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## **Tuning in to the feedback bassline: revealing the operation of AGNs in galaxy clusters with high-resolution radio observations**

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# PUBLICATIONS

## First author

1. *The first high-redshift cavity power measurements of cool-core galaxy clusters with the International LOFAR Telescope*  
**R. Timmerman**, R. J. van Weeren, A. Botteon, H. J. A. Röttgering, L. K. Morabito and F. Sweijen  
Submitted to *Astronomy & Astrophysics*.
2. *Measuring cavity powers of active galactic nuclei in clusters using a hybrid X-ray-radio method*  
**R. Timmerman**, R. J. van Weeren, A. Botteon, H. J. A. Röttgering, B. R. McNamara, F. Sweijen, L. Birzan and L. K. Morabito  
*Astronomy & Astrophysics*, 2022, 668, A65
3. *Origin of the ring structures in Hercules A*  
**R. Timmerman**, R. J. van Weeren, J. R. Callingham, W. D. Cotton, R. Perley, L. K. Morabito, N. A. B. Gizani, A. H. Bridle, C. P. O’Dea, S. A. Baum, G. R. Tremblay, P. Kharb, N. E. Kassim, H. J. A. Röttgering, A. Botteon, F. Sweijen, C. Tasse, M. Brüggen, J. Moldon, T. Shimwell and G. Brunetti  
*Astronomy & Astrophysics*, 2022, 658, A5
4. *Very Large Array observations of the mini-halo and AGN feedback in the Phoenix cluster*  
**R. Timmerman**, R. J. van Weeren, M. McDonald, A. Ignesti, B. R. McNamara, J. Hlavacek-Larrondo and H. J. A. Röttgering  
*Astronomy & Astrophysics*, 2021, 646, A38

## Contributing author

1. *A novel radio imaging method for physical spectral index modelling*  
E. Ceccotti, A. R. Offringa, L. V. E. Koopmans, **R. Timmerman**, S. A. Brackenhoff, B. K. Gehlot, F. G. Mertens, S. Munshi, V. N. Pandey, R. J. van Weeren, S. Yatawatta and S. Zaroubi  
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2. *A ‘MeerKAT-meets-LOFAR’ study of Abell 1413: a moderately disturbed non-cool-core cluster hosting a  $\sim 500$  kpc ‘mini’-halo*

