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Department of Physics and Astronomy

THE UNIVERSITY OF IOWA

Iowa City, Iowa 52242

RESEARCH IN SPACE PHYSICS

AT THE UNIVERSITY OF IOWA

ANNUAL REPORT FOR 1980

Submitted by:

J A Van Allen

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1.0 General Nature of the Work

1.01 Our broad objective is the extension of knowledge of the energetic particles and the electric, magnetic, and electromagnetic fields associated with the earth, the sun, the moon, the planets, comets, and the interplanetary medium.

1.02 Primary emphasis is (a) on observational work using a wide diversity of instruments of our own design and construction on satellites of the earth and on planetary and interplanetary spacecraft and (b) on phenomenological analysis and interpretation.

1.03 Secondary emphasis is (a) on closely related observational work by ground based radio-astronomical and optical techniques and (b) on theoretical problems in plasma physics as relevant to solar, planetary, and interplanetary phenomena.

1.04 Specific matters of current investigation are the following:

(a) All aspects of the energetic particles that are trapped in the earth's magnetic field and are transiently present in the outer magnetosphere including the magnetospheric tail of the earth; and of the solar, interplanetary, and terrestrial phenomena that are associated with these radiations -- solar flares, interplanetary magnetic fields and plasmas, aurorae, geomagnetic storms, corpuscular heating of the atmosphere, electromagnetic waves and magnetostatic and electrostatic fields (both constant and variable) in the magnetosphere, plasma flows in the magnetosphere, and the ionospheric effects of particle precipitation. This field of research was originated to a major extent by this laboratory.

(b) Origin and propagation of very low frequency radio waves in the earth's magnetosphere and ionosphere.

(c) Corresponding studies of the magnetospheres of Jupiter, Saturn, and prospectively Uranus and Neptune.

(d) Radio emissions from Jupiter and Saturn and the relationship of same to their magnetospheres.

(e) Energetic electrons, protons, alpha particles, and heavier nuclei emitted by the sun; the interplanetary propagation and acceleration of these particles, including the effects of shock waves and the generation of electrostatic and electromagnetic waves in the interplanetary medium; and the access of such particles to planetary magnetospheres.

(f) Solar modulation and the heliocentric radial dependence of the intensity of galactic cosmic rays.

(g) The theory of wave phenomena in turbulent plasmas including the interplanetary medium and of the origin of super-thermal particles.

(h) Basic wave-particle-chemical processes as stimulated and diagnosed in the ionospheric plasma through active experiments from the Shuttle/Spacelab.

1.05 The attached bibliography lists specific investigations completed and published in 1980.

2.0 Currently Active Projects

2.01 Hawkeye 1 (Explorer 52, 1974-040A)

This entire satellite and its principal scientific instruments were designed and built at the University of Iowa and launched into a highly eccentric (21 R_E apogee), nearly polar orbit from the Western Test Range on 3 June 1974. Hawkeye 1 re-entered the earth's atmosphere, as predicted, on 28 April 1978 after 667 orbits and nearly forty-seven months of successful in-flight operation. Active analysis on the large body of data continues. Particular emphasis of current work is on constructing a model of the high latitude magnetic field of the earth and on the physical nature of the bow shock, magnetopause, and polar cusp.

[Van Allen, Adnan, Randall et al.]

(Data analysis support by Office of Naval Research and NASA Headquarters)

2.02 Pioneers 10 and 11/Energetic Particles

These two Ames Research Center spacecraft, both carrying University of Iowa energetic particle detectors, were the first to make encounters with Jupiter, in December 1973 and December 1974, respectively. They yielded a large body of detailed knowledge on the distribution of absolute intensities of protons and electrons in Jupiter's magnetosphere, on the sources and sinks of such particles, on absorption by satellites, and on diffusion coefficients. These dramatic advances stimulated a fresh wave of theoretical work and ground-based astronomical work on this planet and its satellites and paved the way for the subsequent encounters of Voyagers 1 and 2.

Pioneers 10 and 11 are also yielding a unique body of data on the intensity of cosmic radiation and the physical properties of the interplanetary medium over long periods of time and to unprecedented distances from the sun. The new data are providing fresh insight into the classical problem of the modulation of cosmic ray intensity by the solar wind and are challenging the theoretical treatments of the subject. Also, Pioneer 11 is providing valuable data on the acceleration of protons by shock waves in the interplanetary medium and on the propagation of solar electrons and protons at great distances from the sun.

