#### UNIVERSITY OF CALIFORNIA

Los Angeles

Investigating the Nature of Dark Matter with Strong Gravitational Lensing

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in Astrophysics

by

Daniel Alejandro Gilman

#### ABSTRACT OF THE DISSERTATION

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Daniel Alejandro Gilman

Doctor of Philosophy in Astrophysics

University of California, Los Angeles, 2020

Professor Tommaso L. Treu, Chair

(Abstract omitted for brevity)

The dissertation of Daniel Alejandro Gilman is approved.

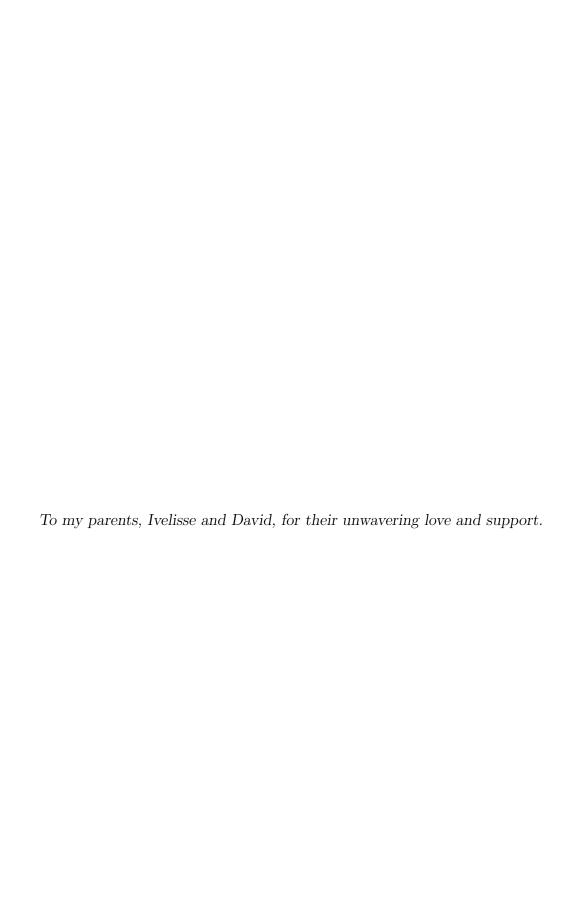
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#### ACKNOWLEDGMENTS

I have done my best in this dissertation to explain the research I have conducted as a linear progression from a set of mysteries and unanswered questions to questions to a set of conclusions. This style of explanation may be best for the sake of clarity, but it is not a faithful representation of the winding journey of discovery, both scientific and personal, that has characterized the past six years of my life.

Throughout this journey, I have benefited from the guidance of many amazing scientists. I am truly lucky to have had the opportunity to work closely with Simon Birrer, who always seems to know the right question to ask in order to solve a problem. I am also indebted to Anna Nierenberg, with whom I have collaborated since day one. Anna has a keen an eye for important details others may overlook, and I believe working with her has made me a better scientist.

It is difficult to convey just how much I admire my PhD advisor, Tommaso Treu. To the astronomy community as a whole, Tommaso is regarded as a productive, creative, and talented scientist. To me, he is a role model, a leader, and the kind of person I want to be. I could not have asked for a better advisor.

Finally, I am thankful for my amazing parents. It must have been wild listening to me try to choose a career path: from a pilot, to joining the foreign service, and then finally setting down with astrophysics. Through it all, you have supported me, challenged me, and believed in me. As I get older, I realize more and more how lucky I am to have you two as my parents - I could not have done it without you!

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#### **PUBLICATIONS**

Gilman, D., et al. Constraints on the mass-concentration relation of cold dark matter halos with 11 strong gravitational lenses. MNRAS in press (2019)

Gilman, D., et al. Warm dark matter chills out: constraints on the halo mass function and the free-streaming length of dark matter with 8 quadruple-image strong gravitational lenses. MNRAS 491, 6077-6101 (2019)

Gilman, D., et al. Probing dark matter structure down to  $10^7$  solar masses: flux ratio statistics in gravitational lenses with line of sight halos. MNRAS 487, 5721-5738 (2019)

Gilman, D., et al. Probing the nature of dark matter by forward modelling flux ratios in strong gravitational lenses. MNRAS 481, 819-834 (2018)

Gilman, D., et al. Strong lensing signatures of luminous structure and substructure in early-type galaxies. MNRAS 467, 3970-3992 (2017)

# Introduction

# Strong lensing signatures of luminous structure and substructure in early-type galaxies

This chapter was published as Gilman, D., et al. Strong lensing signatures of luminous structure and substructure in early-type galaxies. MNRAS 467, 3970-3992 (2017), and is printed here with minor formatting adjustments.

# Probing the nature of dark matter by forward modelling flux ratios in strong gravitational lenses

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# Probing dark matter structure down to $10^7$ solar masses: flux ratio statistics in gravitational lenses with line of sight halos

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Warm dark matter chills out: constraints on the halo mass function and the free-streaming length of dark matter with 8 quadruple-image strong gravitational lenses

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