Extrasolar Terrestrial Planets on Stable Resonant Periodic Orbits

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The recent success of the radial velocity technique in detecting more than 100 extrasolar planets has created rich grounds for the extension of the theories of the formation and dynamical evolution of our solar system to other planetary systems. Such an extension allows planetary scientists to explore the possibility of the existence of habitable planets among extrasolar planetary systems. It is therefore of great importance to explore whether such planets can exist on stable orbits in the habitable zones of their central stars and also whether their orbits will be stable for long enough duration of time to allow the development of life. In multi-body planetary systems, such orbits correspond to mean-motion resonances. When the geometrical configurations of such orbits are periodically repeated, they are known as "Resonant Periodic Orbits". Resonant periodic orbits are quite common in our solar system. For instance, Jupiter and Saturn rotate around the Sun on orbits that correspond to a (5:2) resonance. With the discovery of extrasolar planets, resonant periodic orbits are no longer exclusive to our solar system. For instance, GJ 876 contains two planets in a (2:1) resonance and the system of 55 Cnc shows a (3:1) commensurability between its two innermost planets. These all indicate that it is of great value to study the possibility of the existence and also the stability of resonant periodic orbits for different resonances. In this paper, we present the result of our extensive numerical study of the existence and the stability of different resonant periodic orbits and present a methodology for searching the parameter-space of multi-body systems for regions where resonant periodic orbits can be stable. The application of our results to the stability of extrasolar terrestrial planets is also discussed.