Pioneer 11 encountered Saturn on 1 September 1979, becoming the first man made object to ever approach this planet. The University of Iowa's charged particle detectors on Pioneer 11 discovered the magnetosphere of Saturn and provided much detail on the distributions of energetic protons and electrons, their sources and sinks, their absorption by satellites, and their energy spectra. Previous to this encounter there was no observational knowledge as to whether or not Saturn was a magnetized body and the entire subject was a matter of conjecture. Also the University of Iowa discovered at least four small satellites and two rings, all of which were previously unknown or barely suspected.

Both spacecraft and most of the scientific instruments (including ours) continue to operate properly. Pioneer 10 was launched on 3 March 1972 and Pioneer 11 on 6 April 1973. Data are being received currently from both spacecraft on a daily basis (~ 8 hours of data per day). Pioneer 10 is on a hyperbolic escape orbit from the solar system with heliocentric distances as follows: 24 October 1979, 20 AU; 26 July 1981, 25 AU; May 1983, 30 AU; January 1987, 40 AU; and August 1990, 50 AU. It is judged technically feasible to continue to receive data of good quality (at bit rates ≥ 8 bits/sec) through 1991.

Since its flyby of Saturn, Pioneer 11 is also on a hyperbolic escape trajectory out of the solar system with heliocentric distances as follows: 1 January 1981, 9.7 AU; 1 January 1983, 13.2 AU; 1 January 1985, 17.7 AU; 1 January 1987, 22.5 AU; and 1 January 1991, 32.5 AU. The present expectation is that the diminishing output of the RTG power supply of Pioneer 11 will limit its useful flight life to about 1991.

During 1980, the major effort was directed toward analysis and interpretation of the Saturn encounter data of Pioneer 11 and the preparation of four major papers thereon.

[Van Allen, Thomsen, Randall, Rairden, and Grosskreutz]

(Support by Ames Research Center/NASA and Office of Naval Research)

2.03 Pioneer 11/Plasmas in Saturn's Magnetosphere

An extensive analysis of the detection characteristics of the Ames Research Center plasma instrument on board the interplanetary spacecraft Pioneer 11 was undertaken in order to interpret its responses during this spacecraft's flyby of Saturn. An immense torus of oxygen ions (O^{2+}, O^{3+}) encircling the planet was discovered at Saturnian radial distances of ~ 4 to 8 R_s (R_s, Saturn radii). Maximum ion densities are ~ 50 cm^{-3} in the vicinity of the orbits of Dione and Tethys. The source of these ions is concluded to be the photodissociation of water frost on the surfaces of ring material on the basis of the density and temperature profiles of the ions within the torus. Photodissociation of water frost on the surfaces of Dione and Tethys is interpreted as a secondary source for the oxygen ions. The torus is found to corotate with the planet. At radial distances beyond the torus, ~ 8 to 16 R_s, plasma densities are considerably lesser and in the range of 0.2 to 1 cm^{-3}. The ion composition could not be uniquely identified in this region and the plasma bulk speed is usually lesser than that of corotation. An exciting possibility exists that the energy densities of the plasmas are great enough in the outer boundaries of the ion torus such as to create an occasional massive disruption of Saturn's magnetosphere as plasma is lost in order to relieve the stresses associated with the accretion of plasma from the rings.

[Frank, Ackerson, Burek, DeCoster, Wolfe/ARC, Mihalov/ARC]

(Support by NASA Headquarters and Office of Naval Research)

2.04 Voyagers 1 and 2

The University of Iowa designed and built plasma-wave instruments (very low frequency radio receivers) for both of these planetary flyby missions and is a member of the plasma wave investigation team. Voyager 1 was launched on 5 September 1977 and flew by Jupiter on 5 March 1979, and Saturn on 12-13 November 1980. Voyager 2, which was launched on 20 August 1977, flew by Jupiter on 9 July 1979 and will arrive at Saturn on 25 August 1981. The University of Iowa instruments continue to perform well, with no evidence of any degradation in performance due to radiation effects.

