A PROGRAM FOR THE OBSERVATIONS OF THE SUN AND HELIOSPHERE FROM SPACE 1980-1995

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ABSTRACT

Recent, fundamental discoveries of the phenomena of the Sun and of interplanetary space have led to a far broader definition of the term "solar physics" than was generally perceived a decade ago. The implications of this broadened definition of solar and heliospheric physics will be studied by essentially every solar space mission either now approved, or in the planning stage, for the period of 1980 to 1995. These missions include traditional Earth-orbiting satellites; Shuttle/Spacelab sortie missions, free flyers that transit the solar polar caps and probe the innermost corona (both frontier regions of the heliosphere), and finally possible semi-permanent orbiting platforms for advanced solar/heliosphere observations.

1. INTRODUCTION

The decade of the 1970's saw the discovery of a wide variety of phenomena in both solar and interplanetary physics using space as well as ground-based techniques. Among the observations made from space was the discovery of solar coronal holes and the identification of these holes as the source of the high speed solar wind streams that give rise to recurrent geomagnetic storms. A second observation was that regular expulsions of large quantities of mass from the Sun - called coronal transients - accompany nearly every form of energetic solar event. A third major discovery was that the large-scale, extended structure of the solar wind can be described by a so-called "warped current sheet" model, at least during the declining phase of the solar cycle, which in turn can be related to the large-scale pattern of the Sun's photospheric fields. These

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developments have led to an intense reawakening of interest in the relationship of solar activity to interplanetary phenomena, so much so that the space about the Sun is now increasingly referred to as the heliosphere.

A second class of discoveries relate to the interior of the Sun. Among these are that the observed neutrino flux is only about one-third as much as predicted by standard models of a solar-type star; that the solar cycle apparently disappeared for the 70 year period from 1645 to 1715 (the Maunder minimum); that the five minute p-mode oscillations of the Sun can be used to probe the interior structure and rotation of the Sun (sometimes referred to as "solar seismology"); and that the total solar irradiance (the "solar constant") may vary at a level of a few tenths of one percent on a long time scale, if not with the solar cycle itself.

In order to pursue all of the implications of these discoveries, a number of the major space programs now started or being considered for the period 1980 to 1995 emphasize both the relationship of solar to heliospheric phenomena and solar interior dynamics in addition to the more traditional aspects of solar physics. The rest of this paper will briefly discuss each of these missions to the extent that the current level of planning allows.

2. THE SOLAR MAXIMUM MISSION

The Solar Maximum Mission (SMM), has as its primary goals the study of solar flares, activity-associated coronal phenomena, and the long term monitoring of the total solar irradiance. The phenomenon of the solar flare is one of the oldest problems of solar physics, and whereas the Skylab missions in 1973-74 provided some of our most incisive observations yet of these events, the flare still lacks a satisfactory explanation. Since the hottest parts of the flare, and thus perhaps the key to the mechanism itself, appear in the XUV, X-ray, and gamma-ray portions of the spectrum, the majority of the payload of the SMM consists of these types of experiments (Table 1). Another one of the major discoveries of the Skylab/ATM solar experiments was that virtually every energetic solar event (flare, eruptive prominence, or surge) is accompanied by a coronal transient. Thus, the SMM also carries a coronagraph to monitor the location, frequency, intensity, and polarization of these spectacular events.

Table 1.
Payload of the Solar Maximum Mission

SMM Experiment	Spectral Range	Spatial Resolution
• Gamma-Ray Spectrometer	0.3-17 Mev	Full Sun
• Hard X-Ray Spectrometer	20-300 Kev	Full Sun
• Hard X-Ray Imaging Spectrometer	3.5-30 Kev	8" x 8"
• Soft X-Ray Polychromator	1.4-22.4 Å	10" x 10"
• UV Spectrometer and Polarimeter	1100-3000 Å	4" x 4"
• Coronagraph/Polarimeter	4435-6583 Å	6.4" x 6.4" or 12.8" x 12.8"
• Solar Constant Monitoring Package	UV-IR	Full Sun

