SIRTF - THE MODERATE MISSION

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Abstract. The Space Infrared Telescope Facility (SIRTF) has been planned by NASA and the US scientific and aerospace communities as a cryogenically-cooled observatory for infrared astronomy from space. Within the past few years, severe pressures on NASA's budget have led to the cancellation of many programs and to dramatic rescoping of others; SIRTF is in the latter category. This paper describes the resulting redefinition of SIRTF and the technical innovations which have made it possible to package SIRTF's key scientific capabilities into the envelope of a moderate-class mission.

1. Background and Introduction

The Space Infrared Telescope Facility (SIRTF) has been planned by NASA and the US scientific and aerospace communities as a cryogenically-cooled observatory for infrared astronomy from space. SIRTF will build on the scientific and technical accomplishments of the predecessor IRAS, COBE, and ISO missions. However, SIRTF will take a major step beyond these missions by combining - for the first time - the intrinsic sensitivity of a cryogenically-cooled telescope for infrared astronomy from space with the great imaging and spectroscopic power of large format, low-noise infrared arrays. The scientific capabilities of this combination are very powerful, and the many exciting results from IRAS and COBE have whetted our appetite for a more penetrating look at the infrared sky. As a result, in 1991, SIRTF was designated by the National Academy of Sciences “decade review” of astronomy and astrophysics - chaired by John Bahcall - as the highest priority new major mission for all of US astronomy in the 1990’s.

2. Constraints and requirements

The chief constraint which has driven the redefinition of SIRTF is the requirement that the development phase cost be no greater than $500 M in real year dollars. The system described below has in fact been even more tightly constrained by a self-imposed requirement of $400 M real year dollars, including contingency. In response to this constraint, the SIRTF Science Working Group has rebuilt SIRTF’s scientific and instrument requirements around four major scientific themes which parallel the scientific priorities identified for SIRTF in the Bahcall report. These themes are:

1. Protoplanetary and Planetary Debris Disks
2. Brown Dwarfs and Superplanets
3. Ultraluminous Galaxies and Active Galactic Nuclei
4. The Early Universe

Only facility and instrument capabilities essential for the study of these four problems are allowed to drive the cost and complexity of SIRTF. However, because a system optimized for the exploration of these questions will have powerful capabilities for the study of many other problems, SIRTF retains its broad scientific capabilities and appeal.

The SIRTF scientific and engineering teams have adopted an initial set of facility and instrument requirements to guide the system design process. These requirements, which are consistent with our four scientific goals, are:
1. Aperture - 85 cm
2. Wavelength Range
   - Imaging - 3-180 μm
   - Spectroscopy - 4-40 μm
3. Lifetime - 2.5 yrs.
4. Image Quality - 50% encircled energy within 2" diameter at 3.5 μm
5. Optics Temperature - 5.5 K
6. Instrument Accommodations:
   - Cold mass - 50 kg
   - Cold power dissipation - 10 mW
   - Cold instrument volume - 0.2 m³

In addition, a new “warm-launch” system architecture was chosen for investigation. In this approach, the telescope is launched at ambient temperature and is cooled on orbit by a combination of passive radiation and the boil-off helium gas from the cryogen tank. It therefore differs from the “cold-launch” architecture used by IRAS and ISO, in which the telescope is contained within an annular cryogen tank. The features of SIRTF’s warm launch architecture are discussed further below. A very thorough discussion of purely radiatively-cooled space telescopes is given by Hawarden et al. (1992). In areas where the analyses overlap, such as the prediction of outer shell temperatures, the results of the SIRTF calculations agree with those presented by Hawarden et al. (1992).

3. System Description

3.1. Orbit and Launch Vehicle

An important feature of the new SIRTF mission is the adoption of a solar orbit (Figure 1). To reach this orbit, the spacecraft is launched with slightly greater than the terrestrial escape velocity in such a manner that it ends up trailing the Earth in its orbit around the sun. This orbit makes better use of launch capability than does a conventional Earth orbit, and it permits excellent, uninterrupted viewing of a large portion of the sky without the need for Earth-avoidance maneuvers. In addition, the absence of heat input from the Earth provides a stable thermal environment and allows the exterior of the telescope to reach a low temperature via radiative cooling.