

Nikki Zabel



Title

Galaxy evolution in dense environments: a study of the cold ISM in the Fornax cluster

Abstract

Many galaxies in the local Universe do not live alone, but in groups or even clusters. With many galaxies in little space, as well as the presence of a hot intracluster medium (ICM), the evolution of these galaxies is different from their isolated counterparts. In particular, galaxy clusters host a relatively high number of passive galaxies. Several mechanisms play a role in this, related to the ICM (e.g. ram pressure stripping) or the galaxy number density (e.g. galaxy-galaxy interactions). That these mechanisms affect the atomic gas in galaxies (HI) is well known. However, whether it also affects the more tightly bound and centrally located molecular gas (H₂) is less obvious. In this talk I will present results from the ALMA Fornax Cluster Survey (AlFoCS), an ALMA survey of the CO in Fornax cluster galaxies. I will discuss the molecular gas content in these galaxies, show resolved images of its morphology and kinematics, and show how it differs from galaxies in the field at fixed stellar mass.

Furthermore, I will present results from the collaboration I lead between AlFoCS and the MUSE survey Fornax3D, in which we exploit the powers of ALMA and MUSE to study the resolved star formation relation (Kennicutt-Schmidt relation) in Fornax galaxies. Lastly, I will show some surprising recent results of a study of gas-to-dust ratios in the Fornax cluster compared to the Virgo cluster and the field, using data from ALMA, Herschel, ATCA, and MUSE.

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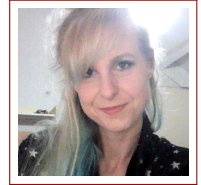
Curriculum Vitae

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Research Interests

I have a broad interest in topics within the field of galaxy evolution. My current research focuses on galaxy evolution in dense environments, in particular how environment affects different phases of the interstellar medium and star formation. My expertise lies in working with interferometry data of nearby galaxies (in particular from ALMA) and multi-wavelength observations (e.g. FIR data, and data from optical IFUs). Currently, I am learning to work with data from large HI surveys, in particular from WSRT-Apertif.

Professional Appointments

2020–present **Postdoctoral Researcher**, *University of Groningen*.

Education

- 2017–2021 **PhD “The Fornax galaxy cluster, unveiled in CO: how dense environments drive galaxy evolution”**, *Cardiff University*, Dr. Timothy Davis, Prof. Haley Gomez.
- 2014–2016 **Master of Science in “Research in Astronomy”**, *Leiden University*.
- 2010–2014 **Bachelor of Science in “Astronomy”**, *Leiden University*.

Publications – first author

- [1] **Nikki Zabel**, Timothy A. Davis, Matthew W. L. Smith, Natasha Maddox, George J. Bendo, Reynier Peletier, Enrichetta Iodice, Aku Venhola, Maarten Baes, Jonathan I. Davies, Ilse de Looze, Haley Gomez, Marco Grossi, Jeffrey D. P. Kenney, Paolo Serra, Freeke van de Voort, Catherine Vlahakis, and Lisa M. Young. The ALMA Fornax Cluster Survey I: stirring and stripping of the molecular gas in cluster galaxies. *MNRAS*, 483(2):2251–2268, Feb 2019.
- [2] **N. Zabel**, T. A. Davis, M. Sarzi, Boris Nedelchev, M. Chevance, J. M. Diederik Kruijssen, E. Iodice, M. Baes, G. J. Bendo, E. Maria Corsini, I. De Looze, P. Tim de Zeeuw, D. A. Gadotti, M. Grossi, R. Peletier, F. Pinna, Paolo Serra, F. van de Voort, A. Venhola, S. Viaene, and C. Vlahakis. ALFoCS + Fornax3D: resolved star formation in the Fornax cluster with ALMA and MUSE. *MNRAS*, 496(2):2155–2182, June 2020.
- [3] **Nikki Zabel**, Timothy A. Davis, Matthew W. L. Smith, Marc Sarzi, Alessandro Loni, Paolo Serra, Maritza A. Lara-López, Phil Cigan, Maarten Baes, George J. Bendo, Ilse De Looze, Enrichetta Iodice, Dane Kleiner, Bärbel S. Koribalski, Reynier Peletier, Francesca Pinna, and P. Tim de Zeeuw. ALFoCS + F3D II: unexpectedly low gas-to-dust ratios in the Fornax galaxy cluster. *MNRAS*, February 2021.