- C. J. Riseley, N. Biava, G. Lusetti, A. Bonafede, E. Bonnassieux, A. Botteon, F. Loi, G. Brunetti, R. Cassano, E. Osinga, K. Rajpurohit, H. J. A. Röttgering, T. Shimwell, **R. Timmerman**, R. J. van Weeren  
*Monthly Notices of the Royal Astronomical Society*, 2023, 524, 4, 6052
3. *VLBI imaging of high-redshift galaxies and protoclusters at low radio frequencies with the International LOFAR Telescope*  
 C. M. Cordun, **R. Timmerman**, G. K. Miley, R. J. van Weeren, F. Sweijen, L. K. Morabito and H. J. A. Röttgering  
*Astronomy & Astrophysics*, 2023, 676, A29
  4. *V-LoTSS: The circularly polarised LOFAR Two-metre Sky Survey*  
 J. R. Callingham, T. W. Shimwell, H. K. Vedantham, C. G. Bassa, S. P. O'Sullivan, T. W. H. Yiu, S. Bloor, P. N. Best, M. J. Hardcastle, M. Haverkorn, R. D. Kavanagh, L. Lamy, B. J. S. Pope, H. J. A. Röttgering, D. J. Schwarz, C. Tasse, R. J. van Weeren, G. J. White, P. Zarka, D. J. Bomans, A. Bonafede, M. Bonato, A. Botteon, M. Brüggen, K. T. Chyży, A. Drabent, K. L. Emig, A. J. Gloudemans, G. Gürkan, M. Hajduk, D. N. Hoang, M. Hoeft, M. Iacobelli, M. Kadler, M. Kunert-Bajraszewska, B. Mingo, L. K. Morabito, D. G. Nair, M. Pérez-Torres, T. P. Ray, C. J. Riseley, A. Rowlinson, S. Shulevski, F. Sweijen, **R. Timmerman**, M. Vaccari and J. Zheng  
*Astronomy & Astrophysics*, 2023, 670, A124
  5. *The LOFAR Two-metre Sky Survey – V. Second data release*  
 T. W. Shimwell, M. J. Hardcastle, C. Tasse, P. N. Best, H. J. A. Röttgering, W. L. Williams, A. Botteon, A. Drabent, A. Mechev, A. Shulevski, R. J. van Weeren, L. Bester, M. Brüggen, G. Brunetti, J. R. Callingham, K. T. Chyży, J. E. Conway, T. J. Dijkema, K. Duncan, F. de Gasperin, C. L. Hale, M. Haverkorn, B. Hugo, N. Jackson, M. Mevius, G. K. Miley, L. K. Morabito, R. Morganti, A. Offringa, J. B. R. Oonk, D. Rafferty, J. Sabater, D. J. B. Smith, D. J. Schwarz, O. Smirnov, S. P. O'Sullivan, H. Vedantham, G. J. White, J. G. Albert, L. Alegre, B. Asabere, D. J. Bacon, A. Bonafede, E. Bonnassieux, M. Brienza, M. Bilicki, M. Bonato, G. Calistro Rivera, R. Cassano, R. Cochrane, J. H. Croston, V. Cuciti, D. Dallacasa, A. Danezi, R. J. Dettmar, G. Di Gennaro, H. W. Edler, T. A. Enßlin, K. L. Emig, T. M. O. Franzen, C. García-Vergara, Y. G. Grange, G. Gürkan, M. Hajduk, G. Heald, V. Heesen, D. N. Hoang, M. Hoeft, C. Horellou, M. Iacobelli, M. Jamrozy, V. Jelić, R. Kondapally, P. Kukreti, M. Kunert-Bajraszewska, M. Magliocchetti, V. Mahatma, K. Małek, S. Mandal, F. Massaro, Z. Meyer-Zhao, B. Mingo, R. I. J. Mostert, D. G. Nair, S. J. Nakoneczny, B. Nikiel-Wroczyński, E. Orrú, U. Pajdosz-Śmierciak, T. Pasini, I. Prandoni, H. E. van Piggelen, K. Rajpurohit, E. Retana-Montenegro, C. J. Riseley, A. Rowlinson, A. Saxena, C. Schrijvers, F. Sweijen, T. M. Siewert, **R. Timmerman**, M. Vaccari, J. Vink, J. L. West, A. Wołowska, X. Zhang and J. Zheng  
*Astronomy & Astrophysics*, 2022, 659, A1
  6. *LoTSS Jellyfish Galaxies III. The first identification of jellyfish galaxies in the Perseus cluster*

- I. D. Roberts, R. J. van Weeren, **R. Timmerman**, A. Botteon, M. Gendron-Marsolais, A. Ignesti and H. J. A. Röttgering  
Astronomy & Astrophysics, 2022, 658, A44
7. *A MeerKAT-meets-LOFAR Study of MS 1455.0+2232: A 590 kiloparsec 'Mini'-Halo in a Sloshing Cool-Core Cluster*  
C. J. Riseley, K. Rajpurohit, F. Loi, A. Botteon, **R. Timmerman**, N. Biava, A. Bonafede, E. Bonnassieux, G. Brunetti, T. Enßlin, G. Di Gennaro, A. Ignesti, T. Shimwell, C. Stuardi, T. Vernstrom and R. J. van Weeren  
Monthly Notices of the Royal Astronomical Society, 2022, 512, 3, 4210



# CURRICULUM VITAE

I was born on August 6, 1996, in the city of Meppel in the Netherlands. Despite initial efforts from my father during my toddlerhood to guide me into a career as a carpenter, like most of my family, it quickly became clear that my career prospects lay elsewhere. However, I did not see myself pursuing a career in science during the majority of my childhood, even though science was something I had a keen interest in. During my childhood, one of my main interests was in computers, which I could imagine myself doing as a career whenever I failed to avoid thinking about my future. At the age of 12, I started my VWO at the Greydanus College in Meppel and later Zwolle. During this time, I thoroughly enjoyed following physics, chemistry, mathematics and computer science classes. I made friends with a few amazing people, whom I am still in contact with to this day, and found it incredibly helpful to have friends who were as passionate as I was in these topics. When the time came at the end of my VWO to find a university programme, I initially looked into going to Utrecht to pursue either computer science or game development together with a friend. However, I was also attracted to the physics and astronomy programme in Utrecht, and attended a few information days. To my disappointment, I discovered that the astronomy component was practically non-existent, which made me realize for the first time that I actually would be very interested in pursuing astronomy. Ironically, it was this lack of astronomy in Utrecht which revitalized the interest in astronomy I have had since I was a child. I subsequently attended a few information days at the Kapteyn Astronomical Institute in Groningen and was immediately hooked. I finished my VWO and enthusiastically moved to Groningen to join the BSc Sterrenkunde programme.

