

Cover Page



Universiteit Leiden



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Title: Studying dark matter using weak gravitational lensing : from galaxies to the cosmic web

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Curriculum vitae

For reasons I cannot begin to understand, I have been interested in Astronomy for as long as I can remember. I must have been about 8 years old when my father started taking me and my brother and sister for weekly library trips. Every time we went I picked books concerning stars, planets, the Solar System and space travel. What I read at that young age astonished me. For instance, I remember that I was quite shocked to find out that the Sun would die in 5 billion years. Everything that happened in space seemed so much bigger and more significant than our life on this tiny Earth.

I started high school in 2002, at the Hervormd Lyceum Zuid in Amsterdam. My interest in the sciences: physics, mathematics, chemistry and biology, grew thanks to my excellent teachers. I was thrilled when my physics teacher, Dick Hoekzema, offered extra classes on special relativity. He always made an effort to discuss modern physics in class, especially quantum mechanics, and even took my class on a field trip to the Large Hadron Collider at CERN, Geneva. In my fifth year, it was 2007, I was a finalist in the first Dutch Astronomy Olympiad, which took place at the Leiden Observatory. Of course in the final year of high school I couldn't wait to study physics and astronomy. I visited several open days at universities in Amsterdam, where I met prof. Huib Henrichs. He immediately became a good friend, and he arranged that I could visit some of the telescopes on La Palma.

I graduated Cum Laude in 2008, and immediately started my study in Physics and Astronomy at the University of Amsterdam. I was overwhelmed with joy to finally be surrounded by people with similar interests, professors and fellow students who were curious and eager to understand the Universe. It was the first time in my life that I truly felt that this important part of me was nourished and accepted. I especially enjoyed the astronomy and fundamental physics classes like cosmology, quantum physics and special relativity. I wrote my bachelor thesis: "Searching for

pulsars with the LOFAR telescope”, under supervision of Jason Hessels. During this project I studied the physics behind the pulsar phenomenon, as well as the workings of the LOFAR radio telescope. At the ASTRON headquarter in Dwingeloo I learned how to interact in a highly international and multi-disciplinary scientific community, and analysed LOFAR data resulting in the discovery of two new pulsar candidates.

Immediately afterwards, in 2011, I started my master program at the GRAPPA (Gravitation and Astro-Particle Physics in Amsterdam) Center of Excellence. This brand new institute combines subjects from theoretical physics, particle physics and astrophysics to develop a broader view of fundamental cosmology and the dark universe. My master thesis with Gianfranco Bertone was called: “Indirect dark matter detection with the Fermi Gamma-Ray Telescope.” During this project I became familiarized with the state of the art of particle dark matter research, as well as the observation of its annihilation products through the analysis of Fermi Gamma-Ray Telescope data. After finishing my thesis I became the very first graduate of the GRAPPA master programme.

As I wanted to continue my investigation into the dark matter problem through a different method, I applied for a PhD position with prof. Koen Kuijken at the Leiden University. I was thrilled that, out of roughly 200 applicants from around the world, and 30 ‘finalists’, I was chosen for his project on ‘galaxy-galaxy lensing’. During this project I used weak gravitational lensing to measure the structure of dark matter, on scales ranging from the dark matter haloes around single galaxies and galaxy groups to the large scale structure of the universe: the cosmic web. The final goal was to obtain a deeper understanding of dark matter: what evidence can we find of its existence, how is it distributed, and how does it behave?

During my research I heard of the new theory of Emergent Gravity by prof. Erik Verlinde, who was still working at my ‘alma mater’. According to him, the dark matter that I was studying did not exist. This piqued my interest enough to visit one of his talks, where he first showed his prediction for the distribution of emergent gravity around a massive object. I immediately knew that I could easily test this prediction by measuring the gravitational lensing distribution around galaxies, and started working on this as a ‘secret side project’. I didn’t know at the time that this would result in a close collaboration with prof. Verlinde and his PhD candidate Manus Visser, and in the publication of the first paper that tested his new theory. I was even more surprised when my paper received both national and international media attention, as I was invited to give talks at events and universities,

and to give interviews for TV series, documentaries, radio shows, websites, newspapers and magazines. On the side I was writing articles for popular science magazines and websites. It was all rather overwhelming, but lots of fun.

