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THE HOMOCLINIC AND HETEROCLINIC CONNECTIONS OF PLANAR SYMMETRIC RESONANT ORBITS IN THE RESTRICTED THREE-BODY EARTH-MOON SYSTEM

Abstract

This study presents planar symmetric resonant orbits in the restricted three-body Earth-Moon system and their homoclinic and heteroclinic connections in the vicinity of the Moon are analyzed in details. In the rotating coordinate frame of the circular restricted three-body problem, there exist planar periodic orbits that appear symmetric about the line connecting the Earth and the Moon. The orbital periods of these orbits demonstrate approximately p:q resonance with respect to the Moon (a spacecraft completes p orbits while the Moon completes q orbits around the Earth in the same time interval). For a specified resonant ratio, four cases of these symmetric resonant orbits (those with resonant ratios of 1:1,1:2,1:3,2:1,2:3,3:1,3:2,3:4 are presented as examples) are defined and computed in the restricted three-body Earth-Moon system.

Subsequently, we focus our attention on those resonant orbits that pass through the vicinity of the Moon. If observed in the inertial coordinate frame, these resonant orbits could be interpreted to be transfers between two quasi-Keplerian elliptical orbits via lunar gravity assist, which indicates that the lunar gravitation plays important roles for constructing a large class of resonant orbits. The stabilities of the resonant orbits are analyzed by using the dynamical systems theory. In terms of the monodromy matrices associated with the resonant orbits, we compute the corresponding stable and unstable invariant manifolds. Poincare maps are plotted by observing the orbital states of resonant orbits at perilunes and we then identify the presence of the homoclinic connection (connection between the invariant manifolds associated with the same resonant orbit) and the heteroclinic connection (connection between the invariant manifolds associated with different resonant orbits with either the same or the different resonant ratios).

It is shown that the patching points of invariant manifolds at perilunes could be above the lunar equator at arbitrary longitudes. Therefore, the orientation of perilunes could be arbitrarily directed via hopping between different resonant orbits by taking advantages of the homoclinic and heteroclinic connections. This characteristic of orbital transfers might provide a means for observing the Moon's low-latitude regions with different longitudes and the insertion into lunar orbit is not necessary. Besides, other potential utilizations of the homoclinic and heteroclinic connections for fully making use of lunar gravity assist are also discussed.

Keywords: resonant orbits; the restricted three-body problem; invariant manifolds; homoclinic connections; heteroclinic connections;