SuperHERO: The Next Generation Hard X-Ray HEROES Telescope

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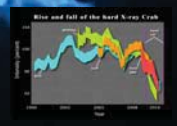
ABSTRACT

SuperHERO is a new high-resolution Long Duration Balloon-capable, hard-x-ray (20-75 keV) focusing telescope for making novel astrophysics and heliophysics observations. The SuperHERO payload, currently in its proposal phase, is being developed jointly by the Astrophysics Office at NASA Marshall Space Flight Center, the Solar Physics Laboratory and the Wallops Flight Facility at NASA Goddard Space Flight Center. SuperHERO is a follow-on payload to the High Energy Replicated Optics to Explore the Sun (HEROES) balloon-borne telescope that recently launched from Fort Sumner, NM in September of 2013, and will utilize many of the same features. Significant enhancements to the HEROES payload will be made, including the addition of optics, novel solid-state multi-pixel CdTe detectors, integration of the Wallops Arc-Second Pointer and a significantly lighter gondola suitable for a Long Duration Flight.

Astrophysics Goals

- Characterize spatial and spectral emission of a pulsar wind nebula.
- Investigate the scale of high energy processes in a pulsar wind nebula.
- Investigate the hard X-ray properties of astrophysical targets such as X-ray binaries and active galactic nuclei.
- Follow-up NuSTAR observations.



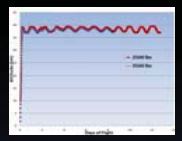
Improvement over HEROES

- Long Duration Flight for significantly improved sensitivity
- Will utilize the Wallops Arc Second Pointes (WASP)
- Add more optics for increased effective area
- Realign & Remount Optics
- Exchange existing detectors for CdTe fine pixel detectors
- Light-weight structure, and power (solar panels) scheme
- Alignment Monitoring System to monitor the optical bench for thermal and gravitational effects during flight.

Long Duration Balloon (LDB) Mission

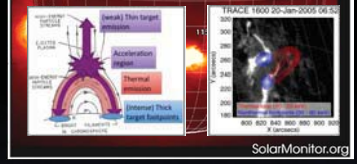
LDB flights can last more than three weeks, offering improved sensitivity over the HEROES payload. However, a complete redesign of the payload is necessary.

- Mass Minimization
- Power (Solar Panels)
- Thermal Analyses
- Flight Profiles



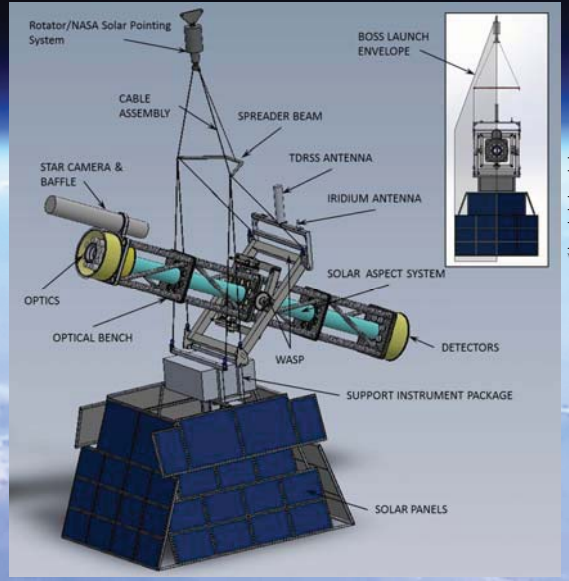
Solar Science Goals

- Determine the presence of energetic electrons in the non-flaring solar corona.
- Determine the role of energetic electrons in solar flares.
- Characterize flare morphology relative to energetic electrons.



Added Optics With Improved Alignment and Mounting

Characteristic	HEROES	SuperHERO
Mirror shells per module (8 modules total)	14 (in 5 modules) 13 (in 3 modules)	19 shells
Focal Length	6 m	Unchanged
Plate Scale	1.75 mm/arcmin	Unchanged
Mirror Coating	Iridium, 20 nm thick	Unchanged
On-axis geometric effective area	75 cm² at 40 keV 21 cm² at 60 keV	95 cm² at 40 keV 38 cm² at 60 keV
Angular resolution	26 arcsec (HPD) 13 arcsec (FWHM)	20 arcsec (HPD) 7 arcsec (FWHM)
Field of View (FWHM)	9 arcmin at 40 keV 5 arcmin at 60 keV	Unchanged



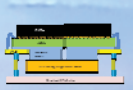
Rutherford Appleton Laboratory (RAL) CdTe Many Pixel Detectors

Detectors	HEXITEC (CdTe)	NuSTAR[v] (CdZnTe)
Pixel Size	250 µm	600 µm
Energy Resolution	1.6 % @ 60 keV	1.3 % @ 68 keV
Size	~4 x 4 cm	~3.84 x 3.84 cm
Pixels	160 x 160	64 x 64
Max. Processing rate	10,000 evt s⁻¹	400 evt s⁻¹

[v]Harrison, F, et al. [2013] *Apj*, **770**, 103

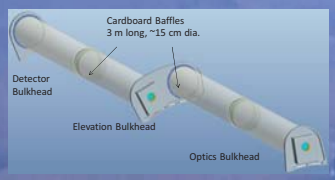
These detectors allow for improved spatial resolution, response and background rejection when coupled with active shielding.

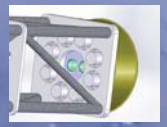
- RAL's detectors will provide a complete telescope suitable for Explorer mission opportunities.
- Cooling schemes have been explored for optimal performance (and also to minimize power)



Solar Aspect System (SAS)

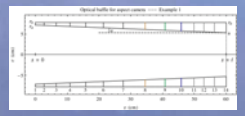
- Required for solar pointing knowledge
- SAS can provide precise pitch-yaw pointing solutions to the Pointing Control System (PCS) (roll is not controlled, only measured)
- SAS can store pointing knowledge (pitch, yaw, roll) for post processing image reconstruction



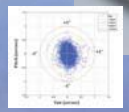


Astrophysics Aspect System - Star Camera, Baffle & Shutter

- New Baffle is only 2 feet -long, allowing for direct mounting on the optics flange.
- Star Camera software has been improved (bugs seen on previous missions have been found and eliminated).
- Star Camera shutter has been added for solar observations.



Wallops Arc Second Pointer (WASP)



- Orthogonal pair of pitch & yaw gimbals for fine motion
- First flight test gave <1 arc-second pointing (consistent with lab tests)
- WASP can accommodate a telescope that is 6-7m long and 1m in diameter, maybe larger
- Can allow for both astrophysical and solar pointing