Lyman- α emission at $z = 6.593$: Witnessing a galaxy directly contributing to the reionisation of the Universe*
J. Matthee, D. Sobral, M. Gronke, A. Paulino-Afonso, M. Stefanon & H. Röttgering
 submitted to A&A, arXiv:1805.11621.

Co-authored publications

1. *The Dynamics of $z = 0.8$ H α -selected Star-forming Galaxies from KMOS/CF-HiZELS*
 D. Sobral, M. Swinbank, J. Stott, **J. Matthee**, R. Bower, I. Smail, P. Best, J. Geach & R. Sharples
 2013, ApJ, 779, 139.
2. *A relationship between specific star formation rate and metallicity gradient within $z \sim 1$ galaxies from KMOS-HiZELS*
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 2014, MNRAS, 443, 2695.
3. *CF-HiZELS, a 10 deg^2 emission-line survey with spectroscopic follow-up: H α , [OIII]+H β and [OII] luminosity functions at $z=0.8, 1.4$ and 2.2*
 D. Sobral, **J. Matthee**, P. Best, I. Smail, A. Khostovan, B. Milvang-Jensen, J-W. Kim, J. Stott, J. Calhau, H. Nayyeri & B. Mobasher
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4. *Evidence for PopIII-like stellar populations in the most luminous Lyman- α emitters at the epoch of re-ionisation: spectroscopic confirmation*
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10. *The KMOS Deep Survey (KDS) - I. Dynamical measurements of typical star-forming galaxies at $z \approx 3.5$*
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11. *A 1.4 deg² blind survey for C II], C III] and C IV at $z \sim 0.7 - 1.5$ - I. Nature, morphologies and equivalent widths*
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12. *A 1.4 deg² blind survey for C II], C III] and C IV at $z \sim 0.7 - 1.5$ - II. Luminosity functions and cosmic average line ratios*
A. Stroe, D. Sobral, **J. Matthee**, J. Calhau & I. Oteo
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13. *Slicing COSMOS with SC4K: the evolution of typical Ly α emitters and the Ly α escape fraction from $z \sim 2$ to $z \sim 6$*
D. Sobral, S. Santos, **J. Matthee**, A. Paulino-Afonso, B. Ribeiro, J. Calhau & A. Khostovan
2018, MNRAS, 476, 4725.
14. *On the UV compactness and morphologies of typical Lyman- α emitters from $z \sim 2$ to $z \sim 6$*
A. Paulino-Afonso, D. Sobral, B. Ribeiro, **J. Matthee**, S. Santos, J. Calhau, A. Forshaw, A. Johnson, J. Merrick, S. Perez & O. Sheldon
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15. *The nature of luminous Lyman- α emitters at $z \sim 2 - 3$: maximal dust-poor starbursts and highly ionising AGN*
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2018, MNRAS, 477, 2817.
16. *Kiloparsec-scale gaseous clumps and star formation at $z = 5 - 7$*
S. Carniani, R. Maiolino, R. Amorin, L. Pentericci, A. Pallottini, A. Ferrara, C. Willott, R. Smit, **J. Matthee**, D. Sobral, P. Santini, M. Castellano, S. De Barros, A. Fontana, A. Grazian & L. Guaita
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17. *The clustering of $H\beta+[OIII]$ and $[OII]$ emitters since $z \sim 5$: dependencies with line luminosity and stellar mass*
A. Khostovan, D. Sobral, B. Mobasher, P. Best, I. Smail, **J. Matthee**, B. Darvish, H. Nayyeri, S. Hemmati & J. Stott
2018, MNRAS, 478, 2999.
18. *On the nature of the luminous Ly α emitter CR7 and its UV components: physical conditions and JWST predictions*
D. Sobral, **J. Matthee**, G. Brammer, A. Ferrara, L. Alegre, H. Rottgering, D. Schaerer, B. Mobasher & B. Darvish
submitted to MNRAS, arXiv:1710.08422.
19. *Predicting Lyman-alpha escape fractions with a simple observable: Lyman-alpha in emission as an empirically calibrated star formation rate indicator*
D. Sobral & **J. Matthee**.
submitted to A&A, arXiv:1803.08923.

