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Methods to Explore Families of Quasi-Periodic Orbits with Applications in Astrodynamics

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Quasi-periodic orbits are of great interest for mission design due to their prevalence in astrodynamics. Incorporating quasi-periodic orbits in the design process expands the design space and have the potential to decreases station-keeping efforts. Quasi-periodic orbits are computationally more complex than periodic orbits, however the benefits of utilizing quasi-periodic orbits and their invariant manifolds can outweigh the computational burden. Methods and tools to handle the larger design space are needed to make the study of families of quasi-periodic orbits tractable to mission designers. In this thesis we leverage single-parameter continuation of n-dimensional quasi-periodic invariant tori to compute quasi-periodic orbits with specific orbit frequencies and with specific orbital characteristics. Additionally, we formulate and solve optimization problems such that the optimization variables are the frequencies of the quasi-periodic orbits. The solution process incorporates a novel parametric constraint, which constrains the direction of travel in frequency space in continuation methods. Moreover, we develop search strategies which successively use parametric constraints to explore families of quasi-periodic orbits. Lastly, we leverage number theoretic properties of quasi-periodic orbits to avoid the effect of resonances in the continuation process. We compute the family of the Earth-Moon L_2 quasi-halo orbits in the circular restricted three-body problem to serve as a test bed and solution space for the work in this thesis.