NASA's Astronomical Search for Origins Program

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Introduction

Science programs within NASA's Office of Space Science (OSS) have been placed into four scientific categories or themes:

- Astronomical Search for Origins (ASO)
- Structure and Evolution of the Universe(SEU)
- Sun Earth Connection (SEC)
- Solar System Exploration (ESS)

Each science theme develops a set of compelling scientific goals and a roadmap to achieve those goals through a series of flight missions. This talk outlines the roadmap for the ASO theme (Black et al, 2000; Origins homepage) emphasizing those aspects which are relevant to the present workshop. In particular, the Large Telescope Systems Initiative (LTSI) program is presented. LTSI will address the technology needs of future missions and is one of the programs through which detectors will be developed. The need for high performing detectors required to achieve the breakthrough science envisaged in long term visionary missions is well recognized.

The Origins Roadmap

The two defining questions of the ASO science theme

- Where did we come from?
- Are we alone? are age old and have forever excited the curiosity of the human mind. ASO will attempt to answer these questions by
- Tracing our cosmic roots through a study of the formation of galaxies, stars, heavy elements, planetary systems, and of life itself on the early Earth.
- Searching for life outside the solar system by the remote detection of the "smoking guns" indicating biological activities on extrasolar planets.

The hierarchical structure of the ASO plan begins with the two defining questions, which are then translated into four goals, eight objectives, and sixteen investigations (Figure 1). The bottom of the pyramid consists of a set of space flight missions, a robust research and analysis program designed to respond directly to the investigations, and technological development to enable the missions. As a recognition of the fact that it is extremely important to kindle and keep alive public excitement and participation in the Origins program, Education and Public Outreach (E/PO) is injected at all levels of the ASO plan.

The ASO theme's two highest priority missions in the near term (2003-2007 window) are:

- Next Generation Space Telescope (NGST) which is targeted for a 2003 new start and a 2007 launch, will use 0.6-10+ mm imaging and spectroscopy to study the early universe;
- Terrestrial Planet Finder (TPF) which is targeted for a 2007 new start and a 2011 launch, will search for and characterize Earth-like planets around ~200 nearby stars.

In addition to their primary goals, NGST and TPF will carry out a broad range of other astrophysics investigations.

Two notional missions are envisioned in the mid term (2008-2013).

- Space Ultraviolet and Optical Telescope (SUVO), which will perform UV spectroscopy with sensitivity 100 times that of the Hubble Space Telescope (HST) and with the principal scientific objectives of (a) determining the fate of the baryonic universe, and (b) following the chemical evolution of the universe.
- Filled Aperture Infrared Telescope (FAIR), which will operate in wavelengths from 30-300 mm to probe critical astrophysics processes on all scales, pricipally (a) mineralogy of the Kuiper belts around

nearby stars, (b) protostellar disks in nearby star-forming regions, and (c) highly red-shifted, dusty galaxies that account for the cosmic IR background emit line (CII) and continuum emission.

Finally, in the long term (beyond 2013), ASO hopes to achieve its strategic goals through a spectroscopy mission to search for the "smoking gun" for evidence of life on other planets, and an imaging mission to obtain high resolution images of distant planets.

The hallmark or the Origins Observatories is that each mission builds on scientific and technological foundations created by the prior missions and feeds forward science and technology to the follow-on missions. Thus, NGST builds on the legacy of HST scientifically in the areas of the origins and evolution of galaxies, structure and chemistry of the Universe, and the physics of stars and planet formation., and technologically in the areas of ultra-lightweight large optics, cryogenic deformable mirror, cryogenic actuator, detector technology, and precision deployable structure. Figure 2 summarizes enabling technologies between the missions currently under development, Space Interferometry Mission (SIM), Space Infrared Telescope Facility (SIRTF), ST-3, a technology development demonstration mission, the new starts, NGST and TPF, and the next generation missions.

The ASO theme is working on a strategy to lay down the groundwork for achieving science goals for which we have no in hand technologies. In this spirit, the Large Telescopes Systems Initiative (LTSI) is proposed to address the next series of science grand challenges which require large telescopes to respond to the needs for very high sensitivity and resolution (spectral and spatial.) Four focus areas have been identified under LTSI.

- Aperture technology, which will utilize NASA's Gossamer Initiative to develop an aperture area ten times that of NGST, an areal density reduction to , 1kg/m^2, efficient packaging and precision deployment, and initial coarse shape control.
- Passive and active cooling, which includes 50 – 100 m sunshield technology, and affordable large-scale aperture refrigeration capable of cooling below the 35K passive limit.
- Active sensing wavefront/control required for a 25 – 40 m class primary, internal metrology, large format, long-stroke deformable mirrors, and a ten times wavefront improvement over NGST.
- Enabling detector technologies, which include UV energy resolving photon counting detectors, and far infrared imaging arrays.

In summary, LTSI will develop the breakthrough capabilities needed for UV to far-IR astrophysics by making telescopes an order of magnitude more lightweight than NGST using new materials, on-orbit deployment, and advanced micro-electronic mechanical (MEMS) devices for precision wavefront control. LTSI will develop the detectors and cooling needed to take full advantage of the low background space environment. LTSI is not about missions but about making possible the measurements that the community will need a decade from now to achieve important scientific goals.

Astrobiology

For completeness, it is worth mentioning that ASO is the "home" to astrobiology within OSS. Its goals are to understand the evolution of life on Earth so as to know how and where to search for life on other planets. Astrobiology objectives are:

- How does life begin and evolve?
- Is there life elsewhere in the universe?
- What is life's future on Earth and beyond?

These objectives have been translated into a series of investigations, which are currently being developed. Astrobiology is a major new initiative for NASA and promises cutting edge science which should help answer both of ASO's defining questions.

Summary

The scientific community has laid out an extremely exciting and challenging roadmap for the ASO theme. A key component in achieving its scientific goals is the development of detectors in the wavelength range

spanning from the UV to the infrared. The next step is to develop a research roadmap for detector development, so that ASO can achieve its long term science goals.

Acknowledgements

I would like to thank Anne Kinney, David Black, Charles Beichman, and Richard Capps for providing me the material presented in this talk.

References

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