Fortunately for me I really enjoy popular science presenting and writing. I had already taken theatre lessons when I was in high school, and during my masters I had been an author and editor at Scoop, the magazine of our science student union at the University of Amsterdam. By that time one of my articles, “Habitable planets in our Milky Way”, had already been published on Kennislink (a Dutch popular science website) and was later elected as “The best article in 10 years of Kennislink” in the Astronomy category. In 2015 I was a semi-finalist of the national Famelab science communication competition, and on the side I was the coordinator of the cosmology exhibition during the renovation of the astronomy museum at the Historical Observatory in Leiden. All these experiences greatly helped me in dealing with my ‘emergent fame’, and at least I can claim that I already was a reasonable science popularizer on my own merit!

After my PhD I will start as a Postdoc at the Universities of Amsterdam and Groningen. Under supervision of prof. Erik Verlinde and prof. Edwin Valentijn I will continue studying and observationally testing the theory of Emergent Gravity, and I will become an instructor and dark matter & energy researcher of the new Euclid space telescope. I am very much looking forward to this new phase in my career, and this new phase in my life, as I move to Groningen with my brand new husband Jasper.

List of publications

- “Dark matter halo properties of GAMA galaxy groups from 100 square degrees of KiDS weak lensing data”

Authors: Massimo Viola, Marcello Cacciato, Margot M. Brouwer, Konrad Kuijken, Henk Hoekstra, Peder Norberg, Aaron S. G. Robotham, Edo van Uitert, Mehmed Alpaslan, Ivan K. Baldry, Ami Choi, Jelte T. A. de Jong, Simon P. Driver, Thomas Erben, Aniello Grado, Alister W. Graham, Catherine Heymans, Hendrik Hildebrandt, Anthony M. Hopkins, Nancy Irisarri, Benjamin Joachimi, Jon Loveday, Lance Miller, Reiko Nakajima, Peter Schneider, Cristóbal Sifón, Gijs Verdoes Kleijn

Published in: MNRAS, Volume 452, Issue 4, p.3529-3550

Publication Date: October 2015

- “The masses of satellites in GAMA galaxy groups from 100 square degrees of KiDS weak lensing data”

Authors: Cristóbal Sifón, Marcello Cacciato, Henk Hoekstra, Margot Brouwer, Edo van Uitert, Massimo Viola, Ivan Baldry, Sarah Brough, Michael J. I. Brown, Ami Choi, Simon P. Driver, Thomas Erben, Aniello Grado, Catherine Heymans, Hendrik Hildebrandt, Benjamin Joachimi, Jelte T. A. de Jong, Konrad Kuijken, John McFarland, Lance Miller, Reiko Nakajima, Nicola Napolitano, Peder Norberg, Aaron S. G. Robotham, Peter Schneider, Gijs Verdoes Kleijn

Published in: MNRAS, Volume 454, Issue 4, p.3938-3951

Publication Date: December 2015

- “Gravitational Lensing Analysis of the Kilo Degree Survey”

Authors: Konrad Kuijken, Catherine Heymans, Hendrik Hildebrandt, Reiko Nakajima, Thomas Erben, Jelte T.A. de Jong, Massimo Viola, Ami Choi, Henk Hoekstra, Lance Miller, Edo van Uitert, Alexandra Amon, Chris Blake, Margot Brouwer, Axel Buddendiek, Ian Fenech

Conti, Martin Eriksen, Aniello Grado, Joachim Harnois-Déraps, Ewout Helmich, Ricardo Herbonnet, Nancy Irisarri, Thomas Kitching, Dominik Klaes, Francesco Labarbera, Nicola Napolitano, Mario Radovich, Peter Schneider, Cristóbal Sifón, Gert Sikkema, Patrick Simon, Alexandru Tudorica, Edwin Valentijn, Gijs Verdoes Kleijn, Ludovic van Waerbeke

Published in: MNRAS, Volume 454, Issue 4, p.3500-3532

Publication Date: December 2015

- “The stellar-to-halo mass relation of GAMA galaxies from 100 square degrees of KiDS weak lensing data”

Authors: “Edo van Uitert, Marcello Cacciato, Henk Hoekstra, Margot Brouwer, Cristóbal Sifón, Massimo Viola, Ivan Baldry, Joss Bland-Hawthorn, Sarah Brough, M. J. I. Brown, Ami Choi, Simon P. Driver, Thomas Erben, Catherine Heymans, Hendrik Hildebrandt, Benjamin Joachimi, Konrad Kuijken, Jochen Liske, Jon Loveday, John McFarland, Lance Miller, Reiko Nakajima, John Peacock, Mario Radovich, A. S. G. Robotham, Peter Schneider, Gert Sikkema, Edward N. Taylor, Gijs Verdoes Kleijn

