Stable Communication Topologies of a Formation of Satellites

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Abstract: Several currently planned space missions consist of a set of satellites flying in formation. While increasing the functionality, this concept introduces several new challenges with respect to the design of the mission. The topology of the sensing or communication network among the satellites can be a bottleneck in the operation because the transmission of information and the coordination of the formation relies on it. Here we study the robustness of the formation dynamics with respect to changes in the communication topology (like the failure of some communication links). Moreover, we propose a special variant of the notion of stability radius in order to measure the robustness of a certain topology.

Keywords: Formation; stability; stability radius.

Mathematics Subject Classification (2000): 70M20, 70K20.

1 Introduction

Space missions with several spacecraft flying in formation have received a lot of attention recently. Increased functionality and robustness of the mission are two key characteristics of this approach. Several currently planned space missions consist of a set of satellites flying in formation, like, e.g., the NASA mission Terrestrial Planet Finder (TPF) and the ESA mission Darwin. In both missions, a network of formation flying spacecraft builds up an infrared interferometer in order to detect and study planets in outer space.

One key challenge in the design of these missions is the question on how to efficiently attain and accurately maintain the desired formation. In [1, 5] it has been shown that formation-stabilizing control laws can be derived for the individual spacecraft that rely on local information only. The key idea is that, together with the stability properties of the dynamics of the individual spacecraft, the spectrum of the Laplacian associated

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