During my bachelor's, I passionately followed physics, mathematics and astronomy courses. Again, I made new friends who were equally invested in learning about the nature of our Universe, and together we attended classes, made homework and prepared for exams. I still consider these friends to be my best friends, and will always appreciate the support they've given me during my bachelor's. In my third year, I followed the radio astronomy course by Dr. John McKean, and fell in love with this area of astronomy. After having successfully broken my cum laude streak with a 6 for the radio astronomy exam, I approached John for a BSc project. John offered me an exciting project on a distant lensed quasar, which required me to process 80 hours of 22 GHz Very Large Array data divided over 42 separate observations. To give me the best training possible, he told me to download the data from the archive without the flags applied by the observatory, so I would have to manually go through the observations to spot erroneous data.

Thanks to extra help from Cristiana Spingola and Hannah Stacey, I reduced and imaged all 80 hours of data, and my love for radio interferometry was awakened. I also first tasted what it was like to do research, and also fell in love with this practical aspect of science. I remember being disappointed to discover it was Friday afternoon, meaning I had to wait till Monday before I got to work on my project again. Unlike during courses, when all the information was presented to you during organized lectures, research requires that you fight for knowledge and insight using your curiosity, persistence and attention to detail. It felt amazing to be curious again on a daily basis and look into the Universe to discover its secrets. After my BSc project, I continued with a master's programme at the Kapteyn Astronomical Institute in Groningen and did not hesitate to approach John again for a project. This time, we would be working on a distant lensed quasar using High Sensitivity Array (HSA) observations, which include the VLBA, VLA, Effelsberg, Arecibo and the Greenbank Telescope (GBT). Unfortunately, Arecibo was offline due to hurricane damage, robbing me of my only opportunity to work with this telescope before old age took it from us. Additionally, the Effelsberg data was lost and the VLA was phased up in A-configuration instead of D-configuration, making it rather useless for HSA purposes. Fortunately, I was still able to obtain my first VLBI experience, reducing and imaging the VLBA and GBT observations in AIPS. Again, I loved every moment of this observational radio astronomy project, which reinforced my desire to pursue a PhD in this direction.

After obtaining my MSc degree cum laude in 2019, I was fortunate enough to be able to continue my academic career with my #1 choice: the LOFAR-VLBI project on radio-mode feedback in clusters at Leiden Observatory under the supervision of Reinout van Weeren. The following four years became some of the best years of my life. I've been able to enjoy the company of some amazing people in the LOFAR group, the observatory and on my trips abroad. I've been able to visit the USA during the 7th VLA Data Reduction School. I attended the LOFAR KSP Meeting in Turin at the end of 2019 before COVID shut everything down, and I've more than compensated for the following lockdown with an observation trip to La Palma to assist with observations for Ian Roberts, LOFAR Family meetings in Cologne and Olsztyn, the IAU General Assembly in South Korea, the SPARCS meeting in South Africa, the VLBI anniversary in Bologna for an invited talk, and LOFAR Long Baseline Busy Weeks in Durham and Paris. During my PhD, I have gained extensive experience with the calibration of LOFAR-VLBI observations, and look forward towards a bright future of radio astronomy where we can make these observations more accessible to the general community. Additionally, the SKA and ngVLA are approaching rapidly, offering a lot to be excited for.

Following my PhD, I will proceed with a postdoc at Durham University in the United Kingdom, where I will be working with Dr. Leah Morabito. In Durham, I will continue in the same research direction, studying radio-mode feedback in galaxy clusters with LOFAR-VLBI observations, but then shifting my focus more towards the high-redshift regime where I started my academic career.

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When I started my PhD in Leiden, I could not have imagined what a beautiful time was ahead of me. Even despite the COVID-19 pandemic, I have enjoyed some of the most amazing years I could have asked for. I am extremely grateful to all my friends, colleagues, and everyone else for this unforgettable experience.

I want to start with my supervisor, Reinout. You told me one should never thank their supervisor because they are simply doing the job they're supposed to do, but you did so much more than that. Not only were you the most knowledgeable, helpful, patient, and supportive supervisor, but you are also one of the nicest, humblest, and friendliest people I know. You will always be a role model to me and so many others. You have guided me smoothly through my PhD, helped me develop myself into an independent researcher and prepared me for the next exciting steps in my career.

Huub, you have been a great second supervisor for me. You have always been supportive, while also never failing to seize an opportunity to challenge my research. You have made me a better researcher, and I will frequently ask myself "what would Huub say?" in my future career. I have really enjoyed working with you.

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