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Tracing life through light: towards detecting life on exoplanets with spectroscopy and spectropolarimetry

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Curriculum vitae

I was born in Hengelo on the 12th of July 1993, just one minute before my sister, Liesbeth. As a child, my inquisitive nature became apparent, from spending hours in the science museum's laboratory, to asking many questions. It is no wonder that my favourite television series was Willem Wever, a show that claimed to know all the answers to every question a child could think of. Around the age of eight, I sent them a letter, because I had a question as well: "Why does the Universe never stop?". Within a month, the studio called me back and apologised that they did not know the answer and asked me if I had another question about the Universe. I was so disappointed that I instantly hung up the phone, and realised that I just had to become a scientist, and answer the question myself.

At the senior general secondary education (HAVO), I was the only female student to choose all science subjects in her major. After graduating cum laude, and working hard to finish my pre-university (VWO) degree, I was super excited to started my Bachelor Sterrenkunde (Astronomy) in Groningen.

My bachelor project was to build a radio telescope from scratch, together with three peers. My responsibility was to determine the design requirements and accurately calibrate the instrument.

During my Master's degree, I explored a broad range of topics - from theoretical astrophysics to instrumentation and even business aspects of science. As part of my Master's research, I contributed to the development of an evolving astrometric reference system in collaboration with the Euclid consortium, and completed an internship at ASTRON (the Netherlands Institute for Radio Astronomy). There, I was challenged to apply machine learning techniques to improve the health monitoring of the LOFAR radio telescope system. With no predefined approach, I independently explored, selected, and implemented suitable methods.

Beyond my studies, I enjoyed sharing my enthusiasm for astronomy: promoting the astronomy degree in Groningen to pre-university students, engaging with the general public during outreach events, and tutoring physics at high schools. In the later years of my Master's, I coordinated the Blaauw Observatory, where I managed the mobile planetarium and organized open nights and public events.

After the opportunity arose to join a conference covering the topic of astronomical outreach in Japan, I realised I could continue my astronomy career with a PhD. It was that same year that I met my future-supervisor, Frans Snik, at the Dutch Conference for Astronomy, during a presentation about artists that use Astronomy as inspiration. I sent a letter to the University of Leiden, specifically directed to Frans, to apply for one of the instrumentation projects he was offering. My application was successful, and I begun my PhD research in collaboration with the instrumentation group at the Leiden Observatory and the planetary group from the Technical University of Delft.

The project took an interdisciplinary approach to develop a full-Stokes spectropolarimetric model of Earth, implementing data that we would collect ourselves using in-house developed spectropolarimeters.

During my PhD, I collaborated with a fantastic team of astronomers and physicists from Leiden University, the University of Bern, the University of Maryland, and the University of Central Florida. With this team I was able to calibrate spectropolarimeters, use them during various field campaigns, and simulated Earth-like exoplanets using radiative transfer models. In the final year of my PhD, I joined Leiden's exoplanet group, where I explored the fascinating atmospheres of brown dwarfs.

In February 2025, I started working as a senior data specialist at Valcon in Utrecht. Here I am combining my ability to quickly switch between different projects, communicate with data scientists, engineers, customers and other stakeholders. From May 2025, I have been lucky to become part of ProRail's computer vision team, where we analyse images from measurement trains and ensure rail safety. As a consultant, I learn new skills every day.

List of publications

Refereed publications

1. *The ESO SupJup Survey VI: $^{12}\text{C}/^{13}\text{C}$ isotope ratio comparison of three L-type brown dwarfs*
Mulder, W., de Regt, S., Landman, R., González Picos, D., Snellen, I. A. G., Zhang, Y., Gandhi, S., Ginski, C., Kesseli, A. Y., Mollière, P., Nasedkin, E., Sánchez-López, A., Stolker, T.
Astronomy and Astrophysics, 694, A164 (2025)
DOI: [10.1051/0004-6361/202452859](https://doi.org/10.1051/0004-6361/202452859)

Non-refereed publications

1. *Spectropolarimetry of life: airborne measurements from a hot air balloon*
Mulder, W., Doelman, Patty, L.C.U., Spadaccia, S., et al.
Light in Nature (SPIE) Conf. Series, 12214, 1221404 (2022),
DOI: [10.1117/12.2633271](https://doi.org/10.1117/12.2633271)
2. *Spatial polarization modulators: distinguishing diffraction effects from spatial polarization modulation*
Mulder, W., Doelman, D.S., Keller, C.U., Patty, L.C.U., Snik, F.
Polarization Science & Remote Sensing (SPIE) Conf. Series, 11833, 118330M (2021),
DOI: [10.1117/12.2595152](https://doi.org/10.1117/12.2595152)