Curriculum Vitae

I was born on 19 May 1990 in the city of Utrecht, son of Toon Matthee and Bertheke Matthee-Ruijs. Together with my brother Wouter and sister Annelotte, I grew up in the city of Roermond in the southern parts of the Netherlands where I attended primary school and high school. During my childhood I developed a strong interest in topics as mythology, ancient history, mathematics, physics, astronomy and philosophy and was often caught devouring books in stores and libraries. My first experience with astronomy was when I tried to find constellations as a young kid stargazing during dark nights in summer holidays – to little avail.

During my penultimate year in high school, I participated in the first Dutch Astronomy Olympiad in 2007, resulting in a third place after an intensive week of workshops in Leiden. Yet, I moved back to Utrecht in 2008 to enrol in the ‘Liberal arts & sciences’ bachelor program, allowing me to pursue a broad curriculum ranging from philosophy, writing and history to mathematics and theoretical physics. After attending a course on galaxy formation and cosmology, I realised I wanted to focus fully on astronomy. I obtained my BSc degree with a focus on theoretical physics and obtained my first research experience with a BSc project on the observability of multiple stellar generations in globular clusters under supervision of Søren Larsen at Sterrekundig Instituut Utrecht. During my studies I have been active in student sports associations on cycling and speed-skating.

I continued my studies with the astronomy MSc program at the Leiden Observatory in 2012. I was fortunate to arrive in a stimulating environment with enthusiastic co-students, engaged teachers and a strong emphasis on research. I worked with David Sobral on finding the most distant galaxies and joined for observing runs on La Palma in 2013 and Hawaii in 2014. My MSc thesis was performed under supervision of Joop Schaye and Rob Crain on analysing the multi-dimensional properties of simulated galaxies in the state-of-the-art EA-GLE simulation using advanced statistical techniques.

I was awarded a Huygens PhD fellowship by Leiden University to work on my own research project under supervision of David Sobral and Huub Röttgering at Sterrewacht Leiden. This allowed me to continue my observational studies of distant galaxies, but also to continue theoretical analysis with Joop Schaye that eventually led to the final three Chapters of this thesis. Throughout my PhD, I was responsible for acquiring own observational data, both from publicly available archives, but also through new observations. I (co-)authored more than 60 observing proposals for telescopes throughout the world and in space, I observed for 60 nights on the INT and WHT on La Palma and I prepared

observing instructions for 106 hours of remote observations with the MUSE and X-SHOOTER instruments on the VLT and with ALMA.

I had the opportunity to present my results to international colleagues during conferences and workshops in Sintra (Portugal), Groningen (NL), Paris (France), Kolymbari (Greece), Nunspeet (NL), Heidelberg (Germany), Salt Lake City (Utah, USA), Cambridge (UK), Leiden (NL), Liverpool (UK), Garching (Germany), Strasbourg (France) and Noordwijk (NL). I also presented my research during visits to astronomy departments in Hilo (Hawaii, USA), Lisbon (Portugal), Santa Cruz de La Palma (Spain), Riverside (California, USA), Pasadena (California, USA), Lancaster (UK) and Nijmegen (NL).

During my PhD, I was a teaching assistant for the second year BSc course 'Sterren' for three years and supervised the research projects of a MSc student and a summer student. I (co)-organised biweekly PhD talks and the Galaxies journal club for a year. I have been the referee for seven scientific articles published in MNRAS and ApJ and wrote several articles that appeared in Dutch popular science magazines. Three press releases followed from my research (based on Chapters 4, 5 and 7, respectively), of which our discovery of the CR7 galaxy had the most impact appearing in for example the New York Times, the news sections from Nature and Science magazines and being the subject of a dedicated documentary from the Japanese NHK broadcaster.

