

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

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ABSTRACT OF THE DISSERTATION

Investigating the Nature of Dark
Matter with Strong Gravitational Lensing

by

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Doctor of Philosophy in Astrophysics

University of California, Los Angeles, 2020

Professor Tommaso L. Treu, Chair

(Abstract omitted for brevity)

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To my parents, Ivelisse and David, for their unwavering love and support.

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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)

CHAPTER 1

Introduction

CHAPTER 2

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.

CHAPTER 3

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

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CHAPTER 4

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CHAPTER 6

Constraints on the mass-concentration relation of cold dark matter halos with 11 strong gravitational lenses

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