NASASBIR2016PhaseISolicitation

S3.08SlowandFastLight

LeadCenter:MSFC

Steepdispersionsinengineeredmediaofawidevarietyhaveopenedupanewdirectionofresearchinoptics.A
positivedispersioncanbefulsteoslowthepropagationofopticalpulsetoextremelysmallvelocities.Similarly,an
negativedispersioncanleadtoconditionswherepulsespropagatesuperluminally.Theseffectshavenowmoved
beyondthestageofintellectualcuriosity,andhaveusheredinstudysofasetofexcitingapplicationsofinterestto
NASA,rangingfromultraprecisesuperluminalgyroscopestopectralinterferometershavingenhancedresolving
power.

Thisresearchsubtopicseeksslow-lightand/orfast-lightenhancedsensorsevenusapplicationsofinterestto
NASAincluding:

**Superluminalgyroscopesandaccelerometers(bothpassiveandactive)**

- Enhancedstrainanddisplacement sensors for non-destructive evaluation and integrated vehicle health
  management applications.
- Slow-light-enhanced spectrally-resolved interferometers for astrophysical and Earth science observations,
  as well as for exploration goals.
- Other applications of slow and fast light related to NASA’s mission areas.

**Superluminalgyroscopes**

In conventional ring laser gyroscopes, sensitivity increases with cavity size. Fast light, however, can be used to
increase gyro sensitivity without having to increase size, for spacecraft navigation systems which are constrained
by weight and volume. The increased sensitivity also opens up new science possibilities such as detection of
subsurface geological features, tests of Lorentz invariance, improving the bandwidth sensitivity product for gravity
wave detection, and tests of general relativity. This research subtopic seeks:

- Prototype fast light gyroscopes, active or passive, that unambiguously demonstrate a scale factor
  enhancement of at least 10 with the potential for 1000. The minimum or quantum-noise limited angular
  random walk (ARW) should also decrease.
- Designs for fast light gyro that do not require frequency locking, are not limited to operation at specific
  frequencies such as atomic or material resonances, and permit operation at any wavelength.
- Fast light gyroscope designs that are rugged, compact, monolithic, rad-hard, and tolerant to variations in
temperature and varying G-conditions.

**Slow-lightenhancedspectralinterferometers**
Slow light has the potential to increase the resolving power of spectral interferometers such as Fourier transform spectrometers (FTS) for astrophysical applications without increasing their size. Mariner, Voyager, and Cassini all used FTS instruments for applications such as mapping atmospheres and examining ring compositions. The niche for FTS is usually thought to be for large wavelength (IR and beyond), wide-field, moderate spectral resolution instruments. Slow light, however, could help boost FTS spectral resolution making FTS instruments more competitive with grating-based instruments, and opening up application areas not previously thought to be accessible to FTS instruments, such as exoplanet detection. A slow-light FTS could also be hyper-spectral, providing imaging capability. FTS instruments have been employed for remote sensing on NASA Earth Science missions, such as the Atmospheric Trace Molecule Spectroscopy (ATMOS), Cross-track Infrared Sounder (CrIS), and Tropospheric Emission Spectrometer (TES) experiments, and have long been considered for geostationary imaging of atmospheric greenhouse gases. This research subtopic seeks research and development of slow-light-enhanced spectral interferometers that are not restricted by material resonances and can operate at any wavelength. An inherent advantage of FTS systems are their wide bandwidth. It will therefore of importance to develop slow light FTS systems that can maintain a large operating bandwidth.