SI – The Stellar Imager: Results from the Vision Mission Study

SI is a UV/optical deep-space telescope to image stars and observe the Universe with 0.1 milli-arcsec angular resolution.

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Quick Facts: Stellar Imager Vision Mission

Science Goals

- Solar and Stellar Magnetic Activity and their impact on Space Weather, Planetary Climates, and Life
- Magnetic Processes and their roles in the Origin and Evolution of Structure and in the Transport of Matter throughout the Universe

Mission and Performance Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Maximum Baseline (B)</td>
<td>150 - 1000 m (250 m typical)</td>
</tr>
<tr>
<td>Effective Focal Length</td>
<td>1 - 10 km (1.6 km typical)</td>
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<tr>
<td>Diameter of Mirrors</td>
<td>1 - 5 m (1.6 m typical)</td>
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<tr>
<td>L-Coverage</td>
<td>UV: 1200 - 1300 Å, Optical: 3000 - 5000 Å</td>
</tr>
<tr>
<td>Angular Resolution</td>
<td>UV: 0.1 mas (resolution limit) Optical: 1.0 mas (resolution limit)</td>
</tr>
<tr>
<td>Operational Orbital Elements</td>
<td>Sun-Earth L2 Lagrange, 120 d, 200,000/300,000 km</td>
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<tr>
<td>Accessible Sky</td>
<td>70° of sky ± 10°</td>
</tr>
<tr>
<td>Host-Dry Mass</td>
<td>1455 kg</td>
</tr>
<tr>
<td>Mission Duration</td>
<td>85 years (BARY) = 120 km (BBMC)</td>
</tr>
<tr>
<td>Total Platform Mass</td>
<td>220 kg</td>
</tr>
<tr>
<td>Total Propellant Mass</td>
<td>750 kg</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>50 mas - 20 arcsec, (1.200 - 5000 Å)</td>
</tr>
<tr>
<td>Imaging time resolution</td>
<td>10 - 30 min (10 microns)</td>
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<tr>
<td>Atmospheric turbulence level</td>
<td>10 µm ideal, 100 µm typical</td>
</tr>
<tr>
<td>FWHM resolution on star</td>
<td>&gt; 1000 times over disk</td>
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<tr>
<td>Minimum PV shift</td>
<td>4 mas</td>
</tr>
<tr>
<td>Minimum flux detectable at 50 Å</td>
<td>5 x 10^9 ergs/cm²/s, above CIV lines 10 Å bandpass</td>
</tr>
<tr>
<td>Precision Formation Fly</td>
<td>spurious control to micron level</td>
</tr>
<tr>
<td>Optical Surface Control</td>
<td>Actuated mirrors to micron level</td>
</tr>
<tr>
<td>Phase Corrections</td>
<td>200,000x800,000 km Sun-Earth L2 Lissajous, 180 d Operational Orbit</td>
</tr>
</tbody>
</table>

The Science Potential of the Stellar Imager

- SI includes as a “Flagship and Landmark, Discovery Mission” in the 2005 SSCS Roadmap as a key component of a “Pathway to Life Observatories” in the EUS Roadmap (508) SI is a multi-mission, co-utilization mission.
- SI previously in NASA SEC (now SSCS) roadmaps for 2000 and 2003
- SI selected in 2003 by NASA HQ for further concept development as an SI Mission

Status

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Mission Concept

- a 0.5 km diameter space-based UV-optical Fizeau Interferometer
- located near Sun-Earth to enable precision formation flying
- 20-30 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 slew requirements
- long-term (> 10 year) mission to study stellar activity cycles:
  - individual telescopes/hubs can be refurbished or replaced by human or robotic servicing
  - Fizeau with remapping of beams from 2D to 1D non-redundant array
- capabilities:
  - angular resolution of 0.1 milli-arcsec ~ 2000 Å
  - more than 1000 pixels of resolution over the surface of nearby dwarf stars:
    - in 10-100 UV pass bands (e.g., C IV [10 10 Å], Mg II & k & k [10 10 Å])
    - plus broadband, near-UV or optical continuum (0.3-10-10,000 Å)
    - ability for imaging spectroscopy

Design Options:

- Classical Fizeau with large focal-plane detector (baseline design)
- Hybrid Hypertelescope which accepts partial pupil densification in order to maintain use of non-redundant array
- Fizeau with remapping of beams from 2D to 1D non-redundant array

SI and the NASA-ESA Strategies

SI addresses science goals of 3 research Themes in NASA Science Mission Directorate:
- learn how galaxies, stars, planetary systems form & evolve (Origins/EUD)
- understand development of structure/flows of magnetic fields (SEU/EUD)
- understand origins & societal impacts of variability in SEC (SSS/SEED)

SI and the Exploration Initiative

SI is a key to developing models for long-term solar-system space weather forecasts
- SI’s population study adds development of dynamo models by exploring the manifestations of magnetic activity as a function of stellar properties and time
- SI’s multi-star data base allows model validation within 10% rather than 10% or more
- Multi-year space-weather forecasts throughout the heliosphere guide vehicle design and mission planning and enable forecasts of extended periods for safe construction at Mars, Moon, Earth-Moon L1, and L2 and LEO imaging orbits
- SI is a “deep-space observatory” essential to the mandate of search and exploration of habitable planets around other stars (see NASA’s “The Vision for Space Exploration,” Feb. 2004 and the exploration Roadmap Rd. 15: “NASA’s Small craft advanced telescope scout for Earth-like planets and habitable environments around other stars”)
- SI will explore the impact of stellar magnetic activity and radiation on the habitability of planets found by planet-search projects such as Kepler and the Terrestrial Planet Finder
- SI will investigate in detail how magnetic fields control formation of planetary systems (transport of mass and angular momentum, star-disk coupling, disk-clearance zones, etc.)
- SI technology & science are milestones towards the development of Planet Imager

Mission concept under development by NASA/GSFC in collaboration with experts from industry, universities, & astronomical institutes:

- Ball Aerospace & Technologies Corp.
- NASA’s Jet Propulsion Laboratory
- Northrop Grumman Space Technology
- Sigma Space Corporation
- Space Telescope Science Institute
- Stanford University
- University of Maryland
- European Space Agency
- Pennsylvania State University
- University of Arizona

Sci- Cross-Sectional Schematic

Principal Elements of SI Hub

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