Co-author publications

1. *Conceptual design and prototyping of a three-color polarimetric imaging instrument for auroral observations*
Stockmans, T.A., Strelow, K., Scheinowitz, N., Fagginger Auer, F., **Mulder, W.**, Stuik, R., Cessateur, G., Bosse, L., Lamy, H., and Snik, F.
Journal of Space Weather and Space Climate (*submitted* 2025),
DOI: [xx.xxxx/xxxx](https://doi.org/xx.xxxx/xxxx)

2. *ESO SupJup Survey VIII: Chemical fingerprints of young L dwarf twins*
Grasser, N., Snellen, I. A. G., de Regt, S., González Picos, D., Zhang, Y., Mollière, P., Stolker, T., Gandhi, S., Nasedki, E., Landman, R., Allard, N. F., Ginski, C., Kesseli, A. Y., **Mulder, W.**, and Sánchez-López, A.,
Astronomy & Astrophysics, 698, A252 (2025),
DOI: [10.1051/0004-6361/202554195](https://doi.org/10.1051/0004-6361/202554195)
3. *ESO SupJup Survey V: Exploring Atmospheric Variability and Orbit of the Super-Jupiter AB Pictoris b with CRILES+*
Gandhi, S., de Regt, S., Snellen, I. A. G., Palma-Bifani, P., Abdoulwahab, I., Chauvin, G., González Picos, D., Zhang, Y., Landman, R., Stolker, T., Kesseli, A. Y., **Mulder, W.**, Chomez, A., Lagrange and A., Zurlo, A.
Monthly Notices of the Royal Astronomical Society, (2024),
DOI: [10.1093/mnras/staf004](https://doi.org/10.1093/mnras/staf004)
4. *Polarized Signatures of a Habitable World: Comparing Models of an Exoplanet Earth with Visible and Near-infrared Earthshine Spectra*
Gordon, E.K., Karalidi, T., Bott, K.M., Miles-Páez, P.A., **Mulder, W.**, Stam, D.M.
the Astrophysical Journal 945 166 (2023),
DOI: [10.3847/1538-4357/aca7fe](https://doi.org/10.3847/1538-4357/aca7fe)
5. *Biosignatures of the Earth: I. Airborne spectropolarimetric detection of photosynthetic life*
Patty, C.H.L., Kühn, J.G., Lambrev, P.H., Spadaccia, S., Hoeijmakers, J.H., Keller, C.U., **Mulder, W.**, Pallichadath, V., Poch, O., Snik, F., Stam, D.M., Pommerol, A., Demory, B.O.
Astronomy & Astrophysics, 651, A68 (2021),
DOI: [10.1051/0004-6361/202140845](https://doi.org/10.1051/0004-6361/202140845)
6. *Comparing Models of an Exoplanet-Earth to Earthshine Observations*
Gordon, K.E., Karalidi, T., Miles-Páez, P.A., Stam, D.M., Bott, K.M., **Mulder, W.**
Bulletin of the AAS, AAS, 53(1). (2021),
URL: baas.aas.org/pub/2021n1i505p03

Acknowledgments

Much like planetary orbits, my progress in this thesis had its fair share of eccentricities, perturbations, and unexpected retrograde motions. But thanks to an incredible support system, of subsequently named people, I've managed to stay in a trajectory toward completion. In my search for life beyond Earth, I have at least confirmed one thing - intelligent life remains elusive. Fortunately, my advisors, colleagues, friends, and coffee supply have provided enough habitability conditions to sustain this academic mission.

Christoph, thank you for the time and effort you put into guiding me and my research, even after moving to the US. I am especially grateful for the incredible hospitality you and Rennie showed me during my stay in Flagstaff, Arizona. **Ignas**, thank you for your unwavering support in the final year of my PhD. You welcomed me into the exoplanet group with open arms, making sure I felt part of the team. Your guidance and help during the last year made all the difference. **Frans**, your enthusiasm for science (and science communication) is truly endless and contagious. I am grateful we had the opportunity to work together and that I was able to visit you and Sabina multiple times in Utrecht for inspiring conversations and invaluable support. **Daphne**, the planetary science community has lost not only an incredibly strong woman but above all, an extraordinary scientist. You were the one who introduced me to this field, and for that, I will always be grateful.

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