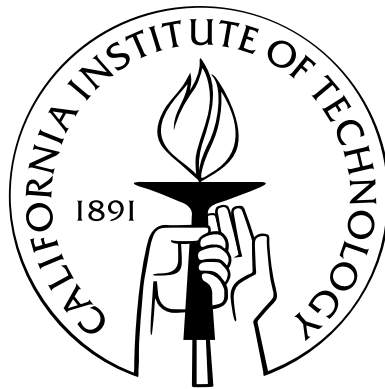


# Orbital Dynamics of Kuiper Belt Object Satellites, a Kuiper Belt Family, and Extra-Solar Planet Interiors

Thesis by  
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In Partial Fulfillment of the Requirements  
for the Degree of  
Doctor of Philosophy



California Institute of Technology  
Pasadena, California

2009  
(Defended May 15, 2009)



To Sarah, Chloe, and Abigail – more important than any thesis

# Acknowledgements

This thesis would not have been possible without the help and support from many others.

For the last four years, I have enjoyed the companionship and constant encouragement of my wife, Sarah. I appreciate her companionship immensely. I am so grateful for her willingness to support and celebrate my desire to be a scientist. To her and to my two beautiful daughters, Chloe and Abigail, I have dedicated this thesis.

There is no way to adequately thank my family, particularly my mother and father, for the years of selfless support that have given me. Having my own children has enlightened my understanding of their tens of thousands of hours of loving service rendered on my behalf. Throughout my early years, my family was instrumental in developing my abilities in mathematics and science. I feel that my father, Alan, knew this day would come (when I would receive a doctorate) long before I did, and has helped to prepare me in any way he could. My mother, Kayleen, has always sought my best interests, often at great sacrifice to herself. Mom and Dad: Thank you.

I consider myself very lucky to have had Mike Brown as my advisor. For the rest of my life, I will be grateful for his ideas, guidance, advice, help, and support for these past five years. Not all advisors are as accommodating as he has been; Chapter 2 of this thesis is a testament to his willingness to let me work on other projects. From him, I have learned many aspects of how to be a good scientist. Discussions with and classes from Oded Aharonson, Geoff Blake, Re'em Sari, Dave Stevenson, and Jack Wisdom have also been very helpful. Watching them has helped me to broaden my understanding and has improved the way I approach difficult scientific problems.

I could not have asked for better office-mates than I have had here in South Mudd 154. I will miss greatly the friendship of Margarita Marinova, Kaveh Pahlevan, Alejandro Soto, and Aaron Wolf. From impromptu conversations on a variety of subjects to helpful scientific advice, from social gatherings to intimate conversations, they are what I will remember the most about my time in grad school. I particularly thank Aaron for asking me about how to determine the  $J_2$  of extra-solar planets which resulted in Chapter 2 of this thesis.

Throughout my time here, I have enjoyed working with many students in planetary science and other fields. In particular, other students in Mike's research group have given me many bits of inspiration, advice, and interesting science over the years. I have enjoyed collaborating with and

learning from Kris Barkume and Emily Schaller, as well as many helpful discussions with Meg Schwamb. Outside of Caltech, I would like to thank Dan Fabrycky at the Center for Astrophysics for motivation and many helpful discussions.

One huge advantage of studying planetary science at Caltech, as opposed to other universities, is that the students worry much less about the source of their salaries and research funding. Even so, I most gratefully acknowledge the support of the Moore Foundation and the NASA Earth and Space Sciences Fellowship Program for their significant financial contributions to my graduate career.

Another advantage of studying planetary science at Caltech is our excellent support staff. I would like to thank the Planetary Science Office Staff (particularly Irma Black and Alexandra Tigno) and the technical support staff (particularly Mike Black and Scott Dungan) for their efforts on my behalf. Overall my experience at Caltech has been very positive, partly thanks to kind administrators.

I would like to thank the astronomical community for tools that have made this research possible. In particular, I would like to mention the Astrophysics Data System, the Hubble Space Telescope, the Keck Observatories, the Gemini Observatories, and Caltech's Palomar Observatories. They provide the information needed to move planetary science forward.

Finally, I would like to thank my Heavenly Father for His inspiration, guidance, and love. Concerning this thesis, I would like to thank Him for making Haumea so interesting. From Him I hope to learn the full truths of planetary science someday.

# Abstract

This thesis discusses research into four different orbital dynamics problems, where the main goal of each chapter is to characterize the strongest non-Keplerian effect. These problems are introduced and discussed in Chapter 1, to help provide context for the subsequent chapters. In Chapter 2, I discuss a new technique for probing the interior density distributions of extra-solar planets by observing apsidal precession. Using a detailed theoretical and observational model of this precession, I conclude that NASA's *Kepler* mission will be able to detect the presence or absence of a massive core in very hot Jupiters with eccentricities greater than  $\sim 0.003$ . The remaining chapters discuss the orbital dynamics of Kuiper belt objects (KBOs) orbiting the Sun beyond Neptune. The family of dwarf planet Haumea (2003 EL61) is characterized in Chapter 3, including a list of candidate family members sorted by dynamical proximity. Using a numerical integration of resonance diffusion, I also show that the Haumea family is at least 1 Gyr old and is probably primordial. In Chapter 4, I analyze and fit astrometric data for the two satellites of Haumea (Hi'iaka and Namaka) to determine their orbital properties and the masses of Haumea and Hi'iaka. The implications of the new orbital solution are discussed, including the exciting conclusion that Haumea and Namaka are currently starting a season of mutual events. A more general investigation of the orbital and tidal evolution of KBO binaries is given in Chapter 5. A new orbital evolution model is described that accounts for perturbations from the Sun, self-consistent tidal evolution, and non-hydrostatic quadrupoles of solid KBOs. Using this model, I find that the orbital parameters of KBO binaries may have been modified significantly over the age of the solar system. Applied to the Orcus-Vanth binary, this model shows that a short-period circular orbit does not necessarily imply a collisional formation. In all, the work in this thesis has sought to analyze observational data by using the theoretical tools of orbital dynamics.

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