One of the major benefits of this time phasing of the SMM will be the ability to correlate the coronal observations with in situ solar wind measurements (composition, ion and electron velocity distributions, magnetic fields, and plasma waves) made by the ISEE-3. This spacecraft is the third of the trio of the International Sun-Earth Explorer series, and is located in a "halo orbit" about the Sun-Earth gravitational libration point located about 0.01 AU toward the Sun along the Earth-Sun line. Thus, the ISEE-3, launched in August, 1978, is always outside the Earth's magnetopause and continuously immersed in the solar wind. (The ISEE-1 & 2 spacecraft orbit the Earth such that they pass through the magnetosphere). Thus, this combination of the SMM coronagraph and ISEE-3 will provide a major set of solar activity/solar wind data at the time of the maximum of the Sun's cycle, to complement the Skylab data taken during the declining phase of the last solar cycle.

A combined group of SMM Principal Investigators, Co-Investigators and Guest Investigators have been meeting regularly for the past two years to plan the SMM mission operations. These operations will be carried out from an elaborate Experiment Operations Facility (EOF) at the Goddard Space Flight Center, which has project management of the mission. Extensive plans for near real-time evaluation and comparison of data will also be carried out at the EOF, thus enabling the rapid updating of observing modes to capitalize on the continuously evolving patterns of solar phenomena. The SMM will operate for a minimum of two years with an option for a third, depending on spacecraft health, value of returned data, and availability of funds.

3. THE THREE DIMENSIONAL STRUCTURE OF THE HELIOSPHERE

3.1. The International Solar Polar Mission

One of the few remaining "frontiers" of the heliosphere is the third dimension well above and below the ecliptic. The new effort which will explore this region of space is the International Solar Polar Mission (ISPM), sponsored jointly by the NASA and the European Space Agency (ESA). The mission architecture of the ISPM will be to send two similarly instrumented spacecraft, one built by the ESA and one by the NASA, out of the ecliptic plane and over the poles of the Sun itself (Figure 1).

There are three main categories of science objectives for the ISPM:

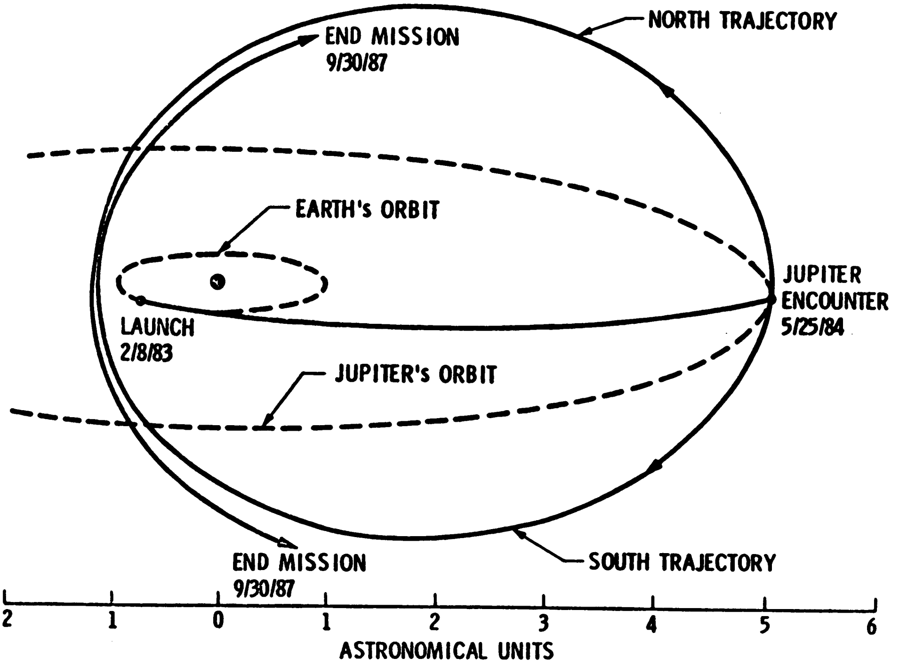

Fig. 1 Schematic of trajectories of the two ISPM spacecraft.

