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NAVIGATION CONCEPT AND CHALLENGES FOR INFRARED ASTRONOMY SATELLITE SWARM INTERFEROMETRY (IRASSI) MISSION

Abstract

InfraRed Astronomy Satellite Swarm Interferometry (IRASSI) is a feasibility study of a formation flying astronomy mission which aims to understand the genesis of planets, star formation and evolution processes. For this purpose, IRASSI mission employs a cluster of spacecrafts orbiting around the second libration point (L2) of Sun-Earth-Moon system in order to achieve high spatial resolution in a far-infrared range. Such a mission introduces high challenges to the existing navigation technology, particularly because it requires unprecedented accuracy of 5 m on the baseline vector between scientific reference points of each spacecraft pair. This accuracy requirement emerges from the observation frequency range of 1-6 THz, which is needed to observe the chemical processes which lead to planet and star formation.

This paper presents the navigation challenges and describes candidate navigation methods to meet the scientific requirements of IRASSI. At first, IRASSI mission concept and requirements of the navigation system are introduced. The proposed navigation concept comprises two components: (I) the absolute positioning, which determines the positions of the satellites with respect to Earth; and (II) the relative positioning, which determines the positions of the satellites with respect to each other. For absolute positioning, Earth-based navigation and autonomous navigation are considered as options. For relative positioning, two options are taken into consideration: a real-time geometric approach, and a reduced-dynamic approach, which can be carried out in near real-time or post processing. The considered options for absolute and relative positioning are analyzed in terms of their dynamic models, observation models and estimation methods. Furthermore, their performance in meeting the requirements and overcoming challenges are discussed and compared in terms of their response time and accuracy.

After initial analysis, the Earth-based navigation method has been chosen as the main approach for absolute positioning due to its potential to satisfy high accuracy expectations for the initialization of the relative positioning algorithms. For relative positioning, both geometric and reduced-dynamic approaches are elaborated. The geometric approach is capable of real-time processing, while the reduced-dynamic approach is intended for near real-time or post processing by combining measurement and force models, thus ensuring a relatively robust solution even in the presence of incomplete and erroneous measurements. Furthermore, open questions are identified and future work is outlined.