DEVELOPMENT TOWARDS A SPACE QUALIFIED LASER STABILIZATION SYSTEM IN SUPPORT OF SPACE-BASED OPTICAL INTERFEROMETERS*

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We report on the development, functional performance and space-qualification status of a laser stabilization system supporting a space-based metrology source used to measure changes in optical path lengths in space-based stellar interferometers. The Space Interferometry Mission (SIM) and Deep Space 3 (DS-3) are two missions currently funded by the National Aeronautics and Space Administration (NASA) that are space-based optical interferometers. In order to properly recombine the starlight received at each telescope of the interferometer it is necessary to perform high resolution laser metrology to stabilize the interferometer. A potentially significant error source in performing high resolution metrology length measurements is the potential for fluctuations in the laser gauge itself. If the laser frequency or wavelength is changing over time it will be misinterpreted as a length change in one of the legs of the interferometer. An analysis of the frequency stability requirement for SIM resulted in a fractional frequency stability requirement of $\sqrt{S_y(f)} \le 2\times10^{-12}/\sqrt{Hz}$ at Fourier frequencies between 10 Hz and 1000 Hz. The DS-3 mission stability requirement is further increased to $\sqrt{S_y(f)} \le 5\times10^{-14}/\sqrt{Hz}$ at Fourier frequencies between 0.2 Hz and 10 kHz with a goal of extending the low frequency range to 0.05 Hz. The free running performance of the Lightwave Electronics NPRO lasers, which are the baseline laser for both SIM and DS-3 vary in stability and we have measured them to perform as follows

$$\frac{9\times10^{-11}}{f(Hz)}\frac{Hz}{\sqrt{Hz}} \le \sqrt{S_y(f)} \le \frac{1.3\times10^{-8}}{f(Hz)}\frac{Hz}{\sqrt{Hz}}.$$

In order to improve the frequency stability of the laser we stabilize the laser to a high finesse optical cavity by locking the optical frequency of the laser to one of the transmission modes of the cavity. At JPL we have built a prototype space-qualifiable system meeting the stability requirements of SIM, which has been delivered to one of the SIM testbeds. We have also started on the development of a system to meet the stability needs of DS-3.

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