Stellar Imager (SI): Observing the Universe in High Definition

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Summary

SI is a space-based, UV/Optical Interferometer (UVOI) with over 200x the resolution of HST.
• It will enable 0.1 milli-arcsec (mas) spectral imaging of stellar surfaces and the Universe in general and open an enormous new “discovery space” for Astrophysics with its combination of high angular resolution, dynamic imaging, and spectral energy resolution.
• SI will provide heretofore unattainable views of the surfaces and interiors of other solar-type stars, of the interior regions and winds of Active Galactic Nuclei, and of the dynamic systems and processes throughout the universe.

Capabilities:
• angular resolution of approximately ~200 Å
• ~1000 pixels of resolution over the surface of nearby dwarf stars:
• 18-Å UV pass bands to enable imaging in spectral lines, e.g., C IV [108 Â], Mg II h&k [109 Â]
• broadband, near-UV to optical continuum (1000-10,000 Å)
• spectroscopic imaging

SI and the Decadal Survey

The SI mission is targeted for the mid-to-late 2020s, the decade after the one under consideration now. However, significant technology development is needed to enable SI and other space-based sparse aperture telescopes and interferometers:
• Precision (~cm-level) formation flying of numerous (up to ~30) spacecraft
• Precision (~mm-level) metrology of spacecraft with many elements (mm-level accuracy in mirror surface placement)
• Staged-control systems covering 12-orders of magnitude, from the nm-level of the mirror surfaces, to the cm-level placement of spacecraft in formation-flying, to the management of km-sized formations

All of these technologies are being worked on at some level, but it is critically important that the importance of these capabilities are called out in the current decadal survey, to enable the flight of such missions in the following decade.

Feasibility of Interferometry from Space

SI is part of a natural evolution from current ground-based interferometers and telescopes to a space-based system.

• Feasibility of interferometry demonstrated by large variety of successful ground-based interferometers (e.g., CHARA, CALI, NSPIRE) or even by a single spacecraft (e.g., ALMA, SIM)

Space provides a better environment:
• Not looking on an atmosphere, which on the ground limits spatial and temporal coherence (aperture size and integration time) of incoming wavemeters
• No need for large and complicated delay lines for off-axis obs.
• Wavefronts not available from ground can be accessed

A simple imaging interferometer, like SI, is a logical first “large baseline, space-based” interferometer – it is easier to build than a space-based full-aperture interferometer.

Baseline Design:
• a 0.5 km diameter space-based UV-Optical Flare Interferometer
• ~Sun-Earth L2 to enable precision formation flying
• ~3 primary (~1m) mirror elements focusing on beam-combining hub
• more than 1 hub provides critical-path redundancy and strongly improved observing efficiency because of reduced slow requirements
• ~long-term (> 10 year) mission to study stellar activity cycles:
  • individual telescopes(hubs) can be refurbished or replaced by human or robotic servicing

High Level Science Goals

High Level Science Goals

Understand by high angular resolution spectral imaging the details and dynamics of herefore unresolved objects and processes:
• Solar/Stellar Magnetic Activity and their impact on Planetary Climates and Life
• Magnetic & Atomic Processes and their roles in the Evolution of Structure and in the Transport of Matter throughout the Universe
• The close-in structure of AGN and their winds

Detailed Science Goals

Support development and validation of a predictive stellar dynamic model by resolving patterns of surface activity and by determining internal structure and flows for a diverse sample of stars:
• to understand the origins of variability in the Sun-Earth system
• to understand long-term forecasting of solar/stellar magnetic activity and understand the impact of that activity on planetary climates and on the origin and maintenance of life
• Study dynamics of systems/processes enabled by sub-orbital resolution

SI is a cross-theme mission addressing Science Goals of both the NASA Heliophysics and Astronomy/Physics Divisions:

High Level Science Goals

SI:
• is included as a “Flagship and Landmark Discovery Mission” in the 2005 Heliohrophysics Roadmap
• is a candidate implementation of the UVOI in the 2006 Science Program for the Astronomy/Physics Division
• was the subject of a NASA/HQ Vision Mission Study (see the anthology “NASA Space Science Vision Mission” 2006, ed. M. Allam)
• has been recommended in the 2008 NRC Report for further study, strongly enhanced by launch on an Ares V (enables larger primary mirrors), though an incrementally-deployed version could be launched using smaller rockets

* The SI Development Team

Mission Concept

SI Cross-Sectional Schematic

Principal Elements of SI Hub

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Mission and Performance Parameters

Launch Date and Vehicle:
• April 2030
• Ares V

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SI and the Constellation Architecture

For more information, see: http://hires.gsfc.nasa.gov/si/