Publications – co-author

- [1] Timothy A. Davis, Jenny E. Greene, Chung-Pei Ma, John P. Blakeslee, James M. Dawson, Viraj Pandya, Melanie Veale, and **Nikki Zabel**. The MASSIVE survey - XI. What drives the molecular gas properties of early-type galaxies. *MNRAS*, 486(1):1404–1423, Jun 2019.
- [2] James M Dawson, Timothy A Davis, Edward L Gomez, Justus Schock, **Nikki Zabel**, and Thomas G Williams. Using machine learning to study the kinematics of cold gas in galaxies. *Monthly Notices of the Royal Astronomical Society*, 491(2):2506–2519, 11 2019.
- [3] M. A. Raj, E. Iodice, N. R. Napolitano, M. Spavone, H. S. Su, R. F. Peletier, T. A. Davis, **N. Zabel**, M. Hilker, S. Mieske, J. Falcon Barroso, M. Cantiello, G. van de Ven, A. E. Watkins, H. Salo, P. Schipani, M. Capaccioli, and A. Venhola. The Fornax Deep Survey with the VST. VII. Evolution and structure of late type galaxies inside the virial radius of the Fornax cluster. *AAP*, 628:A4, Aug 2019.

- [4] S. Viaene, M. Sarzi, **N. Zabel**, L. Coccato, E. M. Corsini, T. A. Davis, P. De Vis, P. T. de Zeeuw, J. Falcón-Barroso, D. A. Gadotti, E. Iodice, M. Lyubenova, R. McDermid, L. Morelli, B. Nedelchev, F. Pinna, T. W. Spriggs, and G. van de Ven. The Fornax 3D project: dust mix and gas properties in the centre of early-type galaxy FCC 167. *AAP*, 622:A89, Feb 2019.
- [5] A. Loni, P. Serra, D. Kleiner, L. Cortese, B. Catinella, B. Koribalski, T. H. Jarrett, D. Cs. Molnar, T. A. Davis, E. Iodice, K. Lee-Waddell, F. Loi, F. M. Maccagni, R. Peletier, A. Popping, M. Ramatsoku, M. W. L. Smith, and **N. Zabel**. A blind ATCA HI survey of the Fornax galaxy cluster: properties of the HI detections. *arXiv e-prints*, page arXiv:2102.01185, February 2021.

Research Experience

Large HI surveys.

I am currently involved in the data reduction, source detection, and scientific analysis of HI imaging data from the WSRT Apertif Medium-Deep Survey. This survey covers ~ 60 square degrees of the Perseus-Pisces supercluster. The main focus of the scientific analysis is the resolved HI morphologies and kinematics as diagnostics for environmental processes, in particular along their infall trajectories into clusters.

Interferometry data.

I have performed manual reduction of a set of interferometry data for 30 galaxies from ALMA. Furthermore, I am a key member of the Data Reduction Working Group of the ALMA large program "The Virgo Environment Traced in CO" (VERTICO), which is investigating the effect of environment on molecular gas by mapping the distribution of CO(2-1) in a representative sample of 51 spiral galaxies in the Virgo cluster using the Atacama Compact Array. I have written the data products pipeline for this program, which creates moment maps, PVDs, radial profiles, etc., for all galaxies. I have also attended several schools and training in the area of interferometry and data processing (see below).

Multi-wavelength astronomy.

Much of my research focuses on relating the different phases of the ISM. I have worked with a variety of datasets across the electromagnetic spectrum, including the optical, near and far infrared, and (sub-)millimetre, both using photometry and spectroscopy.

The molecular ISM.

My research has mainly focused on the molecular interstellar medium. I have studied the morphology and kinematics of molecular gas in a variety of galaxies, and have developed expertise in kinematic modelling to extract physical parameters.

Observing.

I have observed with MUSE (mounted to one of the Very Large Telescope (VLT) telescopes) during the night of 22 November 2019 (in Visitor Mode). Furthermore, I have observing experience with the Institut de Radioastronomie Millimétrique (IRAM) 30 meter telescope, with which I have performed observations during the nights of 1 - 5 June 2018, the nights of 28 December 2019 - 1 January 2020, the nights of 14 - 16 May 2020 (remotely), and 18 July 2020 (remotely). Last, I have observed with the Michigan/Magellan Fiber Spectrograph (M2FS), mounted on the Clay Telescope (Magellan II) at Las Campanas Observatory, during the nights of 19 - 22 May 2017.

Telescope proposals.

I have submitted a successful telescope proposal to VLT/MUSE, programme ID 0104.A-0734: "Disturbed dwarfs in the Fornax cluster: ram pressure stripping and other quenching mechanisms at work."

I have also submitted a successful telescope proposal to the IRAM 30 meter telescope, programme 196-19: "The IRAM COCO survey: CO in the Coma cluster".

Furthermore, I have submitted several proposals to ALMA that were ranked in the second quartile: (e.g. programme ID 019.1.00817.S: "Capturing preprocessing and enhanced environmental effects in the infalling subgroup around Fornax A"), which I aim to resubmit in future cycles.

