Suppressing a Sea of Starlight : enabling technology for the direct imaging of exoplanets

Otten, G.P.P.L.

Curriculum Vitae

I was born on May 11th, 1987 in Geulle, Meerssen and as a kid went to the local primary school 'in 't Riet'. As long as I can remember I loved astronomy, technology and history. In 1999 I went to high school at the Stella Maris College in Meerssen with a specialization on Science and Technology in the final few years and graduated in 2005. I had claimed for many years that I was going to study Archeology but decided in my fifth year of high school to study my other passion, Astronomy, in Leiden. In retrospect, I couldn't have made a better decision.

During my Bachelor's research project I worked with Henk Hoekstra on the impact of the combination of intrinsic alignments in galaxy clusters and foreground/background galaxy contamination on weak-lensing based mass estimates of the galaxy clusters. I received my Bachelor's degree in 2009. During my Master's study I first worked under supervision of Jarle Brinchmann on determining the dependence of stellar mass estimates of SDSS galaxies on the assumed star formation history. Secondly, I worked under supervision of Ignas Snellen and Ernst de Mooij on testing the use of consumer cameras for accurate photometry of the brightest stars in the sky. This was essentially a feasibility study for the later MASCARA project. During this time, Ernst and Ignas provided the opportunity to go on (my first) observing run with the 4 meter William Herschel Telescope in La Palma, Spain to take photometric observations of secondary transits of exoplanets in the NIR. I received my Master's degree in October 2011. While I was a student I also gave many tours at the Old Observatory and was co-chair of the student association for astronomy 'L.A.D. F. Kaiser'.

In November 2011 I started my PhD under supervision of Matthew Kenworthy. He was quickly joined by Frans Snik and Christoph Keller after the dissolution of Sterrenkundig Instituut Utrecht. Initially my work focused on building an Adaptive Optics testbed to test focal-plane wavefront sensing techniques but the focus quickly shifted to the very promising application of liquid crystal manufacturing techniques to the Apodizing Phase Plate coronagraph. I collaborated with the Geometric-Phase Photonics Lab at North Carolina State University to get multiple iterations of broad-band coronagraphs manufactured and also spent one week working in their lab to test the coronagraph. Furthermore, in the process of getting the coronagraph on-sky at the Large Binocular Telescope (USA) and the Clay Telescope (Chile) I collaborated with a team of astronomers at the University of Arizona. Finally, I spent several nights observing at the Clay telescope to test the coronagraph on-sky.

I presented my work at conferences, workshops and schools in Leiden, Noordwijk, Amsterdam, Groningen and Montreal (in both 2014 & 2015) and at seminars in Raleigh, USA and Santiago, Chile. Furthermore I attended the CfAO Adaptive Optics Summer School in Santa Cruz, California in 2012. As part of my teaching duties I assisted Henk Hoekstra with 'Sterrenkundig Practicum 2' for three years where we taught the second year students what to expect from professional astronomical research. This included three weeklong trips to the 2.5 meter Isaac Newton Telescope in La Palma where the students were familiarized with the observational aspect of astronomical research. Furthermore I assisted in assembling, testing and calibration of the new student telescope at the Old Observatory. Starting 2016 I will work as a Postdoc for one year with Ignas Snellen to construct and rollout the southern station of MASCARA on La Silla, Chile.

Acknowledgments

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I am grateful to Ernst and Ignas for giving me the opportunity to spend 11 days on La Palma as a rookie. My gratefulness also extends to Henk, whom I joined three consecutive years in the classroom and on La Palma. Remko's guidance on all things optical and mechanical was invaluable during this thesis. I would also like to thank Xander for sharing his knowledge and experience with PhD projects. The 'Gäölse' translation was done by Jos Tilmans as my own attempt resembled an inconsistent patchwork of dialects. His incredible feat deserves a special mention.

I am very thankful to my collaborators in Raleigh and Tucson for not only making our crazy ideas possible, but also getting the coronagraph on-sky within record time. Their support was crucial to get this done.

