The StarLight Formation-Flying Interferometer System Architecture

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Abstract

The StarLight mission is scheduled for a 2006 launch into an earth-trailing orbit. Over a six month period, StarLight will demonstrate the new technologies of spaceborne long-baseline optical interferometry and precision formation flying (2 cm range and 1 arcmin bearing angle, 1 sigma) necessary for the Terrestrial Planet Finder (TPF) and other future astrophysics missions. A primary goal is to fully characterize the interferometer capabilities by obtaining >200 fringe visibility amplitude measurements for stars in the band 600-1000 nm with a variety of stellar visibilities (0.2-1.0), stellar magnitudes (Mv = 2-5), and baselines (B = 30-125 meters). Interferometry on StarLight will be performed both in a 1 meter fixed-baseline combiner-only mode and in a formation-flying mode, in which two spacecraft operate in a novel Parabolic Geometry Interferometry (PGI) configuration. In this configuration, the combiner spacecraft will remain at the focus of a virtual parabola, while the collector spacecraft assumes various positions along the parabola such that the two arms of the interferometer remain equal over a variety of separations and bearing angles. In this fashion, projected baselines of 30-125 meters can be achieved by separations of 40-600 meters. The interferometer metrology subsystem will also provide precision knowledge (25 um/sec range rate and 10 arcsecond bearing angle, 1 sigma) to validate the formation-flying sensors over separations of 30-1000 meters.

The interferometer will consist of the following subsystems, each of which will have components on both the combiner and collector spacecraft: Stellar, Metrology, Optical Bench, Electronics, and Flight Software. The Stellar subsystem will include the optics, mechanisms, and sensors necessary for star acquisition and pointing control with subarcsecond 1sigma accuracy and 50 Hz bandwidth; optical pathlength control with 35 nm 1 sigma accuracy and 300 Hz bandwidth; and fringe acquisition and control (100 um/sec search speeds over 40 mm optical delay and 500 Hz bandwidth). The Metrology subsystem will supply a 1.3 um laser, along with optics, sensors, and electronics necessary to provide precise bearing angle knowledge and pathlength knowledge. The Optical Bench subsystem will consist of a composite structure on each spacecraft, providing structural support and thermal control (+/- 1 degC across the 1.5 meter bench) for the Stellar and Metrology components. The Electronics subsystem will provide power, control, and signal conditioning and processing for the Stellar, Metrology, and Optical Bench components; support a high speed (< 1 msec latency) interspacecraft communication function to close the left pointing control loop; and also host the Flight Software in a dedicated interferometer computer (one on each spacecraft). The Flight Software will execute command and data handling, fault protection, and interferometer control algorithms. Overall, the Interferometer System will include 30 actuators, 6 control loops, 25 discrete optical elements, 6 optical subassemblies, 20 primary sensors (including a CCD camera), and 185 engineering sensors. The mass and power of the interferometer hardware are estimated to be 146 kg and 310 W for the combiner and 36 kg and 87 W for the collector. This paper provides an overview of the Interferometer System architecture, its subsystems, and operational concepts.