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o First, both theory and observations give strong reason to believe that the solar wind from the Sun's polar caps should have high velocity (500-800 km/s) owing to the presence of the coronal holes usually present at the solar poles. This polar solar wind should be far more homogeneous and radial in structure than the wind from the lower, equatorial "active" solar latitudes.

o Second, the polar view afforded by the ISPM trajectory is ideal for observing in an unambiguous manner the longitudinal structure of the inner solar corona (out to 10 solar radii or so). This longitudinal structure is basic to understanding how coronal holes and streamers relate to the solar wind farther out in the heliosphere.

o Third, the ISPM will have the opportunity to observe the nearly unmodulated spectrum of the cosmic rays, since these particles will only have to traverse the nearly radial, weak polar magnetic field lines rather than the tangled, stronger solar wind fields toward the ecliptic.

The ISPM is a joint venture between the NASA and the ESA, with each agency providing one spacecraft. The management centers for the two spacecraft are the Jet Propulsion Laboratory and the European Space Research and Technology Center, respectively. The payloads of the two spacecraft are similar and divided roughly equally between US and European investigators (Table 2). The major difference between the two spacecraft is the presence of a coronal imaging investigation, consisting of a coronagraph and soft X-ray telescope, on a Sun-pointing gimbal on the NASA spacecraft. This experiment will thus allow imaging of both the inner and outer corona from the unique perspective of the solar poles.

Both spacecraft are to be launched simultaneously by the Shuttle and then boosted by an auxiliary rocket on a transit trajectory in the ecliptic to Jupiter (Figure 1). At Jupiter, about 1.3 years after launch, both spacecraft undergo gravitational swing-bys, one directed north-bound and one south, out of the ecliptic plane and back toward the Sun in "mirror" images of each other. The two spacecraft pass over the north and south solar polar caps approximately 3.8 years after launch, at a distance that will not exceed 2 AU, then swing down to perihelion at 1 AU on their way to respective passages over the other solar poles. Thus, both spacecraft will pass over both solar poles in the period from mid-1986 to early 1987. The total nominal mission duration from launch to shortly after the second polar passages is five years. For the February, 1983, launch window, it is anticipated that each spacecraft will spend about 50 days above 70° heliographic latitude. This duration compares favorably to the rotation period of about 35-40 days of the polar caps, over which significant evolution of the solar polar conditions might occur.

3.2. In-Ecliptic Observations with the ISPM

Even though the ISPM will make fundamental and exciting

Table 2.
Payloads of the International Solar Polar Mission
(* U.S. PI; ** European PI)

NASA SPACECRAFT	ESA SPACECRAFT
SOLAR PHYSICS	
• White light/X-ray Coronal Telescopes*	
• X-ray Burst Monitor*	• X-ray Burst Monitor**
• Energetic Particle Detectors*	• Energetic Particle Detectors*
• Radio Burst Antenna*	• Radio Burst Antenna*
SOLAR WIND PHYSICS	
• Magnetometers*	• Magnetometers**
• Plasma Velocity/Density Exp.**	• Plasma Velocity/Density Exp.*
	• Plasma Ion Composition* &**
	• Plasma Wave Detector*
COSMIC ASTROPHYSICS	
• Cosmic Ray Spectrometer*	• Cosmic Ray Spectrometers*; **
• Gamma-Ray Burst Exp.*	• Gamma-Ray Burst Exp.**
INTERPLANETARY MEDIUM	
• Zodiacal Light Photometer**	• Interplanetary Dust Exp.**
• Interplanetary Gas Exp.**	
RADIO SCIENCE & GRAVITY WAVES	
3 U.S. PI's; 2 European PI's	
THEORETICAL & INTERDISCIPLINARY PHYSICS	
5 U.S. PI's; 3 European PI's	

observations by itself alone, its observations will be considerably enhanced by in-ecliptic space measurements of the solar wind plasma and the solar corona. Actually, owing to the well-known "convergence" effect of the high-latitude corona towards the solar equator, such simultaneous in-ecliptic measurements with the out-of-ecliptic ISPM may reveal that a substantial portion of the solar wind flow at the Earth may originate from the edge of the solar polar holes themselves.

