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

Thesis by

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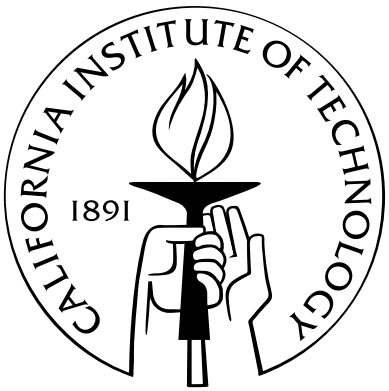

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To Sarah, Chloe, and Abigail – more important than any thesis

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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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