Peer review.

I have reviewed 20 telescope proposals for the supplementary ACA call for proposals during the autumn of 2019.

Major master thesis.

title	<i>Polycyclic Aromatic Hydrocarbon in regions of massive star formation</i>
supervisors	Prof. dr. A.G.G.M. Tielens, Dr. B.W. Holwerda
description	I studied the morphology of stellar superbubbles as revealed by the emission of polycyclic aromatic hydrocarbon (PAH) emission in the nearby galaxy M51, and their relation to massive stellar clusters. I studied the processing of PAH by stellar light and shocks. I compared observations with models of the interactions between massive stars and the ISM, and with lab studies.

Minor master thesis.

title *Dusty steps: the extreme CO ladders of the U/LIRGs Arp 220 & NGC 4418*
supervisor Prof. dr. P. van der Werf
description I modelled the CO rotational ladders of the U/LIRGS NGC4418 and Apr220, to investigate whether the dust radiation field is (partly) responsible for the excess CO emission at the higher transitions in the ladder in these extreme environments.

Bachelor thesis.

title *Improving Nebular Abundances*
supervisor Dr. J. Brinchmann
description I studied the influence of the uncertainty in the atomic parameters used in the models used for calculations of the oxygen abundances in HII regions in galaxies. I created my own calibration for these abundances, using nitrogen as an indicator rather than oxygen.

Teaching Experience

2017–2020 **Teaching Assistant**, *Cardiff University*.
I was a Teaching Assistant for the first year courses “Electricity, Magnetism, and Waves” and “Mathematical Methods for Physicists 2”, as well as the second year courses “Structured Programming”, “Observation Techniques in Astronomy” and “Observing the Universe”. The main focus in these last two courses was to help students write a telescope proposal, and help them with the data reduction and results.

2013–2015 **Teaching Assistant**, *Leiden Observatory*.
I was a Teaching Assistant for the first year course Introduction to Astrophysics for two years. My main tasks were teaching problem classes, and marking homework and exams.

2011–2013 **Tutor**, *StudentsPlus Tutoring*, Leiden.
During my student time, I worked as a tutor for high-school students. I helped them out with their homework for physics, mathematics, and chemistry.

Invited Talks & Seminars

2019 **ESO Santiago**, *Lunch talk*, “How does the galaxy cluster environment affect molecular gas and star formation? - The ALMA Fornax Cluster Survey”.

2019 **MPIA Heidelberg**, *Coffee talk*, “The ALMA Fornax Cluster Survey & F3D: resolved molecular gas and star formation in the Fornax cluster”.

2019 **Stockholm University**, *Seminar*, “How does the galaxy cluster environment affect molecular gas and star formation? - The ALMA Fornax Cluster Survey”.

2019 **Groningen University**, *Lunch talk*, “The ALMA Fornax cluster survey: Stirring and stripping of the molecular gas in cluster galaxies”.

2018 **Armagh Observatory**, *Seminar*, “The ALMA Fornax cluster survey: Stirring and stripping of the molecular gas in cluster galaxies”.

Highlighted Contributed Talks

2019 **ALMABO19**, *Conference* “Views on the ISM in galaxies in the ALMA era”, “The ALMA Fornax cluster survey: Stirring and stripping of the molecular gas in cluster galaxies”.

2019 **Royal Astronomical Society meeting**, *Meeting* “Quenching galaxies at low and high redshift”, “The ALMA Fornax cluster survey: Stirring and stripping of the molecular gas in cluster galaxies”.

2018 **Cardiff University**, *Postgrad Conference*, “The ALMA Fornax cluster survey: Stirring and stripping of the molecular gas in cluster galaxies”.

2018 **EWASS/NAM**, *Conference*, “The ALMA Fornax cluster survey: How do dense environments drive galaxy evolution?”.

2018 **BBECss**, *Postgrad Conference*, “The ALMA Fornax cluster survey: How do dense environments drive galaxy evolution?”.

Schools & Training

2020 **17th Synthesis Imaging Workshop**, *National Radio Astronomy Observatory (NRAO)*, A virtual school on various aspects of synthesis imaging, spread over several weeks..

- 2018 **ALMA Data Processing Workshop**, *The Portuguese ALMA Center of Expertise (PACE)*, I have attended a three-day school on ALMA data reduction (using CASA) and interferometry in general.
- 2018 **Training at the UK ALMA Regional Centre**, *The University of Manchester*, I spent three days at the UK ALMA Regional Centre to receive direct support doing ALMA data reduction.
- 2018 **Various Doctoral Academy workshops**, *Cardiff University*, I have attended a number of workshops on a variety of topics, both teaching related (e.g. unconscious bias) and research related (e.g. statistics, programming).