During the past year the principal emphasis in the Voyager data analysis was on the continued study of the data from the Jupiter encounters and on the first-order analysis and interpretation of the Voyager 1 Saturn encounter. The major results obtained include the first observations of whistler-mode chorus and hiss in the magnetosphere of Saturn, the first indication of the control of Saturn kilometric radiation by the moon Dione, and the observations of plasma waves in the vicinity of Saturn's moon Titan, including measurements of the electron density in the wake of Titan which indicate that a dense plume of plasma is being swept downstream of Titan by the interaction with the rapidly rotating magnetosphere of Saturn. Also, data obtained on Voyager 2 while approaching Saturn have recently indicated the presence of continuum radiation apparently associated with the magnetotail of Jupiter. These date provide substantial evidence that the magnetotail of Jupiter extends at least 3 AU downstream of Jupiter and that the tail may have a filamentary structure possibly similar to the tail of a comet.

[Gurnett, Shaw, Kurth, Anderson et al.]

(Support by the Jet Propulsion Laboratory, NASA Headquarters, and the Office of Naval Research)

2.05 International Sun-Earth Explorers (ISEE)/ Recent Results from Plasma Analyzers

The analysis and interpretation of the plasma observations with the quadrispherical Lepedeas on ISEE-1 and -2 are providing remarkable findings concerning the plasma environment of the earth. These plasma instruments are capable of the first, and presently the only truly three-dimensional measurements of the ion and electron velocity distributions in the earth's magnetosphere. First measurements of the field-aligned currents which couple the earth's ionosphere with the magnetosphere have been reported. These particular currents were found in the magnetotail at the boundary of the plasma sheet. Recently such field-aligned currents at the dayside magnetopause have been identified. The capability of directly measuring these currents allows significant advances in our perception of magnetospheric dynamics. Previous reports of observations of merging at the dayside magnetopause with instrumentation not capable of three-dimensional coverage (MPI-Lindau and LANL) have been shown to be incorrect by using the simultaneous measurements with the quadrispherical Lepedea on ISEE-1. This finding demonstrated that errors in the crucial determination of bulk flow velocities were not correctly accounted for. Thus observational confirmation of dayside reconnection of the terrestrial and solar wind magnetic fields is not yet available, a situation which encourages the development of new ideas concerning the transfer of mass, energy, and momentum from the solar wind to the earth's magnetosphere. A new model for the presence of ions propagating upstream from the bow shock is based upon detailed observations of this phenomenon with the quadrispherical Lepedeas. The principal features of this model are the propagation of collimated ion beams near the foreshock (the surface of maximum penetration of these ions against the solar wind flow) and the subsequent breakup of these beams into more diffuse velocity distributions. In the inner magnetosphere near the plasmapause, the measurements of charged particle velocity distributions have been used to identify the sources of free energy for the generation of intense electrostatic waves (with D. Gurnett and W Kurth). These studies of wave-particle interactions are being extended to the outer magnetosphere and the plasma sheet. With the three-dimensional ion velocity distributions it is now finally possible to determine definitively the bulk motions of plasmas in the magnetosphere. One of the first results of these studies is the presence of a high-speed "explosion" of plasmas in the evening side of the magnetosphere during the onset of magnetic substorms.

[Frank, Eastman, DeCoster, Ackerson, Sentman/UCLA, Kennel/UCLA]

(Support by Goddard Space Flight Center/NASA)

2.06 International Sun-Earth Explorers (ISEE)/ Plasma Wave Results

The University of Iowa has plasma wave instrumentation on all three of the ISEE spacecraft. The ISEE 1 and 2 spacecraft are in highly eccentric orbits with apogee radial distances of about 23 R_E and provide coordinated measurements at separation distances on the order of a few thousand km along the same orbit. The ISEE 3 spacecraft is located at the Lagrangian point of the earth-sun system, at a distance of about 235 R_E sunward of the earth. The plasma wave instruments on all three spacecraft continue to function normally.

During the past year several topics have been investigated using the ISEE plasma wave data. In a series of papers W. Calvert has undertaken a detailed investigation of the auroral kilometric radiation and has obtained several important results including observations of the apparent triggering of auroral kilometric radiation by type III solar radio bursts, observations of ducting of the kilometric radiation along field-aligned density depletions, and evidence of a low density "auroral cavity" at altitudes of several R_E along the auroral field lines. A major effort has also been undertaken to study the characteristics of plasma waves upstream of the bow shock. One paper has been completed on this subject by R. Anderson and co-authors, and further studies of the fine structure of the upstream waves are being carried out by a graduate student, A. Persoon, for her M.S. thesis. An extensive study of plasma waves at the magnetopause has also been completed, following up an earlier initial discovery of intense plasma wave turbulence associated with the plasma boundary layer. For his Ph.D. thesis, L. Reinleitner is investigating an unusual correlation which has been discovered in the ISEE data between whistler-mode chorus bursts and electrostatic emissions near the local electron plasma frequency. A publication on this phenomenon is nearly complete, and a theoretical investigation of the possible nonlinear effects involved is underway.

