FUTURE PLANS

NASA PLANS RELEVANT TO THE STUDY OF CIRCUMSTELLAR MATTER

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ABSTRACT. The Astrophysics program of the National Aeronautics and Space Administration of the United States emphasizes use of vehicles to obtain above-the-atmosphere observational advantages, including expanded electromagnetic frequency access, enhanced sensitivity resulting from reduced or eliminated atmospheric absorption of light and image smearing. Space technology provides a superior means for astrophysical inquiry, particularly in the case of circumstellar material. Much of the flight program is undergoing intensive review following the Space Shuttle disaster of January 1986.

1 PROGRAM STRATEGY AND STATUS

As part of a national and international effort, experiments useful for the study of circumstellar matter often must have additional application to a wide range of important current research topics in astronomy, in order to help justify the cost of development. The approach being taken by the NASA Astrophysics Program involves a succession from initial modest experiments, building toward the more ambitious, all underpinned with theory and supporting work in related physics. The theoretical scaffolding that underlies our interpretation of the cosmos must be relied upon as the basis for choice among several attractive options. Also, without the input of physicists and chemists, the interpretation of atomic and molecular spectra, relativistic phenomena and other processes would be impossible.

1.1 THEORY AND LABORATORY ASTROPHYSICS

In addition to ongoing support of individual theoretical investigations, NASA solicitied proposals in 1984 for the first Astrophysical Theory program, intended to support small teams of scientists working on significant modern problems. These first round selections in a kind of "mini-Sonderforschungsbereiche" included studies of UV and X-ray spectral processes, solar and stellar oscillations, physics in the early Universe and of compact objects, star formation and high energy shock processes in astrophysics.

In the realm of laboratory astrophysics, NASA continues to support a variety of lab and theoretical efforts at Universities and its centers for the quantitative spectroscopy of

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atoms, ions, molecules and solid state materials relevant to astrophysics. Examples include the atomic data center at the National Bureau of Standards (Wiese and Martin), ultraviolet cross sections and transition probabilities (Parkinson and Smith at CfA, Lee at SDSU), infrared molecular and PAH spectroscopy (Huntress and Poynter at JPL; Allamandola at Ames) and microgravity interstellar particle simulations (Nuth and Donn at Goddard).

1.2 SUB-ORBITAL EXPERIMENTS

The initial experiments in a new area (e.g. extreme ultraviolet astronomy) have been modest, low cost efforts to sample existing celestial sources with state of the art detector systems. These experiments include telescopes and instruments mounted on sounding rockets, under high altitude balloons, or, on the Kuiper Airborne Observatory (KAO) – a telescope-equipped aircraft specializing in infrared work. The KAO has recently returned from a successful Halley observing expedition in Australia where H_2O of cometary origin has been detected for the first time.

The SPARTAN program has begun to move this class of efforts into the Space Shuttle era. SPARTAN is a semi-autonomous satellite, capapble of being carried into orbit on the Shuttle, deployed for a few days as a temporary free-flying experiment, then retrieved and returned. The scientific experiment is pre- programmed and the data captured on tape. SPARTAN, like the sub- orbital efforts, offers a low cost way to pursue timely, well focused experiments, as well as hands-on experience for instrument developers and students. In this way, new technology can be tested and verified in space prior to major investments in larger efforts.

Whereas a dozen SPARTANs were selected for development after the first successful flight of an Xray experiment in June 1985 (Cruddace et al. 1986), the curtailment of the Space Shuttle launches for an indefinite period has forced re-evaluation of these efforts. Many are being reconsidered for sounding rocket interim experiments until Shuttle launches resume.

1.3 MODERATE COST EXPERIMENTS

An important step in this logical succession is to inventory the celestial information that the latest technology can provide. Such sky surveys have been accomplished at several wavelengths so far, most notably in the infrared with IRAS and in the X-ray regime with UHURU. These surveys provide the basis for future work, both in terms of focused, modest scale efforts and for facility class instruments which perform detailed studies. This class of experiments includes the Explorer program, which is a series of space science efforts dating back to the beginning of the space age. Recent Explorers include the International Ultraviolet Explorer (IUE), the Infrared Astronomy Satellite (IRAS), the Solar Mesopheric Explorer (SME), the Dynamics Explorers (DE) and others.

Explorers presently under development include the Cosmic Background Explorer (COBE) and the Extreme Ultraviolet Explorer (EUVE). COBE was being readied for launch in 1987, but is now being refitted for a Delta launch at great cost to the Explorer queue. EUVE is on a slowed development track. NASA had solicited new concepts for the next generation of Explorers and received nearly 50 responses in July 1986, but the fate of those proposals hangs in the balance as the impacts of the Shuttle reprogramming affect the entire agency (see below).

A separate class of comparable cost efforts called Spacelab experiments sadly may never see fruition beyond the flights of Spacelab 1 and 2 because of the Shuttle hiatus. An important payload called Astro was being readied to observe comet Halley with a trio of ultraviolet imaging, spectroscopy and polarimetry telescopes of the meter class. This instrument was also programmed to perform a number of important new astronomical investigations over a several reflight effort, but its fate is presently as dark as the warehouse near Cape Kennedy in which it is being stored.