Published in: MNRAS, Volume 459, Issue 3, p.3251-3270

Publication Date: July 2016

- “Dependence of GAMA galaxy halo masses on the cosmic web environment from 100 square degrees of KiDS weak lensing data”

Authors: Margot M. Brouwer, Marcello Cacciato, Andrej Dvornik, Lizzie Eardley, Catherine Heymans, Henk Hoekstra, Konrad Kuijken, Tamsyn McNaught-Roberts, Cristóbal Sifón, Massimo Viola, Mehmet Alpaslan, Maciej Bilicki, Joss Bland-Hawthorn, Sarah Brough, Ami Choi, Simon P. Driver, Thomas Erben, Aniello Grado, Hendrik Hildebrandt, Benne W. Holwerda, Andrew M. Hopkins, Jelte T. A. de Jong, Jochen Liske, John McFarland, Reiko Nakajima, Nicola R. Napolitano, Peder Norberg, John A. Peacock, Mario Radovich, Aaron S. G. Robotham, Peter Schneider, Gert Sikkema, Edo van Uitert, Gijs Verdoes Kleijn

Published in: MNRAS, Volume 462, Issue 4, p.4451-4463

Publication Date: November 2016

- “First test of Verlinde’s theory of Emergent Gravity using Weak Gravitational Lensing measurements”

Authors: Margot M. Brouwer, Manus R. Visser, Andrej Dvornik, Henk Hoekstra, Konrad Kuijken, Edwin A. Valentijn, Maciej Bilicki,

Chris Blake, Sarah Brough, Hugo Buddelmeijer, Thomas Erben, Catherine Heymans, Hendrik Hildebrandt, Benne W. Holwerda, Andrew M. Hopkins, Dominik Klaes, Jochen Liske, Jon Loveday, John McFarland, Reiko Nakajima, Cristóbal Sifón, Edward N. Taylor

Published in: MNRAS, Volume 466, Issue 3, p.2547-2559

Publication Date: April 2017

- “A KiDS weak lensing analysis of assembly bias in GAMA galaxy groups”

Authors: Andrej Dvornik, Marcello Cacciato, Konrad Kuijken, Massimo Viola, Henk Hoekstra, Reiko Nakajima, Edo van Uitert, Margot Brouwer, Ami Choi, Thomas Erben, Ian Fenech Conti, Daniel J. Farrow, Ricardo Herbonnet, Catherine Heymans, Hendrik Hildebrandt, Andrew. M. Hopkins, John McFarland, Peder Norberg, Peter Schneider, Cristóbal Sifón, Edwin Valentijn, Lingyu Wang

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Publication Date: July 2017

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First off: it is stated on the Sterrewacht Wiki that it is “not customary to acknowledge directly your advisor”, since he/she is just “doing his/her job”. Nevertheless, I really want to say that Koen was the best supervisor I could have wished for. Whenever I encountered an obstacle, he was available for an illuminating discussion. These always provided me with a new way to attack my problem, and often ended with: “Okay, do it!” (although I would have preferred “Make it so!”). He was there for me when I needed him, and he trusted me when I was progressing on my own. Koen, you trusted me even when others doubted me, you trusted me even when I doubted myself.

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One aspect of life at the Sterrewacht I will dearly miss is being a member, and later leader, of the Social Committee. I’m very grateful to Henri-

ette, who is the reason I became both. You were a magnificent leader of the SocCom and you taught me well. Of course a big thank you to our members: Wouter, Jackie, Soumyajit, Maaïke, Maria Cristina, Jeb, and especially Chris and Ann-Sofie who are now sharing the SocCom leadership. But most of the work was of course done by the support staff: Debbie, Marjan, and Erik Deul, who have been truly invaluable. And although they might prefer to stay anonymous, I really want to thank all the staff-members who have so graciously agreed to play Sinterklaas while I was at the Sterrewacht: Matt, Evelijn (yes, our female Sinterklaas!), Michiel and Frans. Also a big thank you to Adrian and Michael for playing the piano at our events. Sinterklaas was already my favourite holiday, but you all somehow managed to make it even better!

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As I look to the future, I am very grateful to Edwin Valentijn and Erik Verlinde for allowing me to continue my work in cosmology. Thanks to you I am able to stand at the cradle of the new and exciting theory of Emergent Gravity, and of Euclid: the best cosmology telescope devised by mankind. Working with both of you truly feels like a dream come true. This also goes for you Manus, as we will soon continue our elaborate discussions on the secrets of theoretical physics and observational cosmology. I'm looking forward to learning more from all of you.

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