The mechanism for accomplishing these in-ecliptic wind measurements is the Interplanetary Plasma Laboratory (IPL) of the space program called the Origin of Plasmas in the Earth's Neighborhood (OPEN). This OPEN program is designed to study the plasma sources, sinks, and processes within the Earth's magnetosphere and ionosphere using a system of four satellites: the IPL measures the "input" solar plasma, whereas the other three spacecraft are located at various places within the magnetosphere (and thus shielded from direct access to the solar wind). Thus the IPL, which carries a relatively standard complement of solar wind detectors, will serve the double function of monitoring the in-ecliptic wind for both the OPEN program and the ISPM. The plan is to launch the IPL in 1985, in time to be in its halo orbit about the Sun-Earth libration point when the ISPM spacecraft begin their out-of-ecliptic ascent following Jupiter swing-bys.

The in-ecliptic observations of the visible light and X-ray corona would be accomplished by a Solar Cycle and Corona Mission, which is part of a Solar Cycle and Dynamics program discussed in detail in Section 5 below.

4. THE SOLAR SHUTTLE/SPACELAB MISSIONS

4.1. The Shuttle/Spacelab Transportation System

The Space Shuttle/Spacelab System is considered a keystone to the NASA's solar physics programs of the 1980's through its ability to carry payloads of experiments for discipline-dedicated sortie missions of up to 30 days. The advantages of these Shuttle missions for solar physics, in spite of their relatively short length, are several:

- The Shuttle can carry much larger experiments than can the typical free flying spacecraft;
- The pointing and operation modes can be

under direct, real-time control of on-board crew members (Payload and/or Mission Specialists);

- o Sub-arc second pointing will be possible through a variety of ESA and NASA pointing gimbal systems; and

- o The instruments can be retreived for refurbishment, evolutionary upgrading, and/or changing film canisters.

The expected mode of operation for the Shuttle science missions is through the Spacelab system, which is an array of pressurized modules (for manned operations consoles) and/or unpressurized pallets (for experiments) that are mounted in the Shuttle bay (Figure 2). These Spacelab systems are being built by the ESA as part of a joint US-European venture. The general plan for Shuttle/Spacelab sortie missions is to mount preintegrated experiment pallets and the module (if required) into the Shuttle bay at the Kennedy Space Center. After launch and in-orbit checkout, the instruments are operated by the on-board crew working in close collaboration with scientists at the Payload Operations Control Center (POCC) at the Johnson Space Center.

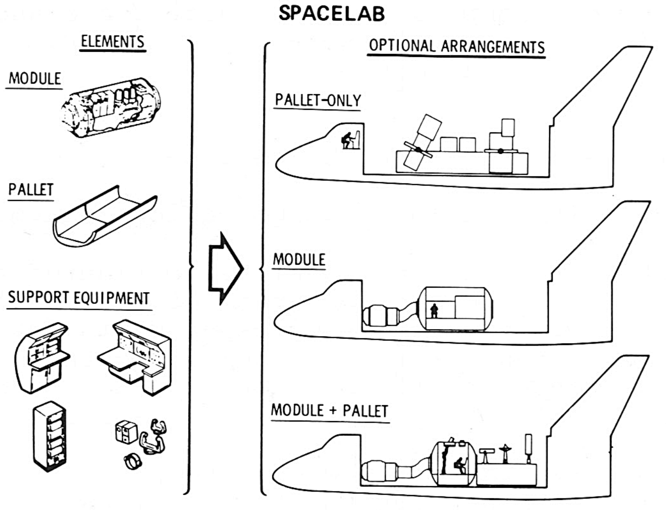

Fig. 2 Schematic of Shuttle with different Spacelab module and pallet configurations.

