NASA SBIR 2011 Phase I Solicitation

S2.02 Proximity Glare Suppression for Astronomical Coronagraphy

Lead Center: JPL

Participating Center(s): ARC, GSFC

This subtopic addresses the unique problem of imaging and spectroscopic characterization of faint astrophysical objects that are located within the obscuring glare of much brighter stellar sources. Examples include planetary systems beyond our own, the detailed inner structure of galaxies with very bright nuclei, binary star formation, and stellar evolution. Contrast ratios of one million to ten billion over an angular spatial scale of 0.05-1.5 arcsec are typical of these objects. Achieving a very low background requires control of both scattered and diffracted light. The failure to control either amplitude or phase fluctuations in the optical train severely reduces the effectiveness of starlight cancellation schemes.

This innovative research focuses on advances in coronagraphic instruments, starlight cancellation instruments, and potential occulting technologies that operate at visible and near infrared wavelengths. The ultimate application of these instruments is to operate in space as part of a future observatory mission. Measurement techniques include imaging, photometry, spectroscopy, and polarimetry. There is interest in component development, and innovative instrument design, as well as in the fabrication of subsystem devices to include, but not limited to, the following areas:

Starlight Suppression Technologies

- Advanced starlight canceling coronagraphic instrument concepts.
- Advanced aperture apodization and aperture shaping techniques.
- Advanced apodization mask or occulting spot fabrication technology controlling smooth density gradients to 10-4 with spatial resolutions ~1 Âµm, low dispersion, and low dependence of phase on optical density.
- Metrology for detailed evaluation of compact, deep density apodizing masks, Lyot stops, and other types of graded and binary mask elements. Development of a system to measure spatial optical density, phase inhomogeneity, scattering, spectral dispersion, thermal variations, and to otherwise estimate the accuracy of masks and stops is needed.
- Interferometric starlight cancellation instruments and techniques to include aperture synthesis and single

input beam combination strategies.

- Pupil remapping technologies to achieve beam apodization.
- Techniques to characterize highly aspheric optics.
- Methods to distinguish the coherent and incoherent scatter in a broadband speckle field.
- Methods of polarization control and polarization apodization.
- Components and methods to insure amplitude uniformity in both coronagraphs and interferometers, specifically materials, processes, and metrology to insure coating uniformity.
- Coherent fiber bundles consisting of up to 10^4 fibers with lenslets on both input and output side, such that both spatial and temporal coherence are maintained across the fiber bundle for possible wavefront/amplitude control through the fiber bundle.

Wavefront Control Technologies

- Development of small stroke, high precision, deformable mirrors and associated driving electronics scalable to 104 or more actuators (both to further the state-of-the-art towards flight-like hardware and to explore novel concepts). Multiple deformable mirror technologies in various phases of development and processes are encouraged to ultimately improve the state-of-the-art in deformable mirror technology. Process improvements are needed to improve repeatability, yield, and performance precision of current devices.
- Development of instruments to perform broadband sensing of wavefronts and distinguish amplitude and phase in the wavefront.
- Adaptive optics actuators, integrated mirror/actuator programmable deformable mirror.
- Reliability and qualification of actuators and structures in deformable mirrors to eliminate or mitigate single actuator failures.
- Multiplexer development for electrical connection to deformable mirrors that has ultra-low power dissipation.
- High precision wavefront error sensing and control techniques to improve and advance coronagraphic imaging performance.
- Optical Coating and Measurement Technologies.
- Instruments capable of measuring polarization cross-talk and birefringence to parts per million.
- Highly reflecting broadband coatings for large (> 1 m diameter) optics.
- Polarization-insensitive coatings for large optics.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.