

## Jorryt Matthee



### Title

(Re)solving reionisation with high-redshift analogues at cosmic noon

### Abstract

The bright Lyman- $\alpha$  ( $\text{Ly}\alpha$ ) line is a key observable in studies of galaxies in the early Universe.  $\text{Ly}\alpha$  emitters (LAEs) are, by selection, in the very first stages of their formation. The  $\text{Ly}\alpha$  line profile is a tracer of the escape fraction of ionising photons and the  $\text{Ly}\alpha$  equivalent width and escape fraction trace the evolution of the neutral fraction of intergalactic gas. However, empirically, the  $\text{Ly}\alpha$  production, escape and the line profile emerging from the ISM are poorly understood at high-redshift due to the typical limited spectral resolution and the lack of rest-frame optical spectra. Currently, cosmic noon ( $z\sim 2$ ) is the ideal redshift to study LAEs in detail. These galaxies resemble galaxies in the very early Universe with their similarly short formation times, extreme emission-lines and sizes. Importantly, the rest-frame optical lines are still observable from the ground at  $z\sim 2$ . In my talk, I will present the first results of the 'XLS-z2' survey which is based on  $\sim 100$  hours of VLT/X-SHOOTER observations of 30 LAEs at  $z\sim 2$  with stellar masses  $\sim 10^9 M_{\text{sun}}$ . I will present the properties of the ISM and stellar populations that can be derived from their average UV to optical SED. I will focus in particular on the diversity in  $\text{Ly}\alpha$  line profiles and what these tell us about the structure of the ISM in young distant galaxies. Finally, I will discuss the implications for the role of galaxies in the epoch of reionisation.

# JORRYT MATTHEE

Department of Physics, ETH Zürich, Wolfgang-Pauli-Strasse 27, 8093 Zürich, Switzerland

email: mattheej@phys.ethz.ch



## RESEARCH INTERESTS

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Galaxy formation in the early Universe; Cosmic reionization; Properties of the inter-stellar medium, stellar populations and AGN; Escape of ionizing radiation; Galaxy scaling relations; Galaxy-halo connection; Star formation histories; Chemical evolution.

## CAREER & EDUCATION

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**Zwicky Fellow, ETH Zürich** *October 2018 -*  
Independent postdoctoral researcher

**PhD in Astronomy, Leiden University** *September 2018*  
Thesis: “Identifying the origins of galaxy formation”  
Promotors: prof. H. Röttgering, prof. J. Schaye, Supervisor: dr. D. Sobral (Lancaster)

**Master of Science (MSc) in Astronomy, Leiden University** *September 2014*  
De Sitter Cosmology specialisation *Cum Laude*. GPA 4.0/4.0.  
Thesis: “The origin of scatter in galaxy scaling relations”  
Supervisor: Prof. J. Schaye, dr. R. Crain

**Bachelor of Science (BSc) in Liberal Arts & Sciences, Utrecht University** *September 2012*  
Major Physics & Astronomy *Cum Laude*, GPA 4.0/4.0  
Honours minor ‘Descartes College’ on Philosophy of Science  
Thesis: “Multiple stellar generations in globular clusters”  
Supervisor: dr. Soren Larsen

## HONORS

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- MERAC Prize for best PhD Thesis in Observational Astrophysics, 2020
- IAU PhD Prize, Division J Galaxies and cosmology, International Astronomical Union, 2018
- C.J. Kok Jury Award, Best PhD thesis, Science Faculty, Leiden University, 2018
- Zwicky Prize Fellowship, ETH Zurich, 2018 -
- Huygens PhD fellowship, Leiden University, 2014-2018
- Master of Science Cum Laude, Leiden University, 2014
- Bachelor of Science Cum Laude, Utrecht University, 2012

## PUBLICATION RECORD

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I have co-authored **50 peer-reviewed publications**, of which I published **14 as first author**. These articles have acquired **1800 citations**, of which **600 on first author papers**. *h*-index: 27.

**Recent publications that I consider my most important contribution to the field:**

“ALMA Reveals Metals yet No Dust within Multiple Components in CR7”

2017, ApJ, 851, 145 (cited 61 times)

Matthee, J.; Sobral, D.; Boone, F. et al.

“Confirmation of double peaked Ly $\alpha$  emission at  $z = 6.593$ . Witnessing a galaxy directly contributing to the reionisation of the Universe”

2018, A&A, 619, 136 (cited 36 times)

Matthee, Jorjyt; Sobral, David; Gronke, Max et al.

“The origin of scatter in the star formation rate-stellar mass relation”

2019, MNRAS, 484, 915 (cited 44 times)

Matthee, Jorjyt & Schaye, Joop

## SERVICES

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- Referee for MNRAS, ApJ, Nature, Nature Astronomy, A&A.
- Organiser PhD talks in 2016 and Galaxy Journal Club in 2017-2018, both at Leiden Observatory.

## STUDENT SUPERVISION

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Supervisor **MSc thesis** research projects:

- Andrea Gebek, ETH Zurich, 2020 (now a PhD student at University of Ghent with M. Baes).
- Sergio Santos, University of Lisbon (co-supervisor), 2016 (continued to PhD at Lancaster University with D. Sobral).

Supervisor **undergraduate** research projects:

- Artem Basyrov, Yuzheng Kang and Andrea Gebek at ETH Zurich, 2019-2020.
- Bayu Wilson, summer student at Leiden Observatory, 2017.

