Toward NGST

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ABSTRACT

A telescope to follow the HST does not necessarily have to be a lot bigger to make a dramatic advance in observing capability. Provided it is cooled to allow exploration the 2 - 4 μm window of very dark sky background, and has several times the 0.85 m aperture of SIRTF, it would have already unique capability to resolve and study the crowded fields of the most strongly red-shifted, distant galaxies. Such a telescope could test many of the advanced technologies needed for the mirror elements in future deployed telescopes or interferometers of very large size.

Keywords: space telescope, infrared, ultra-lightweight, optical performance

The natural sky background above the atmosphere, from zodiacal dust, is darkest at wavelengths 2 - 4 μm between the peaks from reflected sunlight and thermal emission[1] (figure 1). But the remarkable potential for very deep astronomical observations in this region, for example of galaxies forming at high redshift, remains unrealized. The thermal radiation from the atmosphere and the warm mirrors of the Hubble telescope have so far prevented background limited observations beyond 1.8 μm[2]. With its mirrors cooled to 5.5 K, the 0.85 m SIRTF will take pioneering steps in this window, but its strengths are primarily at still longer wavelengths[3]. Its ~ 1 arcsec diffraction limited resolution at ~ 4 μm will have difficulty in resolving crowded fields of distant galaxies. A telescope optimized to explore the dark sky window should be larger, for better light grasp and smaller diffraction limited images, but the optics need only passive cooling, 50 K being adequate to keep telescope background less than zodiacal for wavelengths < 10 μm.

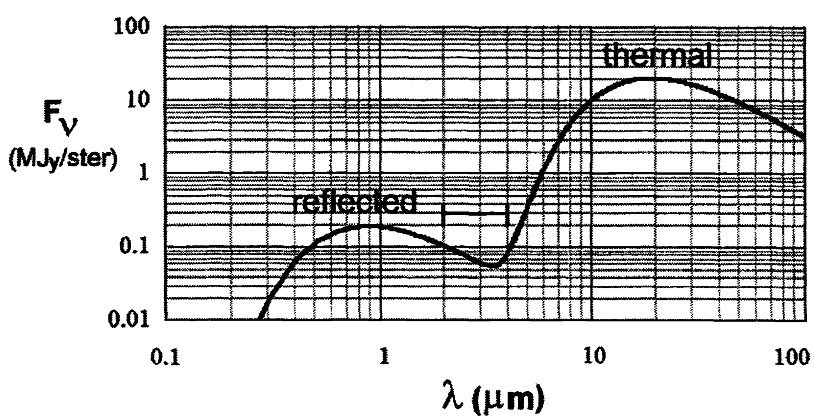

Figure 1. The natural sky background seen from outside the Earth's atmosphere, due to zodiacal dust in the solar system (from Angel and Woolf[1]). The dark sky minimum from 2 - 4 μm is marked.

Much of the present thinking on NGST is directed toward 8 m aperture and the formidable set of technical advances driven by this size[4]. Both the primary mirror and the telescope structure to thermally shield it would have to be folded up to fit inside the launch vehicle. Smaller telescopes that could be completely assembled and tested before launch would be limited to a maximum size of about 6 m, to fit in the largest fairing that could be built for Ariane 5 or EELV[5]. For the Shuttle or currently available fairings, the aperture would be limited to ~ 3.5 m. The projected sensitivity for different telescopes is given in table 1. The smaller assembled telescopes are worthy of serious consideration, as a step toward larger deployed telescopes, both filled-aperture ≥ 8 m and interferometric such as TPF[6], and in their own right as bringing powerful new imaging capability. They involve less risk and development time, would allow already a major scientific exploration of the dark window[7], and would better assure continued capability at shorter wavelengths after HST.

telescope	aperture (m)	10 σ flux limit 10^5 sec (nJy)	image FWHM (arcsec)
SIRTF	0.85	350	0.85
HST	2.4	6,000	0.30
Pre-assembled	3.5	4.2	0.21
Pre-assembled	6	1.4	0.12
NGST baseline	8	0.8	0.09
Bigger deployed	12	0.35	0.06
Ground with AO	8	440	0.09

Table 1. Sensitivity to point sources of different sized telescopes for broadband imaging (R=4) at 3.5 μm. SIRTF and NGST sensitivities are taken from website estimators[8], the HST limit is calculated based on warm telescope emission, and the other space telescope sensitivities are scaled from the 8 m NGST by area. The ground based 8 m estimate is from Gillett and Mountain[9]. Note that SIRTF sensitivity at 3.5 μm is limited by detector sampling and noise in addition to zodiacal background photon noise.

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