4.2. Shuttle/Spacelab Experiment Categories

Two classes of experiments will be flown: First are the Principal Investigator (PI)-class experiments for which Announcements of Opportunity (AO's) have been released. Several fundamental aspects are envisaged for the on-going Spacelab opportunity which differ from the usual PI flight opportunities (Figure 3). First, the AO is not for a given,

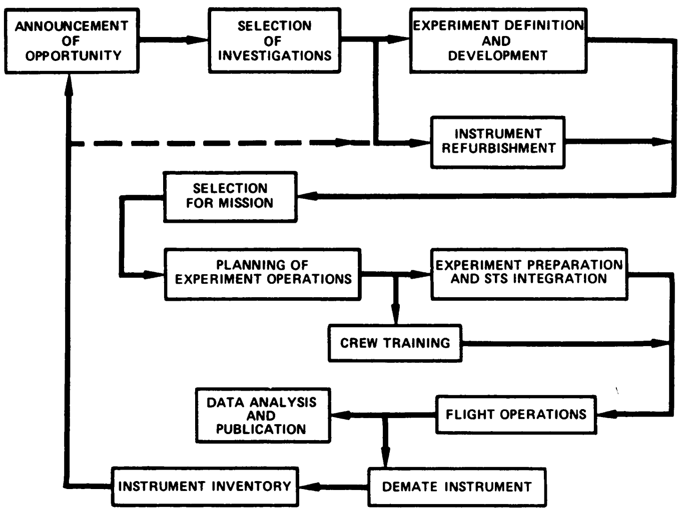

Fig. 3 Evolutionary schematic of Principal Investigator Class Spacelab experiments.

single flight. Rather, selected experiments are to be developed in parallel to a state of flight readiness, and then a second review will choose from among those experiments for a designated Shuttle flight. Second, the PI will be solely responsible for delivering a functioning, documented instrument; the NASA will exercise only general control to insure compliance with negotiated cost, interface, and safety requirements. Third, all developed instruments will be held in inventory and are expected to be reflown a number of times, either by the original PI or by other investigators who propose to use them.

The second class of Shuttle experiments is that of facility or Multi-User Instruments (MUI's), whose cost and versatility for the science community puts them in a class apart from the lower cost, more single-purpose PI instruments. An MUI is developed by a Facility Definition Team (FDT) chosen by the NASA and is developed as a NASA project through one of the NASA centers. MUI's have a much higher cost than PI experimens and work only in conjunction with other focal plane and/or auxiliary instruments. In general, these auxiliary pieces of equipment will be solicited by AO from the science community. Once developed and tested, they become part of the facility system and thus available for a variety of Guest Investigations.

4.3. Solar Physics Spacelab Investigations in the 1980's

As a result of two previously released AO's, a variety of PI solar physics investigations have been chosen (Table 3). These experiments are for an early Orbital Test Flight (mainly to test the Shuttle, only secondarily for science) in 1981; a dedicated space science flight, Spacelab 2, in 1982; and future, as yet unspecified, flights of Spacelab starting in 1983. This last AO is still open for a second round of selections as noted in an update issued in June, 1979.

A Facility Definition Team, formed in 1975, resulted in the development of the first Spacelab solar physics facility, called the Solar Optical Telescope (SOT), which was approved as a new project start in August, 1979. The basic SOT is a 1.25 m, diffraction-limited, f/3.6 telescope designed to accommodate a variety of focal-plane and auxiliary PI-class instruments (Figure 4). Unique features of the SOT are its Gregorian design, which eliminates the concentrated heat load on the secondary mirror (at the expense of field-of-view); a fine focus/alignment system using six linear drives to translate the primary mirror through all

Table 3.
Solar Physics Investigations Selected for Shuttle/Spacelab

Orbital Test Flight 4

- Solar UV Spectral Irradiance Monitor
- Solar Flare X-Ray Polarimeter

Spacelab 2

- Coronal Helium Abundance Experiment
- Solar UV High Resolution Telescope & Spectrograph
- Solar Magnetic & Velocity Field Measurement System

Future Spacelab Flights

- Solar Optical Telescope Facility (including baseline of two focal plane instruments)
- Lyman-Alpha & White Light Coronagraphs
- X-Ray Telescope & Spectrometer System
- Solar EUV Telescope & Spectrograph

