ASTROTECH 21: TERAHERTZ TECHNOLOGY FOR SPACE ASTRONOMY IN THE 21ST CENTURY

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ABSTRACT

Two major missions are now being considered by NASA for launch in the first decade of the 21st century. The Large Deployable Reflector (LDR) is a filled-aperture telescope 20 meters in diameter which will be erected in space with ultralightweight optical elements and support structures. The Lunar Submillimeter Interferometer (LSI) will be a dilute-aperture phased-array telescope with seven 5-meter aperture elements on a 2-kilometer baseline. Collectively, these observatories will observe emission from cold molecules in the universe on various spatial scales from planet-forming regions to clusters of galaxies providing information about their temperatures, molecular constituents and dynamical motions. They will provide fundamental information on the origin of planets and stars and the evolution of galaxies. To attain these objectives, high performance terahertz receivers operating in the frequency range from 0.3 THz to 10 THz will be needed. Single element mixers and tunable local oscillators for 0.3 to 1 THz will be needed by 1994 in order to demonstrate terahertz technologies in space during the 1990s. Arrays of mixers and local oscillators operating from 0.3 to 10 THz will be needed by the end of the decade to enable the LDR and LSI. The Astrotech 21 program is being formulated by NASA to respond to the technology needs of a broad suit of major astronomy missions launched in the first two decades of the 21st century. An aggressive program of terahertz technology development is anticipated to be included in the program.

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INTRODUCTION

Space astronomy is about to embark on a great period of discovery. During the 1990s, four Great Observatory missions will be launched and will probe the universe in spectral regions ranging from gamma radiation to the far infrared. But NASA is already looking beyond the Great Observatories to other major missions in the first decade of the 21st century. To enable its New Century Astronomy program, and thereby assure continued U.S. leadership in space science, a substantial investment in technology will be required during this decade. This will be provided by the Astrotech 21 program. Submillimeter (terahertz) technology will be a major area of emphasis.

ASTROTECH 21

During early 1989, the Astrophysics division at NASA Headquarters determined that significant advances in capability over the Great Observatories would require major advances in the techniques of observation from space. Observations with higher angular and spectral resolution and greater sensitivity are clearly needed. The exploration of new spectral regimes is also needed. Space interferometers located on large space structures or on the lunar surface have been identified as the most promising approach for achieving major advances in angular resolution. Observations of gravitational waves using laser interferometry are seen as a fundamentally new tool for probing the violent accelerations of matter within opaque clouds. In addition, the largely unexplored submillimeter (terahertz) spectral region was identified as particularly promising for investigation. NASA recognized that this capability would require a sustained technology development effort over the next decade, and asked JPL to lead the definition of technology development program. The technology development program is known as Astrotech 21.

The first step in the definition of the Astrotech 21 program was the specification of the observational requirements for future missions. This was followed by the definition of telescopes and science instruments. In many instances, the Astrotech 21 study team has been able to draw on earlier mission studies to streamline the planning process. This is now leading to an assessment of the status of the relevant technologies. At the time of writing, the process of planning an Astrotech technology program is well underway.

The planning and implementation of Astrotech 21 involves a partnership between the Astrophysics Division, which is part of the Office of Space Science and Applications (OSSA) at NASA, and the newly reorganized Office of Aeronautics and Exploration Technology (OAET). Currently, only the planning phase is funded and the implementation phase will require budgetary action by both OAST and OSSA.

SUBMILLIMETER SCIENCE AND TECHNOLOGY

Submillimeter science and technology is already part of the NASA program. The OAET's Information Systems and Human Factors Division is supporting the development of submillimeter technology for space science applications at the Center for Space Microelectronics technology at JPL and other NASA centers. OAET also funds the University Space Engineering Research Centers Program which supports the NASA Center for Space Terahertz technology at the University of Michigan. OSSA, on the other hand, supports the development of flight instruments and the acquisition and analysis of submillimeter science data. Currently, only one submillimeter astrophysical instrument is under development: the Submillimeter Wave Astronomy Satellite (SWAS) which is described at this symposium. The Astrotech 21 submillimeter planning activity will lead to the establishment of technology goals enabling the set of missions beyond SWAS. These missions include the Submillimeter Moderate Mission (SMMM), the Large Deployable Reflector (LDR) and a Lunar Submillimeter Interferometer (LSI). A preliminary schedule for implementing these missions appears in Fig. 1. Illustrations of the SMMM (which includes two possible configurations), the LDR and the LSI appear in Fig. 2.

