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FUEL-FREE FORMATION FLIGHT FOR INTERFERENCE OBSERVATION AROUND THE SUN-EARTH L2 POINT USING SOLAR RADIATION PRESSURE

Abstract

In recent years, capabilities of Earth-based telescopes are approaching their limits due to the diffraction limit and atmospheric dispersion, such that higher performance can only be achieved by placing a large telescope in space. However, since it is impracticable to launch a large single-dish telescope, a distributed approach is necessary. Therefore, interferometric observations using satellite formation flight have been well proposed. A central concept to radio and infrared interferometric astronomy is the u-v or visibility plane, in which all possible combinations of baseline vectors between aperture elements are plotted. For a successful interferometric observation, the interferometer must fill this u-v plane evenly with minimal gaps. This is done by changing the distances and relative orientation between the telescopes during observation, where conventional formation flight interferometers expend finite fuel in this process. In this work, the authors propose to place a formation flight interferometer on an artificial halo orbit around the Sun-Earth L2 libration point, where these maneuvers can be made at low enough energy to allow solar radiation pressure (SRP) to contribute as the sole control input. The L2 point is convenient for astronomical missions because thermal and communication environments remain exceptionally stable. This advantage can be amplified by selecting a halo orbit with its radius artificially shrunk by use of continuous thrust, using SRP. Acceleration due to SRP can be controlled through the sun-relative attitude. In this work, a new class of Archimedean spiral relative orbits on an artificial halo orbit is proposed. By designing an artificial halo orbit that serves as a reference orbit and having two satellites orbit around it at high speed in opposite phases, the relative position vector between the two satellites can be propagated in a spiral. This approach allows the formation-flying satellites to rapidly fill the u-v plane for accelerated astronomical observations. This is a new type of orbit that can only be achieved by using the microgravity and frozen nature of SEL2, which is not possible in conventional Earth orbit where space VLBI satellites tend to be placed. This periodic orbital motion can be created through SRP by an equally periodic attitude motion. In addition, the reference orbit has a long-period and the spiral orbit has a short-period, and the time constants of each period correspond to those of precession and nutation in attitude motion, so there is a prospect of a smooth realization based on the natural motion of the attitude.