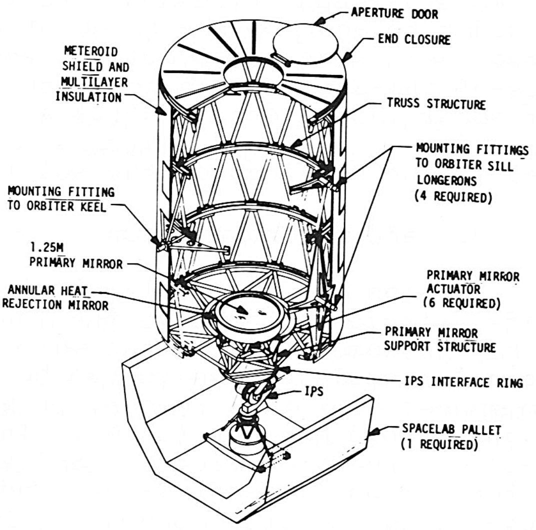

Fig. 4 Cutaway of the basic Solar Optical Telescope.

six degrees of freedom (thereby accomplishing focus and alignment continuously in-orbit); and a large (3.8 m dia) truss structure that can accommodate up to six focal plane instruments and three, 1 m diameter, PI-class or other facility instruments simultaneously. Thus, the fully configured SOT alone offers the possibility of up to nine instruments all co-aligned and co-mounted on a single pointing system within the Shuttle bay.

5. THE SOLAR CYCLE AND DYNAMICS PROGRAM

5.1. Background

The cyclic nature of solar activity has been known since the 1840's and recorded with relatively high accuracy back to the early 1700's. However, in the last decade, several facts have emerged which indicate that the Sun's cycle and thus, by implication, its structure are not nearly as regular or as well understood as had been thought (Section 1).

These findings, combined with the fact that the solar dynamo itself is not understood, led to a recent study to identify the key questions of solar variability (to the extent they can currently be identified) and to determine which of these questions would benefit from study by space techniques. The conclusion of this Solar Cycle and Dynamics study was that a program of solar observations is needed involving probably two missions in order to address the range of problems. Briefly, these two basic sets of objectives would be met by (1) a fully state-of-the-art mission to measure certain known aspects of solar variations; and (2) a far more exploratory mission using advanced instruments to measure phenomena related to the workings of the solar dynamo itself.

5.2. The Solar Cycle and Corona Mission

The first type of mission for this Solar Cycle and Dynamics Program has as its principal objective the long term observations of key phenomena of the Sun which are now known to vary with the solar cycle and which can be only, or best, carried out from space. For this reason, it has been called the Solar Cycle and Corona Mission (SCCM). In particular, this mission would observe the structure and evolution of the inner and outer corona (in soft X-rays and white light, respectively), the resonance line corona (to infer outflow velocities of the solar wind), the total and spectral solar irradiances, and perhaps the photospheric velocity and magnetic fields.

The technology for all of these instruments is currently in hand, and little if any new development work is required. Ideally the mission would be launched in early 1986 for a nominal three-year lifetime, in a standard, low-inclination Earth orbit. As such, the SCCM is also an ideal complement to the ISPM and the IPL experiment discussed in Section 3. In particular, the SCCM would allow a 90° "stereo" view of the corona in conjunction with the ISPM, and would thus fully exploit those out-of-ecliptic observations.

5.3. The Solar Dynamics Mission

The second part of this Solar Cycle and Dynamics Program would be far more ambitious than the SCCM in that the required instrument technologies are not all currently available. The thrust of this second mission is to investigate the interior workings of the solar dynamo itself, and so it is aptly named the Solar Dynamics Mission. To this end, the payload should include an ultra-high precision photospheric velocity analyzer (with a sensitivity of 1 m/sec in radial velocity on the Sun's surface); a solar diameter and global oscillations telescope to detect possible oblateness and/or global oscillations of the Sun; and an ultra-high precision differential intensity analyzer to measure extremely small differences in temperature over large-scale solar convection cells. The first instrument would also serve to measure p-mode oscillations, which act as a probe of the solar interior.

