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SOFIA: STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY

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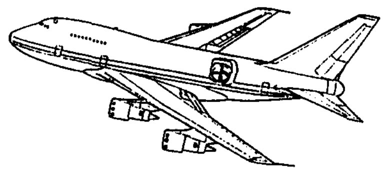
Introduction



SOFIA will be a 2.5 meter telescope installed in a Boeing 747 aircraft. It will replace NASA's smaller Kuiper Airborne Observatory (KAO), which for the past 18 years has provided the *only* routine access to most of the vital infrared spectrum (1 - 1000 μm). The aircraft platform opens a valuable window to the universe by enabling measurements of infrared radiation from celestial sources which the Earth's atmosphere absorbs at lower altitudes. SOFIA will have 10 times the sensitivity and 3 times the angular resolution of the KAO throughout most of the infrared spectrum.

SOFIA will be operated during its 20 year lifetime as an international facility for astronomy. It would fly 160 astronomy missions per year for about 50 science teams, selected by annual peer review. Nearly a third of these teams will furnish the observatory with specialized instrumentation, including array cameras, polarimeters, and several types of spectrometers. The frequent flight opportunities with state-of-the-art instruments guarantee extensive community participation and hands-on training of young scientists.

Science Objectives

As demonstrated by the KAO and IRAS (the Infrared Astronomical Satellite), infrared (IR) radiation characterizes a multitude of rich and varied physical processes, and reveals astronomical phenomena occurring in otherwise hidden regions of the cosmos. SOFIA will exploit and extend this scientific legacy by means of high spectral and spatial resolution observations spanning the infrared domain. On SOFIA the spectral resolution will span a range up to $(\lambda/\Delta\lambda) \sim 10^6$, and at 100 μm the λ/D beamsize will be 8 arcsec. SOFIA thus will complement future cryogenic infrared satellite programs such as ISO (Infrared Space Observatory) and SIRTF (Space Infrared Telescope Facility) which will be more sensitive than SOFIA, but will have lower spectral and spatial resolutions. Topics that would be addressed by astronomers using SOFIA include: Interstellar cloud chemistry, dynamics, and star formation in our galaxy; Proto-planetary disks and planet formation in nearby star systems; Origin and evolution of biogenic materials in the interstellar medium; Composition and structure of planetary atmospheres and rings, and comets; Star formation, dynamics, and chemical content of other galaxies; And the dynamic activity in the center of the Milky Way.

Many of these science topics overlap with those of the MM (millimeter) and SMM (submillimeter) Interferometry community. SOFIA would complement the observations of this community by exploiting the continuum and line emission in the far-IR to measure the properties of the warm components of circumstellar and interstellar media. For example, SOFIA can probe the 60 μm emission region of the spectrum from proto-planetary disks. This emission comes from the region of the disks where planets are expected to form. This information will complement the longer wavelength images of the outer (cooler) parts of the disks, which will be obtained with very high spatial resolution using ground based MM interferometers. Although SOFIA will not be able to match the spatial resolution of the MM Interferometers (60 μm beam corresponds to ~ 700 AU at Taurus), SOFIA's real and confusion-limited sensitivity, in partnership with the MM results, will enable detailed modelling of the observed IR and MM emission.

Aft-Mounted Telescope

Before 1992, the SOFIA design had the telescope cavity forward of the wing in a Boeing 747SP. Studies in 1991 and 1992 showed, however, that mounting the telescope behind the wing appreciably simplifies the modification of the aircraft and that the same size telescope can be accommodated. Major cost saving features (relative to the previous configuration) are: Only one pressure bulkhead is required; Fuselage is nearly cylindrical, simplifying the structural reinforcement and telescope cavity door; Fewer electrical and mechanical control systems are disturbed; Forward upper deck removal is unnecessary; Ballast in the tail is eliminated.

The most significant science impacts of mounting the telescope aft of the wing were found to be: seeing (in the visible and near-IR) is degraded by the thicker boundary layer; and that radiative noise in the focal plane can increase for the telescope in the low elevation range (ie., $< 30^{o}$) due to scattering of the emission from hot engine exhaust. Both these effects have been studied extensively, and the conclusion was reached that their impact to science was considered acceptable considering the potential cost saving to the project.

Status

In its recent report, the U.S.A.'s National Academy of Sciences' Astronomy and Astrophysics Survey Committee ranked SOFIA as the highest priority moderate cost new mission for NASA in the 1990's. This priority was based on SOFIA's potential for education and for development of new instrument technology in addition to its unique science capabilities. NASA and its potential partner DARA (the German Space Agency) have agreed the SOFIA project is ready for development, and if funding is available in FY95, SOFIA could be operating before the end of the decade.