## TEACHING

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- Substitute lecturer ‘Astrophysics I’ at ETH Zurich, 2020.
- Substitute lecturer and teaching assistant ‘Evolution of the Universe’ at ETH Zurich, 2019.
- Teaching assistant BSc course ‘Life in the Universe’ at ETH Zurich, 2019 and 2020.
- Teaching assistant for 2nd year BSc course ‘Stars’ at Leiden University in the years 2014-2017.

## AWARDED TELESCOPE TIME

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- **Principal Investigator** for **93 hours** on VLT<sub>8m</sub>/X-SHOOTER (2017A & 2018B), **6 hours** on VLT/MUSE (2017A), **36 nights** on INT<sub>2.5m</sub>/WFC (2016-2018) and **15 hours** on ALMA (Cycles 5-7).
- Co-Investigator on a total of 24 succesful proposals for 91 hours VLT, 106 hours VST, 9 hours ALMA, 16 orbits HST, 3 nights Keck, 10 nights CFHT, 15 nights WHT and 34 nights INT.

## RESEARCH PROJECTS AND EXPERIENCE

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- **Observations of distant galaxies using multi-wavelength world-class facilities in the UV, optical, near-infrared and sub-mm.**

Major science goals: understanding the physics driving the Ly $\alpha$  escape fraction; tracing how and when the Universe reionized; exploring the properties stellar populations and active nuclei at low metallicity; measuring the build up of galaxies in the first Gyr

- Proposal writing and designing, preparing and executing observations (both wide-field imaging surveys and spectroscopic follow-up campaigns).
- Pipeline development for data reduction in optical and near-infrared imaging data. Top-level reduction and analysis of optical and near-infrared slit spectroscopy, sub-mm interferometry and optical integral field spectroscopy.
- Automated object identification and photometry, emission-line selection and measurements, modelling spectral energy distributions, dynamical analysis.

- **The origin of scatter in galaxy scaling relations.**

Major science goals: identifying the connection between dark matter halo assembly and galaxy formation through multi-dimensional analysis; the connection between present-day galaxy properties and star formation histories and their imprint on chemical enrichment.

- Measurements of galaxy properties of simulated galaxies in the cosmological, hydrodynamical simulation EAGLE.
- Multi-dimensional analysis of galaxy properties, statistics of time-series (i.e. power spectra), mimicking biases in observational surveys, creating mock-spectra

## TECHNICAL STRENGTHS

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<b>Languages</b>	Dutch (native), English (expert), French (basic), German (advanced)
<b>Computer skills</b>	Python (advanced), R (basic), LaTeX (advanced), HTML (basic), C (basic), IRAF (basic), IDL (basic), Microsoft Office (advanced), Adobe Photoshop & InDesign (basic), Windows, MacOS, Linux.
<b>Astronomy software</b>	ds9, gaia, Topcat, SExtractor/Swarp/Scamp
<b>Data reduction</b>	UV-optical-NIR spectroscopy (advanced), NIR imaging (expert), optical imaging (expert), sub-mm interferometry (basic), optical integral field spectroscopy (basic)
<b>Data analysis</b>	Photometry, surface brightness profiles, stacking techniques, principal component analysis, multi-dimensional MCMC fitting, spectroscopy, photometric redshifts, 3D data-cubes.
<b>Observing</b>	45 nights optical imaging 2.5m INT/WFC (without operator), 2 nights imaging Subaru/S-Cam, 14 nights spectroscopy WHT/AF2 & LIRIS. Prepared remote observing instructions for VLT/MUSE (optical IFU), VLT/X-SHOOTER (UV-optical-NIR spectrograph).
<b>Editing</b>	Editor and (co-)writer of lustrum almanac student sports association (2012), monthly journal (2010-2012) and a novel (2006-2008).

## OUTREACH ACTIVITIES

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- Public talk ‘Witnessing the formation of galaxies’, part of a series on ‘Cosmos: Science & Arts’, Museum Boerhaave Leiden (NL), March 2020.
- Public seminar on ‘Where do we come from? An astrophysical perspective’, Windisch (CH), June 2019.
- Public talk on ‘The first stars’, Physics on Tap, ETH Zurich, March 2019.
- Public talk on ‘The first stars’, Astronomy on Tap, Leiden University, July 2018.
- Volunteered on ‘NEMO/Klokhuis vragendag’ organised by Dutch public broadcaster NTR (~ 500 participants). Answered live questions on astronomy from 6-12 year olds. May 2018.
- Research article on ALMA observations of CR7 featured in ‘NOVA’ - research highlights from the American Astronomical Society. 18 April 2018.

## OUTREACH WRITINGS

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- Publication in Dutch amateur astronomy magazine ‘Universum’, target audience 8-18 year old, Spring edition 2018, in Dutch.
- Publication in the Dutch magazine for physicists, ‘Nederlands Tijdschrift voor de Natuurkunde’, June 2017. Printed Dutch version, online Dutch+English version.
- Press release ‘Photons struggle to escape distant galaxies’, January 2017. Covered in national and international astronomy news websites.
- Press release on the CR7 galaxy through ESO, June 2015. World wide coverage in e.g. NY Times, Nature news, Phys.org, National Geographic, BBC sports, and others. Japanese NHK broadcasted a 1hr TV documentary. Story covered in several popular science magazines.

## NON-ACADEMIC INTERESTS

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Reading (literature, history, popular science, mythology, politics, economics, philosophy); Sports (practicing cycling, speedskating, hiking); Music (playing piano); Writing (fiction).