This mission should have a polar Earth orbit to provide continuous sunlight and will require sub-arc second pointing stability. It is reasonable that such instruments could be proof-tested on Shuttle sortie missions before committing to a free-flying satellite. A final mission duration of the order of several years is required.

6. AN ADVANCED SOLAR OBSERVATORY

A natural consequence of an agressive program of Shuttle flights in solar physics in the 1980's will be a rather complete inventory of sophisticated, large solar experiments. A strong case can be made for flying a subset of these experiments on some type of permanent orbiting Space Platform in the time frame of the early 1990's for the following reasons.

First, the Shuttle sortie flights will have necessarily been of rather short duration (30 days or less), and thus any solar phenomena having a long evolutionary period or low event rate will not have been satisfactorily observed. Second, the next maximum of solar activity should occur in the early 1990's, and observation of flares with these new high resolution instruments requires both long orbit-stay times and large free-flyer capabilities.

Combined, these requirements call for an Advanced Solar Observatory (ASO), visited periodically by the Shuttle for servicing, which can make full, continuing use of the experiments and facilities (including the SOT) previously developed. (In fact, it is conceivable that the Solar Dynamics Mission would constitute one subset of the instruments on an ASO.) The basic concept would be for the Shuttle to mount pre-integrated Spacelab pallets of experiments to a basic orbiting bus that provides power, telemetry, and orientation services. Such platform concepts are currently under study for feasibility, and could be orbited by the late 1980's.

7. THE SOLAR PROBE

Perhaps the most audacious mission under consideration is that of the Solar Probe, the intent of which is to send a spacecraft to within three solar radii of the Sun's surface (Figure 5). The science objectives for this mission were discussed at the Jet Propulsion Laboratory in a symposium in

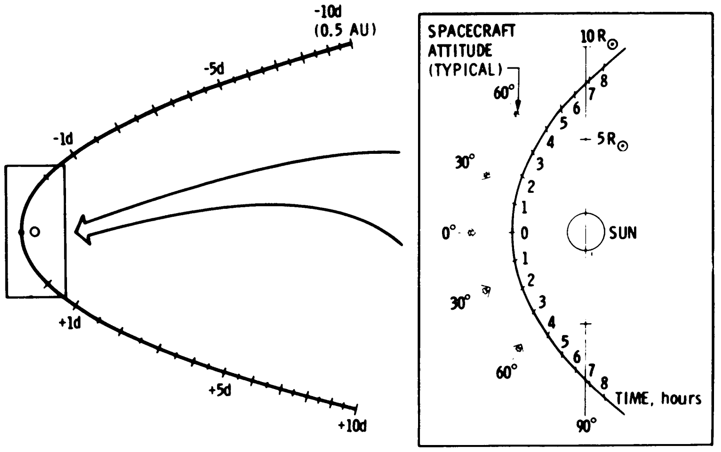

Fig. 5 Schematic of Solar Probe trajectory near perihelion.

May, 1978. It is currently envisaged that only a Solar Probe can address certain fundamental aspects of the Sun and heliosphere that the other missions previously discussed above will leave unanswered:

- o the mechanism(s) for the acceleration of the solar wind;
- o the acceleration and/or storage of energetic paticles in the corona;
- o the distribution of mass and angular momentum in the solar interior;
- o the three dimensional structure of photospheric and chromospheric fine structure at the limits of the scale heights of those atmospheres; and
- o the plasma temperature, density, and magnetic field strength as a function of radius in the inner corona.

In addition, several important other objectives can be studied, such as the distribution of interplanetary dust (and its ultimate thermalization) in the inner heliosphere and the possible existence of gravity waves as measured during the cruise phase of the mission.

Several mission architectures have been considered, but the one currently most in favor is called the Delta Velocity-Earth Jupiter Gravity Assist (Delta V-EJGA) trajectory. This scenario calls for a launch in the late 1980's into an initially elliptical orbit about the Sun; near aphelion (about 2 AU), a rocket burn retargets the spacecraft to achieve a grazing encounter with the Earth (about 1.8 years after launch), the gravity assist from which sends the spacecraft out to Jupiter. A retrograde gravity swing-by around Jupiter results in the Probe essentially free-falling back to the Sun for a perihelion encounter 4.9 years after launch. In this mission version, the Solar Probe spends 20 days inside 0.5 AU and 16 hours inside about 9 solar radii (Figure 5).