Sharing six different offices[2] over the years with numerous inhabitants was an inspiring experience. Officemates Carolina Ödman (outreach) and Martin Weiss (history) showed what an amazingly varied environment Leiden Observatory is to work in. Both Marissa's zeal in achieving her goals and knowing when to wind down & relax are admirable. I hope your dream of becoming an astronaut and going to space comes true. You deserve it. Many thanks go out to Jesse[3] for allowing me to join him in his office. I never anticipated the great time we would have while sharing offices. Both in terms of practical jokes and solving scientific conundrums. My current office mates Stephanie, Jos, Christian, and Rob provide a very vibrant working environment and make it possible to get instant feedback on various topics.

Former group members Gerard, Tim, Maria, Laurens and Ritse still form a source of (comedic) relief. I was fortunate to be able to share thoughts and ideas with Tiffany during my PhD. Furthermore, I can not forget David Huijser's role during my undergraduate studies by challenging me in homework assignments, exams and videogames.

I am indebted to Harry Timmermans who guided me many years and introduced me to genealogical research. Sascha, thank you for your unwavering support throughout the years and in years to come. I would like to end by dedicating this thesis to my parents, and Maria and Leon. If one of you had been missing I would have been a different person.

[2] as a historical reference and in chronological order: Oort 454, 553, 462, 564, 568, 571

[3] future director of ESO

List of acronyms

8OPM: Eight-Octant Phase Mask
ADI: Angular Differential Imaging
AGPM: Annular Groove Phase Mask
ALC: Apodized Lyot Coronagraph
AMZ: Angel-Mach-Zehnder
AO: Adaptive Optics
APCMLC: Apodized Pupil Complex Mask Lyot Coronagraph
APP: Apodizing Phase Plate
AU: Astronomical Unit
BLC: Band-Limited Lyot Coronagraph
CCD: Charge Coupled Device
CMOS: Complementary Metal Oxide Semiconductor
DM: Deformable mirror
dOTF: Differential Optical Transfer Function
DPM: Disk Phase Mask
DZPM Dual Zone Phase Mask
E-ELT: European Extremely Large Telescope
EE: Encircled Energy
ELT: Extremely Large Telescope
EPICS: Exo-Planet Imaging Camera and Spectrograph
FFT: Fast Fourier Transform
FP: Focal Plane
FQPM: Four-Quadrant Phase Mask
FWHM: Full Width Half Maximum
GPI: Gemini Planet Imager
gvAPP: grating vector Apodizing Phase Plate
HARMONI: High Angular Resolution Monolithic Optical and Near
-infrared Integral field
HDR: High Dynamic Range
HLC: Hybrid Lyot Coronagraph
HST: Hubble Space Telescope
HWP: Half-Wave Plate
IFU: Integral Field Unit
LBT: Large Binocular Telescope
LHC: Left-handed Circular
LMIRCam: Large Binocular Telescope mid-infrared camera
LOCI: Locally Optimized Combination of Images

MagAO: Magellan Adaptive Optics
METIS: Mid-infrared E-ELT Imager and Spectrograph
MICADO: Multi-Adaptive Optics Imaging Camera for Deep Observations
MMTO: MMT Observatory
MTR: Multi-Twist Retarder
NACO: NAOS-CONICA
NCP: Non-common path
NCPA: Non-common path aberrations
NWO: Nederlandse Organisatie voor Wetenschappelijk Onderzoek
OVC: Optical Vortex Coronagraph
PCA: Principal Component Analysis
PDI: Polarization Differential Imaging
PG: Polarization Grating
PIAA(C): Phase Induced Amplitude Apodization (Coronagraph)
PIAACMC: PIAA Complex Mask Coronagraph
PP: Pupil Plane
PPA: Pupil Plane Apodization
PSF: Point spread function
PSI: Phase-Sorting Interferometry
QWP: Quarter-Wave Plate
RDI: Reference Differential Imaging
RHC: Righthanded Circular
RV: Radial Velocity
ScexAO: Subaru Coronagraphic Extreme Adaptive Optics
SD: Spectral Deconvolution
SDI: Simultaneous / Spectral Differential Imaging
SLM: Spatial Light Modulator
SP: Shaped Pupil
SPHERE: Spectro-Polarimetric High-contrast Exoplanet REsearch instrument
SR: Strehl Ratio
UV: Ultraviolet
IR: Infrared
vAPP: vector Apodizing Phase Plate
VLT: Very Large Telescope
VVC: Vector Vortex Coronagraph
WFS: Wavefront sensor