STATUS

The Astrotech 21 technology plan for submillimeter missions will be completed in late April, 1990. This plan will include not only sensor technology but also cryogenics, telescope technology, space assembly and servicing. In the field of submillimeter heterodyne technology, contributions from the scientific and technical communities have been solicited by Dr. Margaret Frerking of JPL. Dr. Frerking will use thse contributions in formulating a major section of the Astrotech 21 submillimeter plan. The submillimeter plan will be consolidated with plans for other disciplines to form a single integrated plan which will be submitted to the agency by the late spring or early summer.

ACKNOWLEDGEMENTS

The author acknowledges the contributions of a large number of people in the NASA community to the Astrotech 21 planning effort. In particular, the contributions of Dr. Larry Caroff and Mr. Wayne Hudson of NASA Headquarters in the formulation of the Submillimeter planning process are recognized.

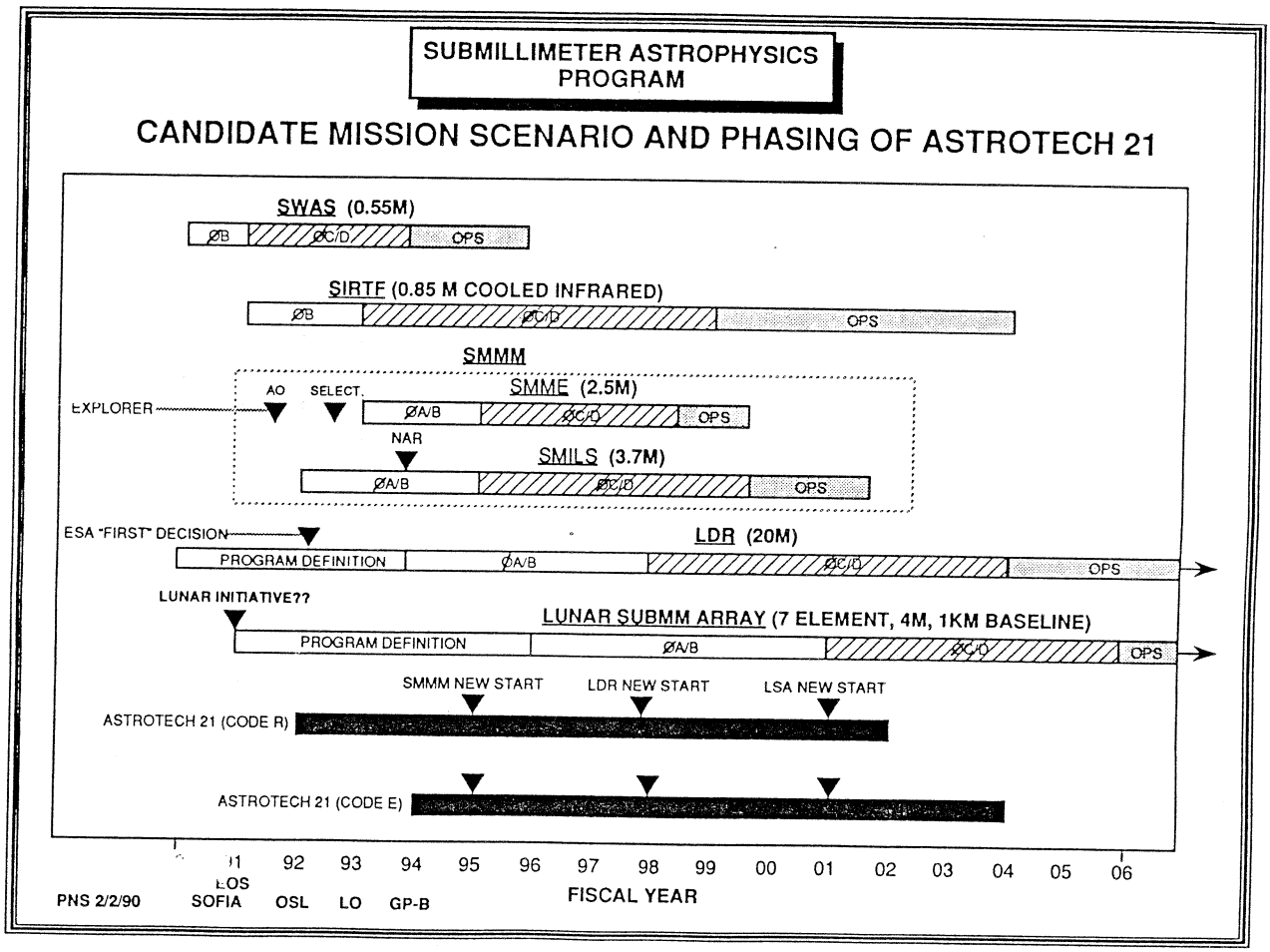

Figure 1

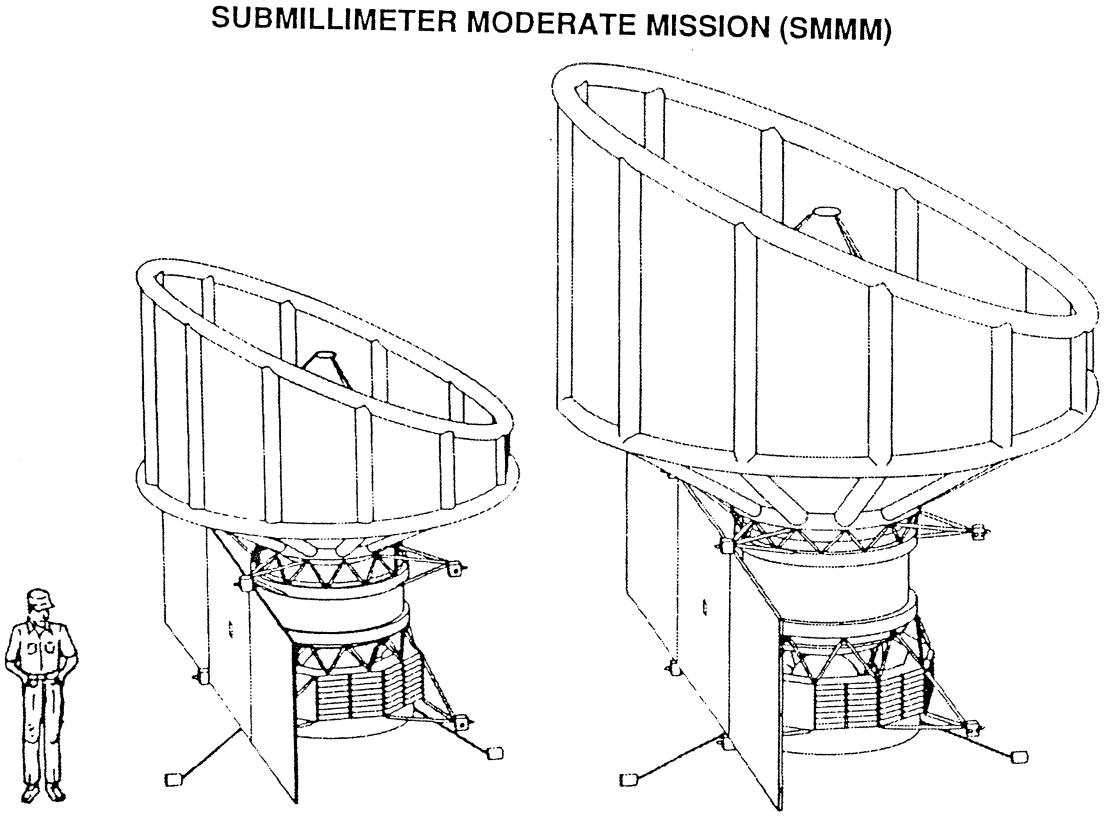

Figure 2a

THE LARGE DEPLOYABLE REFLECTOR

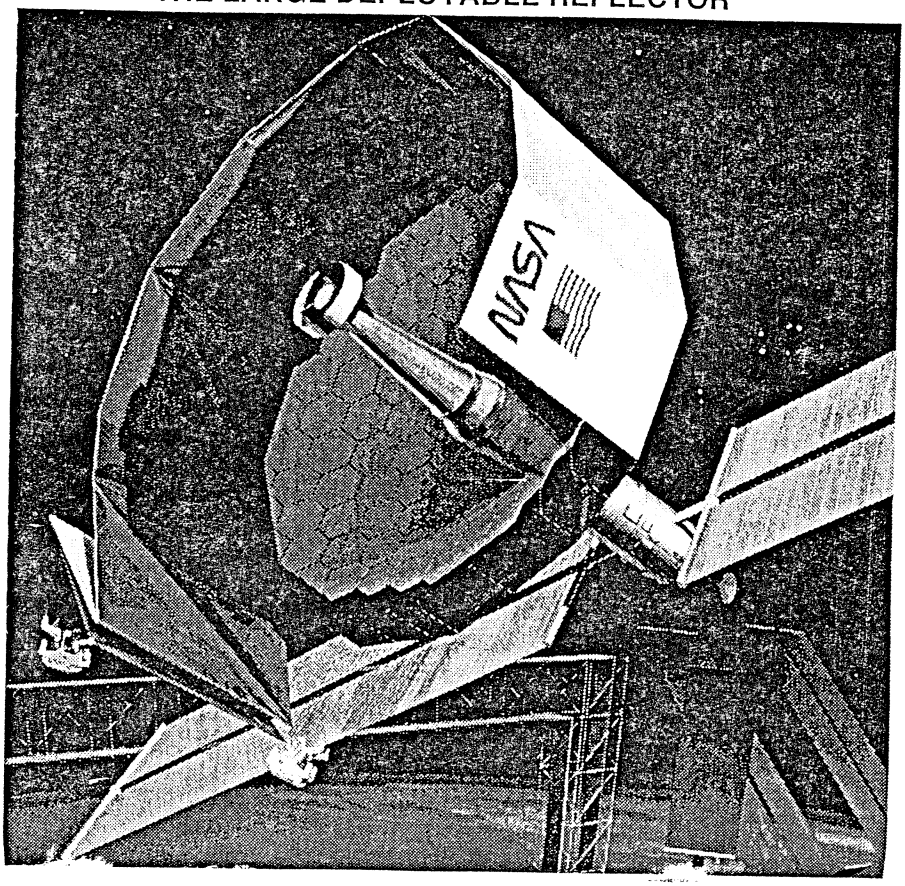

Figure 2b

SUBMILLIMETER INTERFEROMETER

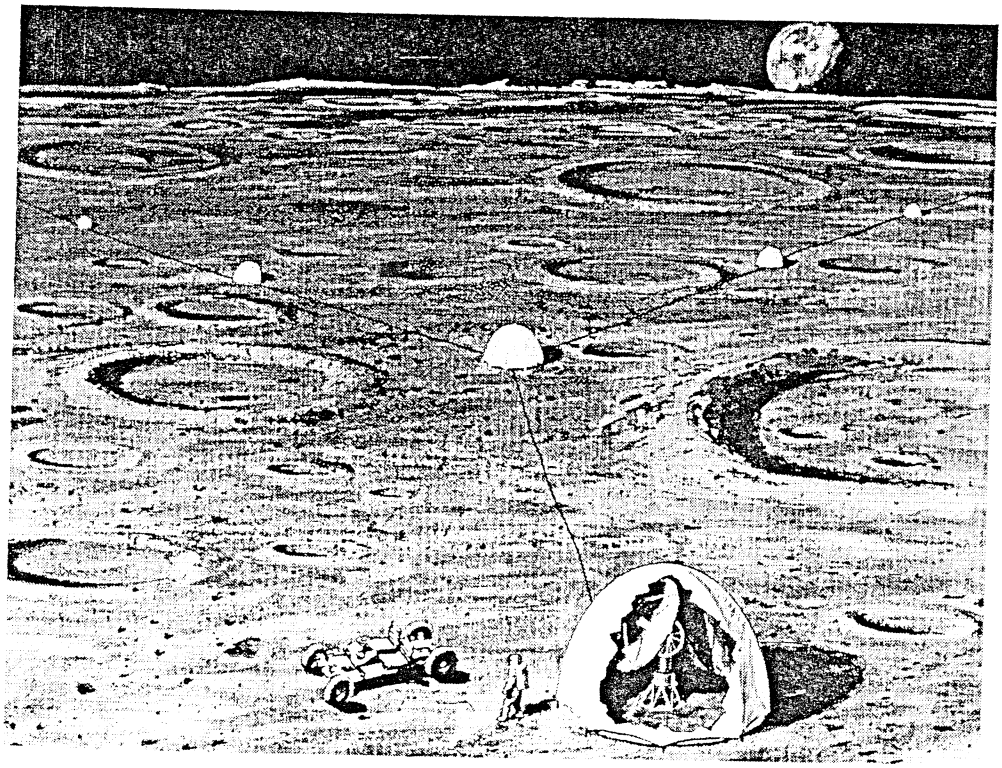

Figure 2c