

NASA SBIR Super Subtopic
“Balloon Telescope Assembly”

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New Concept

Super Sub-Topic has higher limits:

Phase 1 up to \$200K

Phase 2 up to \$1.5M

To accomplish tasks too big for standard sub-topics.

For each Super Subtopic, we expect to fund:

Phase 1 2 to 3

Phase 2 1 to 2

Funded projects will be assigned a NASA Science PI.

Motivation

Astro2010 Decadal Report recommended increased use of sub-orbital balloon-borne observatories.

Two specific needs include:

Far-IR telescope systems for CMB studies

Optical/NIR telescope systems for Dark Matter and/or
Exoplanet studies

Balloon Telescope Assembly

Build one or more telescope assemblies for a potential balloon mission:

Grazing Incidence X-Ray Telescope

Ultra-Stable 1-meter Class UVOIR Telescope

Low-Cost CMB Telescopes

Low-Cost Far-Infrared Telescopes

Cryogenic Far-Infrared Telescope

5 to 10 meter Segmented Far-IR Telescope

Heliophysics UVOIR Telescope

Phase 1 deliverable is reviewed design ready for manufacture.

Phase 2 deliverable is a fully integrated and tested telescope assembly, ready to be incorporated into a potential balloon mission payload.

Successful Proposals Shall

Provide credible plan to deliver telescope ready to be integrated into a balloon mission. Past experience will be given appropriate weight.

Demonstrate understanding of how engineering specifications meets science requirements and balloon operational envelop:

- Thermal Environment from 330K to 150K

- 10G shock

- Constrained Mass Budgets

Phase 1 delivery plan includes optical, mechanical (static and dynamic), thermal designs and performance analysis.

Phase 2 delivery shall be a completely assembled and tested telescope assembly ready to be integrated into a potential balloon mission. Testing shall confirm compliance of the telescope assembly with its requirements.

X-Ray Telescope

A complete grazing incidence x-ray telescope is desired with:

- effective collecting area of $\sim 3 \text{ cm}^2$ for 0.1-4 nm wavelengths,
- 4 meter effective focal length,
- 0.8 degree angle of incidence, and
- surface roughness of 0.2 nm rms.

Ultra-Stable 1-meter Class UVOIR Telescope

Potential Exoplanet balloon studies require a telescope with:

- Collecting aperture of 1 meter or larger collecting aperture
- diffraction limited at 500 nm
- Spectral range from 300 to 1100 nm (ideally 1600 nm)
- Field of view > 10 arc-seconds
- Field of regard from 20 to 70 degrees elevation angle
- Dynamic wavefront stability < 0.3 nm rms per 100 seconds
- Real centimeter scale image
- Total mass ~ 300 kg.

Telescope can achieve the stability requirement via either passive design or an actively controlled mirror (i.e. secondary mirror, fine steering mirror, deformable mirror, etc.)

Un-obscured off-axis system is preferred, but on-axis systems with simple secondary support spiders are allowed.

Low-Cost CMB Telescopes

Potential balloon measurements of CMB linear polarization require complete off-axis telescope systems with the following optical, mechanical and operational requirements.

Optical requirements:

- 3 meter to 4 meter diameter primary mirror

- Diffraction-limited performance at 500 micron wavelength at 250 K

- Wavefront stability of 15 micrometers rms per K

- F/1 to F/1.5 primary mirror

- 70 arc-minute field of view at 500 micron wavelength

- Strehl ratio > 0.95 at edge of field of view

Mechanical and operational requirements

- Telescope to operate at ambient temperature 250 K (200 to 300K range)

- Telescope and mount to survive 10G shock (vertical)

- Telescope and mount to survive 5G shock (tilted 45 deg)

- Mass of telescope to be 200 kg or less

- Recurring production cost $< \$200$ K per telescope

Low-Cost Far-Infrared Telescopes

Potential balloon Far-IR missions require complete off-axis telescope systems with the following optical, mechanical and operational requirements.

Optical requirements:

2.5 meter to 4 meter diameter primary mirror

Diffraction-limited performance at 100 micron wavelength at 250 K

Wavefront stability of 2.5 micrometers rms per K

F/1 to F/1.5 primary mirror

15 arc-minute field of view at 100 micron wavelength

Strehl ratio > 0.95 at edge of field of view

Mechanical and operational requirements

Telescope to operate at ambient temperature 250 K (200 to 300K range)

Telescope and mount to survive 10G shock (vertical)

Telescope and mount to survive 5G shock (tilted 45 deg)

Mass of telescope to be 200 kg or less

Recurring production cost $< \$200$ K per telescope

Cryogenic Far-Infrared Telescope

Potential Far-Infrared balloon missions achieve significant improvements in sensitivity using cryogenic optics. Anticipated missions require a complete telescope system with 3 meter on-axis collecting aperture maintained at temperatures below 20 K. Low mass and long cryogenic hold time are particularly important.

Optical requirements:

- Diffraction-limited performance at 300 micron wavelength at 20 K

- F/1 to F/1.5 primary mirror

- Field of view 20 arc-minutes minimum, 40 arc-min desired

- Strehl ratio > 0.95 at edge of field of view

Cryogenic requirements

- Maintain entire telescope at 20 K or colder

- Hold time 48 hours or longer, with goal of 21 days

Mechanical requirements

- Telescope and cryostat to survive 10G shock (vertical)

- Telescope and cryostat to survive 5G shock (tilted 45 deg)

- Mass of telescope + cryostat to be < 1000 kg (goal 500 kg)

5 to 10 meter Segmented Far-IR Telescope

Potential Far-IR balloon studies required a complete optical telescope system with a 5 to 10 meter segmented aperture; 250 to 500 micrometer diffraction limited performance; wavefront stability of less than 10 micrometers rms; and a total mass of 400 (5m) to 800 kg (10m).

Heliophysics UVOIR Telescope

Potential Heliophysics studies require a complete optical telescope and/or camera system with: 1 to 2 meter collecting aperture, 20 degree field of view, 0.001 degree angular resolution and UV to Visible (120 to 700 nm) spectral range.

Any Questions?