I will continue my research in astronomy as an independent Zwicky fellow at ETH in Zürich in October 2018.

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'If I have seen further it is by standing on the shoulders of giants'

– Isaac Newton

This thesis would certainly have been a bit heavier had I listed the names of the numerous 'giants' that contributed directly or indirectly, but unfortunately there is limited space available. On the other hand, perhaps it may not be the few 'giants' that helped me the most in being able to finish this thesis, but rather the numerous modest contributions from many, sometimes not even noticeable. Where to start? Who should I thank explicitly?

I could start thanking the people that helped me get to the position to be able to start a PhD project in the first place. Such as my grandparents, who taught me already early on how much fun it is to learn and to enjoy the beauty in nature and in numbers, until they were not longer able to do so. I could think of thanking my parents for their unconditional support, for being an example of what can be achieved through hard work and for raising us in an environment where each question was allowed to be asked. I could thank my close family, my brother and sister, my uncles, aunts and cousins for always showing their interest and open-mindedness. I could also pay tribute to my high school friends, whom I hope to keep for a very long time. Together we built confidence in being different, started and finished bold projects and found out that it is fine to speak out being proud about that. This mentality helped me a lot over the past few years.

I should definitely be grateful for the welcoming and stimulating environment at the Leiden Observatory that I joined when I started my MSc in 2012. The resources have been excellent – I have never been slowed by bureaucracy or computer issues, which is remarkable given the amount of time I spent behind a computer. Thanks to the support staff for making this possible, in particular to Alexandra Schouten and Erik Deul. Perhaps I could even expand this to a 'thank you' for the astronomical community in general. We should cherish excellent resources such as the arXiv, ADS and the widespread availability of data, such as the databases from Subaru, ESO and STScI, that I used extensively. While it could always be improved, astronomy is an example for other scientific disciplines due to availability of raw data and the open access to preprints that are submitted to a well defined and limited number of journals. I thank the reviewers of my thesis for their time going through these many pages. I also thank the majority of anonymous referees for the articles I (co-)authored for their constructive comments and willingness to contribute to the advancement of science without directly benefitting themselves.

Each PhD project is a journey on its own, but it is always pleasant to know you are not the only one travelling. I therefore want to thank my colleagues for sharing experiences and stories. Thanks to Aayush Saxena, Andrew Ridden-Harper, Ann-Sofie Nielsen, Chris Barber, Christian Eistrup, Eleonora Zari, Eva Bøgelund, Gabriela Calistro Rivera, Geert Jan Talens, Leindert Boogaard, Mieke Paalvast, Mike Wilby, Sierk van Terwisga and Steven Bos and many others in Leiden. Aayush, thanks for the amazing broad range of discussions reaching topics far beyond the concerns of daily life. Chris, I admire your perpetual positive state of mind and hope you never lose it. Geert Jan, it has been a pleasure being your office mate for five years and getting to know you in the meantime. Please make sure I do not lose a bet about when strong evidence for extraterrestrial life will have been found (there are only less than nine years left). Steven, thanks for your contagious enthusiasm combined with proper Dutch pragmatism, it is too bad we did not share an office for a longer time.

Thanks to my academic siblings Ali Khostovan, Ana Afonso, Andra Stroe, João Calhau and Sérgio Santos for making me feel part of a research group even though we were separated spatially. In particular, thanks for staying awake with me during the numerous observing nights and our numerous (failed) attempts to improve the weather with well-motivated rituals and sacrifices. I thank my colleagues in Leiden and abroad for numerous discussions regarding the latest preprints, aspects of my own and other research and the topic of galaxy formation in general, in particular thanks to Allison Hill, Behnam Darvish, Bruno Ribeiro, Corentin Schreiber, Daniel Schaerer, Iván Oteo, Jarle Brinchmann, Ken Duncan, Leindert Boogaard, Mauro Stefanon, Marijn Franx, Max Gronke, Michael Maseda, Philip Best, Rychard Bouwens, and Themiya Nanayakkara.

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