[Gurnett et al.]

(Support by Goddard Space Flight Center/NASA, NASA Headquarters, and the Office of Naval Research)

2.07 International Sun-Earth Explorer/ Interferometer

Work is progressing on determining the apparent size of the auroral kilometric radiation source regions. Three simultaneous sets of corrected data from ISEE-1 and ISEE-2 at 125 kHz indicate a size less than 0.1 R_E. Another fifty cases have been identified for longer spacecraft separations and for 62.5 kHz and 250 kHz frequencies as well as for better statistics and better resolution.

[Stanley D. Shawhan and Mark Baumback, Guest Investigators]

(Support fo NASA/NAG 5-118)

2.08 IMP 8/Scientific Results from Plasma Instrument

Analysis is continuing for the plasma measurements obtained with a cylindrical-plate Lepedea on board the IMP-8 spacecraft. This spacecraft was launched on 26 October 1973 into an orbit with initial perigee and apogee radial distances of 23.1 and 46.3 R_E, respectively. The plasma instrument continues to provide usable observations of positive ions and electrons in the energy range 50 eV to 45 keV. Recently the existence of a persistent boundary layer of jetting plasmas at the edge of the plasma sheet in the magnetotail was established. These plasmas are jetting toward the earth and are thought to provide the energy source for discrete auroral arcs in the earth's ionosphere. In addition, simultaneous measurements in the earth's plasma sheet with this instrument and with those of the ISEE spacecraft are being used to determine structure and plasma bulk flows on spatial scales $\sim 10\ R_E$. This information is of great importance in identifying the principal mechanisms responsible for the dynamical behavior of the magnetotail.

[Frank, DeCoster, Eastman]

(Support by Goddard Space Flight Center/NASA, NASA Headquarters, and the Office of Naval Research)

2.09 Dynamics Explorer
[Formerly called Electrodynamics Explorer]

This NASA program comprises a coordinated pair of earth orbiting spacecraft, one in an eccentric polar orbit with apogee at about 5 R_E and another in a low-altitude polar orbit, 320 x 1200 km. The central theme of the DE program is study of the physical coupling of the magnetosphere, ionosphere, and neutral atmosphere of the earth. Two University of Iowa instruments were selected for this mission. One of them is a set of global auroral imaging instruments (SAI) considerably more advanced than the current state of the art and the other a set of plasma-wave ELF-VLF receivers (PWI). Both will be on the eccentric orbiter (DE-A).

Construction of the flight instruments is complete and both instrument complements have been integrated into the spacecraft for the 31 July 1981 launch. Work has been underway for more than a year to develop programs for data analysis and display. A PDP 11/23 terminal is installed at the University of Iowa which ties to the GSFC Sigma-9 project computer. Images are processed initially on the UI Univac 418 computer system.

[Frank, Craven, Ackerson et al., auroral imaging photometers]

[Shawhan and Gurnett, plasma wave instrument]

(Proposal and engineering design support by the Office of Naval Research and NASA Headquarters)

(Hardware and data analysis support by Goddard Space Flight Center/NASA)

2.10 Dynamics Explorer/Global Auroral Imaging Instrumentation

The auroral imaging instrumentation for the high-altitude Dynamics Explorer spacefraft consists of two spin-scan photometers for visible wavelengths and one such photometer for vacuum-ultraviolet emissions. These instruments will provide the first global images of the visible aurora as seen from great altitudes. Such an observational task has not been previously attempted since the high intensities of light from the sunlit earth as seen from these altitudes "blind" optical instrumentation to the faint auroral emissions. The Dynamics Explorer photometers use an off-axis reflecting optical array, super-reflecting surfaces and narrow-band interference filters in order to circumvent this viewing problem. The vacuum-ultraviolet photometers will allow images of the aurora in both the dark and sunlit ionospheres due to a vacuum-ultraviolet "window" at ~ 145-175 nm. Since the photometers are equipped each with a filter wheel that accommodates twelve filters, it has been possible to extend the scientific observational objectives to imaging the global distributions of atmospheric ozone, to implementing the first global survey of marine bioluminescence, and to monitoring the diffuse hydrogen envelope of the earth's exosphere. The imaging instrumentation has been designed and constructed at the University of Iowa and is integrated on the spacecraft in anticipation of the currently scheduled launch date of 31 July 1981.