Several severe technological problems faced by the Probe are under intensive study. First is the thermal shield which must keep the payload to the order of "room" temperature during perihelion, while itself sustaining a photon flux load of about 3000 "Suns." Second is a communications system for dependable telemetry during perihelion passage through the corona and a large on-board storage device for data. Third is a "drag-free" control system to reduce the non-gravitational accelerations on the spacecraft to the order of 10^{-10} g, for solar mass and oblateness determinations and the gravity wave search during the mission's long cruise phase.

7. SUMMARY

The period from 1980 through 1995 could prove to be a definitive epoch of solar and heliospheric studies by the NASA space program. The array of missions begins with the Solar Maximum Mission, which will be launched by February of 1980 and operate for at least two years. The International Solar Polar Mission will begin its five year sojourn through the heliosphere in 1983, culiminating in passages over the solar poles in 1986-87. In this same time frame, the Solar Cycle and Corona Mission should begin a series of basic observations of key phenomena of the solar cycle and, in concert with the Interplanetary Plasma Laboratory, take critically important complementary observations with the ISPM.

Ideally the Solar Probe will be launched in 1987 or 1988 to begin a five year trip through the solar system, finally having its perihelion at only four solar radii in order to measure <u>in situ</u> the inner corona. Meanwhile, a Solar Dynamics Mission should be returning definitive data for the study of the workings of the solar cycle dynamo itself. Finally, a series of Shuttle/Spacelab flights throughout the 1980's will allow a variety of PI-class experiments to be developed in conjunction with the Solar Optical Telescope facility to achieve a breakthrough in the temporal and spatial resolution limits of solar observations. These instruments will measure phenomena important to the solar dynamo, to the composition and structure of the Sun's surface layers, and to the still enduring problem of the origin of the solar wind. The end evolution of many of these Spacelab experiments could be their inclusion on an orbiting platform called the Advanced Solar Observatory by 1990, in time for the next maximum of solar activity.

DISCUSSION

Moore: What are the possible durations of SMM, Solar Polar and Solar Synoptic Mission, and the probable relative timing of Solar Synoptic with respect to Solar Polar?

Bohlin: The SMM will be launched in very early 1980, and nominally will have a two year lifetime. Extended operations will depend on the health of the spacecraft, the expected science return by the longer operations period and the availability of funds. The International Solar Polar Mission (ISPM) will be launched in February 1983, and nominally will end in September 1987 (the end of the fiscal year 1987), after the second solar passage of each spacecraft. Additional operations depend on the same factors as for SMM. Our plan is to launch the Solar Synoptic Mission (or SCADM) by mid-1986, in order to provide in-ecliptic coverage of the corona to complement the ISPM polar passage period from mid-86 through mid-87. Nominally I propose at least a three year lifetime, with the option for in-orbit refurbishment.

McIntosh: Ground-based solar synoptic programs are presently in dire straits. Is NASA actively concerned about revitalizing these programs as a necessary complement to the long-term NASA solar programs?

Bohlin: Yes, the NASA is deeply concerned about the status of adequate ground-based observations as they relate to the support of its solar programs. To the extent that financial resources allow, we are trying to keep the most important elements active and healthy.

Petelski: Is there a chance for direct, in situ measurements of interplanetary neutral gas to be performed by one of the probes you mentioned?

Bohlin: Yes. The Interplanetary Plasma Laboratory (IPL) of the OPEN program does not have all of its spacecraft resources (mass, telemetry, power) by the strawman payload needed for the prime science objectives. These residual resources should be available for secondary objectives, of which the neutral gas is a good example. Moreover, the location of the IPL permanently in the solar wind flow is an ideal location for a neutral gas experiment.

Callahan: What is the difference between IPL and Solar Synoptic observatory?

Bohlin: IPL is to make in situ solar wind measurements with no direct solar observations, while the synoptic observations will be just the opposite.

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