Outreach

- 2019–present **Writer for Popular Astronomy**.
I write for the AstroNews section of Popular Astronomy. This is the members magazine for the Society of Popular Astronomy, whose target audience is amateur astronomers.
- February 2020 **Volunteer at Cardiff Science Festival**, *Cardiff*.
As a volunteer, I helped out with several public events related to the Science Festival: an annual, nationwide science event for the public.
- 2018–2019 **Team Leader Pint of Science**, *Cardiff*.
I led the team in charge of the organisation of the session “From Atoms to Galaxies” during Pint of Science 2019. Pint of Science is an outreach event spanning three evenings filled with talks and activities for the general public.
- 2015–2016 **Team Leader Astronomy Olympiad**, *Leiden Observatory*.
I chaired the committee in charge of organising the Astronomy Olympiad 2016 (an astronomy contest for students in the last year of high school). My team was both in charge of organising the contest itself (designing and marking questions), and organising a three-day final at the university, including lectures, excursions, and a final exam with award ceremony.
- 2012–2015 **Student Ambassador**, *Leiden University*.
As a student ambassador I was concerned with the recruitment of new students, as part of the PR team of the Physics and Astronomy department. My tasks included the organisation of open days, giving talks during open days and at schools, talking to prospective students and showing them around, and joining various trainings and meetings.
- 2011–2012 **Outreach Ambassador**, *Universe Awareness*, Leiden.
As an outreach ambassador for Universe Awareness, an initiative to interest children in and educate them about astronomy, I helped out with several events at schools and museums.
- 2010–2011 **Volunteer**, *RINO foundation*, Leiden.
As a volunteer at the RINO foundation I gave the physics demonstration “Freezing Physics” at various high schools in the Netherlands. The goals of the RINO foundation is to make high school students enthusiastic about physics.

Other Relevant Extracurricular Activities

- 2017–2020 **PostGrad Representative**, *Cardiff University*, Cardiff.
Throughout my PhD, I have been representative for my peers. This means that I am their point of contact in case they face any issues (both research and teaching related) and I form a connection between young researchers and the School and University. I attend several meetings on the school and university level.
- 2012–2013 **Assessor Education & Book Sales, Vice-president**, *Study Association De Leidsche Flesch*, Leiden.
During my year in the board of study association De Leidsche Flesch (the study association for Physics, Astronomy, Mathematics and Computer Science in Leiden), I was responsible for all education related matters and I was the contact person for various people in all four departments who had something to do with the education. I organised book sales for both semesters and as the vice president I was a support to the president and took charge of his tasks whenever he was absent. I also organised weekly lunch talks.
- 2011–2012, 2015–2016 **Student Representative**, *Leiden Observatory*.
As a member of the Educational Committee I represented my fellow students and formed a link between them and the staff. I attended frequent meetings about and helped guarantee and improve of the quality of the education.
- 2010–2015 **Various committees**, *Study association De Leidsche Flesch*, *Astronomical society “F. Kaiser”*, Leiden.
I participated in many committees within the study association and astronomical association at my department. I fulfilled various functions within these committees, such as secretary, treasurer and president. Among other things, I organised the Introduction Weekend twice, I was jointly responsible for the program of a trip to Berlin for first-year students, I organised the “Kaiser Lente Lezingen” (Spring Lectures); a series of four astronomy related lectures for the public.

Awards & Grants

- 2019 **Cardiff University**, Bessie Jones Prize for “Outstanding Contribution to Research”.
- 2018 **RadioNet**, I received funding to support my visit as observer to the IRAM 30m telescope.
- 2019 **Cardiff University**, Vera Rubin award for “Consistent Contribution to Community Engagement”.
- 2019 **ALMABO**, I received funding to attend the conference “Views on the ISM in galaxies in the ALMA era”.
- 2018 **Cardiff University**, Georges Lemaître Award for “Contribution to Community Engagement”.
- 2018 **RadioNet**, I received funding to attend the PACE ALMA Data Processing Workshop from the European Union’s Horizon 2020 research and innovation programme.

Computer skills

Computer languages (fluent) Python, L^AT_EX

Computer languages (moderate) IDL, C++, R

Software CASA, PyCharm, TOPCAT, the KINematic Molecular Simulation package (KinMS), Git, pPXF, DS9, Gaia

Operating systems Linux, Windows

Languages

Dutch Mother tongue

English Fluent

Italian Beginner level

Spanish Beginner level

Personal Interests

Music (keys, guitar), being active/outdoors, sports, travel, photography, reading.