Laser Technologies for Gravitational Wave Detection

NASA is now developing the Laser Interferometer Space Antenna (LISA) mission to search for gravitational waves from astrophysical phenomena such as the Big Bang, mergers of supermassive black holes, and galactic binary inspirals. Detection of gravitational waves would open a new astrophysical window on the universe with great potential for unexpected discoveries. A number of gravitational wave follow-on missions to LISA are also under study.

The disturbance caused by the passage of a gravitational wave is expected to be very small (of order picometers) and will be measured with laser interferometry. The technology areas below deal with technical problems in these measurements. Because the systems will be deployed in space, the technologies to be considered must have credible paths toward space flight qualification. Background information on LISA, along with preliminary technology discussions, can be found in the Proceedings of the 5th International LISA Symposium, Penn State University, 19-24 JULY 2002, published in the Classical and Quantum Gravity Journal, Vol 20, Number 10, 21 May 2003.

Issues of Space Qualification of LISA Laser: the LISA laser must produce >1W CW of 1.06 micron light with fiber coupled output (for example, a combination of a lower-power master oscillator (eg, NPRO) with suitable amplifier). The laser will have the following characteristics:

- 10 year lifetime;
- Power stability
- Linewidth

This task will involve investigating the issues of space qualification of the system, experimentally studying the relevant problems, and proposing a realistic plan of development of this system. Given the magnitude of the effort to develop a space qualified LISA laser, it is not expected that the outcome of this task will result in a space qualified laser; rather, the outcome should be a sufficient understanding of the important technical issues in space qualification (e.g., diode lifetime, thermal and vibrational robustness, etc.) so that a clear path towards the development of a fully space qualified system can be identified.
LISA Electro-optical Modulator: produce a phase modulator for a 1 W continuous laser beam, providing 10% power modulation depth at frequencies from 1.9 to 2.1 GHz. The modulator should be fiber coupled (input and output), at 1.06 micron wavelength. The modulator must be space qualified.

LISA Telescope Articulator: produce a mechanical actuator that can articulate the LISA telescope over a 5 mm dynamic range with a 0.1 nm resolution. The actuator must be space qualified and have noise.