1.4 MAJOR FACILITIES

The success of the Explorer program and the impressive capabilities of aerospace engineering offered impetus to scientists and NASA officials to consider large experiments which could serve as observatories in space. The Hubble Space Telescope (HST), the approval of which was intricately connected with the approval for the Shuttle program itself, set the tone for a series of proposed "Great Observatories". These include the Advanced X-ray Astrophysics Facility (AXAF), the Space InfraRed Telescope Facility (SIRTF), the Gamma Ray Observatory (GRO) and the Large Deployable Reflector (LDR). The approximate expected capabilities of these instruments are detailed in Table 1. While the HST and the GRO have both been under development and are nearing launch readiness, the others remain unstarted high priorities to the US space astronomy community (see the recent Report of the Astronomy Survey Committee of the National Academy of Sciences). Under present economic conditions, a choice may ultimately have to be made between timely execution of the Great Observatories program and any of the new Explorer concept proposals.

The circumstellar material experiments possible with the Hubble Space Telescope are a good example of the type of science that would be possible with the Great Observatories. For example, the High Resolution Spectrograph (HRS) will be able to examine cool star spectra with enough signal-to-noise and spectral resolution to determine whether the chromospheric motions suggested in several IUE studies are real. These include "downflows" in stars with transition regions (Ayres et al. 1983; Brown et al. 1984), and non-monotonic outflows in red supergiant star winds (Carpenter 1984). To fully assess the energetics and origins of circumstellar matter, a fuller understanding of the underlying stellar atmosphere is necessary. The HRS offers this possibility, particularly given the preparation of scientific questions made possible with IUE studies.

A second important class of experiments will be done with the imaging experiments on HST, including the Wide Field/Planetary Camera and the Faint Object Camera. In either case, the image scale and selection of narrow band filters plus occulting modes should be sufficient to permit unique studies of extended material around nearby or other stars with angular extent in excess of roughly 50 milliarcseconds.

Finally, the capability of the Faint Object Spectrograph to perform polarimetry as well as spectroscopy offers an entre into the important study of inhomogeneities and the

Table 1: Approximate expected capabilities of proposed experiments

	Wavelength or Energy	Angular Resolution	Spectral Resolution	Sensitivity
GRO	0.1-1000MeV	0.1 deg.	6-250	10 x CosB
AXAF	0.1-10 keV	0.5 arcsec	10^3	100 x HEAO-B
HST	1200-8000A	0.1 arcsec	10^5	V = 25
SIRTF	3-700 micron	1-18 arcsec	10^3	1000 x IRAS

role of magnetic fields in circumstellar environments. The impact of the instruments on HST to all phases of stellar astronomy concerned with circumstellar matter promises to be immense.

2 COMMENTS ON THE CHALLENGER DISASTER

Whereas a detailed discussion of the cause of the Space Shuttle accident of 1986 January is beyond the scope of this review, I feel that given the international impact of the event to space astronomy programs, IAU members and other readers deserve whatever additonal insight I can provide based on my recent four years of experience at NASA Headquarters. An excellent and critical review of the origins of the Shuttle program was published by Logsdon (1986) and this is to be recommended as a basis for understanding the present circumstances. The Shuttle program labored under several pressures: (1) the post Apollo era search by NASA for a major mission to justify its existence, plus increasing federal budget pressures, which lead to the agreement to fly a "commercially viable" Shuttle; (2) government-wide increasing reliance on contract labor rather than in-house engineering expertise, which distanced managment and the workers, and, (3) that NASA commanded a declining percentage of US aerospace business, and could no longer influence pricing during high inflation periods.

These factors lead to a configuration of circumstances in 1986 January which contributed to the launch outside of safe limits despite objections from knowledgeable engineers. The Shuttle launch frequency had been growing from every few months toward an ambitious monthly rate. This included opening a second launch pad at Kennedy in time for the planned 1986 May twin launches of Ulysses and Galileo interplanetary probe payloads on Shuttles, as well as opening a new launch facility at Vandenberg in California for Department of Defense use, also in 1986 (March). All of this growth in capability relied heavily upon a central set of crews at Kennedy which already were being worked seven days a week, 24 hours per day. Compounding this was the pressure to meet cometary observation windows. The warning implied by the increasing frequency of launch delays for STS 61-C and 51-L was unfortunately not heeded. Much of the recent pressure to reduce costs while increasing launch frequency came from a Directive from President Reagan in August 1984, ordering NASA to develop a "fully operational and cost effective shuttle program by 1 August 1988" (Goodwin, 1986).

While we can hope that history records this period as a pause to reformulate a successful space exploration strategy, the consequences of the present situation are not yet clear. Whereas the cost to space astronomy and other space sciences will be large in terms of maintaining launch readiness of developed instruments like HST at the expense of starting any new initiatives, there may also be several benefits. First, the previously planned frequency of Shuttle launches would have aggravated a growing problem of low earth orbit debris buildup, which already was manifest in the Shuttle glow problem that harmed certain astronomical observation attempts from Shuttle (e.g. Faust on Spacelab 2). Second, a reassessment of the balance between manned and unmanned launch vehicles is underway. This balance influences the kinds of space astronomy that are possible as a function of payload capacity, pricing, flight frequency and opportunity. Third, before embarking on a major developmental effort such as the proposed Space Station, a larger consideration of the committment for the project may be in order. As Logsdon (1986) points out "Decisions to make capital improvements in major facilities require more than [just] an initial approval. To be effective, they must be accompanied by a political committment to provide the resources required over the lifetime of the program on a timely basis. Further, it makes little sense to invest in a capability intended to enable a wide range of scientific and technological activities if adequate support for those activities is not also provided."

We are fortunate as astronomers that our fellow citizens possess so much interest in exploration of the cosmos, that our proposals for scientific instruments receive national and international support. It is encumbent upon us to channel this support into productive capabilities that enrich the intellectual lives of all thinking persons.

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