LEIDEN UNIVERSITY

MASTERS THESIS

# Design and Demonstration of Focal Plane Wavefront sensing for co-phasing the GMT

*A thesis submitted in fulfillment of the requirements for the degree of Masters Thesis*

*in the department for*

Astronomy and Instrumentation

May 30, 2020

# Declaration of Authorship

I, Alex Tripsas, declare that this thesis titled, "Design and Demonstration of Focal Plane Wavefront sensing for co-phasing the GMT" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date:

*"Now is the moment that everything can change*
*You are completely responsible for your own life*
*And no one is coming to save you from yourself*
*So stop blaming your problems on any or everything else*
*It does not matter one tiny fucking bit*
*How unfair you think the world is*
*It's only what you do*
*Right here, right now*
*Right this fucking instant that matters*
*It's your choice to*
*Sink or swim"*

D. Randall Blythe

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# *Abstract*

Astronomy Department
Astronomy and Instrumentation

Masters Thesis

**Design and Demonstration of Focal Plane Wavefront sensing for co-phasing the GMT**

by Alex Tripsas

The 25 meter, Giant Magellan Telescope (GMT) will be comprised of seven 8.4 meter mirrors that will have a resolving power ten times greater than that of the Hubble Space Telescope. The GMT will be capable of directly imaging nearby exoplanets with an angular resolution of 10-30 milliarcseconds in the near-IR. To make this possible, the seven separate mirrors need to be co-phased to a fraction of a wavelength to act as one 25 meter aperture. To co-phase the mirrors, we propose to use an Asymmetric Pupil vector Apodizing Phase Plate (APvAPP). The APvAPP generates two science images which can be used to sense aberrations in the pupil. This focal-plane wavefront sensing (FPWFS) technique will allow for the determination of segment piston, tip, and tilt. For simulation work, the python software package HCIPy was used to optimize the asymmetry of the APvAPP. Simulations are veried in the laboratory with a low-order deformable mirror (DM) to induce and then correct wavefront errors into a liquid crystal APvAPP located in a conjugate pupil plane. Here we present results of the development, optimization, and testing of the APvAPP in the laboratory.

# *Acknowledgements*

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Lastly, Professor Matthew Kenworthy

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# List of Abbreviations

| | |
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| **GMT** | Giant Magellan Telescope |
| **PSF** | Point Spread Function |
| **DM** | Deformable Mirror |
| **AO** | Adaptive Optics |
| **WFS** | WaveFront Sensor |
| **FPWFS** | Focal Plane Wavefront Sensing |

*Dedicated to my friends and family who helped keep me going.*

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