LISA On-Board Signal Processing

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In the simplest mode of operation, LISA is a Michelson interferometer with two spacecraft located close to each other (~ 200 km apart) forming the beam splitter with two distant (5 million km) spacecraft forming the end mirrors. One of the spacecraft at the central vertex is the aster spacecraft with its laser frequency controlled by a thermally-stable reference cavity. The lasers on the other spacecraft are phased-locked to an incoming beam. The signals consist of phase differences between the reference laser and the returned beams.

Signal processing on the master spacecraft is done to remove the frequency noise caused by remaining instability of the master reference cavity. This is done by performing Fourier transforms of the beat signals and combining them with phase shifts corresponding to the nominal arm lengths; this removes the reference cavity noise to a satisfactory level. The signal is then inverse transformed to produce a time sequence of normalized phase differences. These phase differences represent the differential changes in the arm lengths. The time sequence of phase differences is telemetered to the ground at about 1 sample per second.

Another source of noise is introduced by a difference in the rate of change of the arm lengths. An on-board oscillator is required to remove the frequency difference imposed by this velocity difference. If the velocity difference is too large then the noise introduced by realistic space-qualified oscillators will be larger than desired. The oscillator noise can be kept small by either controlling the difference in the arm velocities to a small enough values, through a series of orbit maneuvers, or by using two laser frequencies (or a modulation on the main laser frequency) on each arm to provide a local oscillator signal which has noise that cancels between the two arms. Both alternatives will be described and the system implications of each discussed.

The current configuration of the LISA mission has six spacecraft, two at each vertex. This is partly for reasons of redundancy and partly to provide additional information. A candidate scheme for processing and transmitting the information from the third arm to the ground will be discussed