[Frank, Craven, Ackerson, Eather/Boston College, Carovillano/Boston College]

(Developmental support by the Office of Naval Research and NASA Headquarters)

(Hardware and data analysis support by Goddard Space Flight Center/NASA)

2.11 Galileo
[Formerly called Jupiter Orbiter with Probe Mission]

This NASA mission was approved and given start-up funding in late October 1977. The scientific payload consists of two separable parts -- a Jupiter orbiter (JPL) and an atmospheric entry probe (ARC). The former is to be placed in a loose eccentric orbit about Jupiter, then navigated by a combination of satellite encounters and on-board propulsion to make multiple flybys of the Galilean satellites and an extended tour of the magnetosphere of the planet. A useful lifetime in orbit of twenty months or more is contemplated. The original plan and, after intermediate vacillation, the present plan are that the orbiter and the probe be launched together by a single vehicle -- a shuttle and one or more upper stages (yet to be chosen and developed). They will remain attached to each other until about 100 days before encounter with Jupiter, at which time they will be separated and given slightly different approach trajectories. The probe will enter the atmosphere directly in order to provide data on its structure and composition. The larger of the two bodies will be slowed by retro-propulsion near its point of closest approach to become a captive orbiter (artificial satellite) of the planet.

At the date of writing, there are major program uncertainties, caused principally by lack of a firm status of the launch vehicle. However, construction and testing of the two spacecraft and the scientific instruments are going forward toward a launch readiness status in early 1984, even though such a date of launch now seems unlikely.

There is a broad range of scientific objectives at Jupiter in (a) magnetospheric physics, (b) satellite science, and (c) atmospheric physics. The design of the instruments and the plan of the mission are based on previous findings of Pioneers 10 and 11 and Voyagers 1 and 2.

Two of the three University of Iowa proposals for instruments on the Galileo orbiter were selected and underwent, after a period of design definition work, formal confirmation in late summer 1978. The two investigations and the investigators are as follows:

2.11.1 "A Plasma Wave Investigation for the 1981/1982 [originally planned launch date] Jupiter Orbiter"

D. A. Gurnett, Principal Investigator (U. of Iowa)
F. L. Scarf, Co-Investigator (TRW)
R. Gendrin, Co-Investigator (CNET)
C. F. Kennel, Co-Investigator (UCLA)
S. D. Shawhan, Co-Investigator (U. of Iowa)

2.11.2 "Comprehensive Investigations of Jovian Plasmas with the Jupiter Orbiter Spacecraft (Jupiter Orbiter Probe 1981/1982 [originally planned launch date] Mission)"

L. A. Frank, Principal Investigator (U. of Iowa)
F. V. Coroniti, Co-Investigator (UCLA)
V. M. Vasyliunas, Co-Investigator (MPI)

2.11.3 In addition, J. A. Van Allen has been appointed an Interdisciplinary Scientist as well as a member of the Project Science Group and chairman of the Magnetosphere Working Group.

(Proposal work supported by the Office of Naval Research and NASA Headquarters)

(Hardware support by Jet Propulsion Laboratory/NASA)

2.12 Galileo/Status of Implementation of Plasma Instrument

A sophisticated plasma instrument for the orbiter of the Galileo Mission is currently being constructed. This plasma analyzer will provide the first definitive measurements of the three-dimensional velocity distributions of positive ions and electrons in the vicinity of Jupiter. Two nested quadrispherical electrostatic analyzers accompanied respectively by two arrays of sensors are used to obtain these measurements. In addition three miniature mass spectrometers are included in the instrument to obtain first unambiguous identification of the ion composition, specifically the M/Q of the ion species, throughout the Jovian magnetosphere. The energy range of the plasma analyzer extends from 1 eV to 45 keV. Since a diverse body of plasmas exists in this magnetosphere, e.g., hot isotropic plasmas, ion beams, and magnetically aligned currents, an on-board computer system has been designed to allow measurement flexibility and to interface with the spacecraft telemetry system. This computer design includes a dual-microprocessor configuration that precludes single-point electronic failure in consideration of the length of the mission and the severity of the radiation environment at Jupiter. The present launch date is given in the Galileo Mission plan as 1985.

[Frank, Coroniti/UCLA, Vasyliunas/MPI-Lindau]

2.13 Spacelab and Orbital Flight Test Missions

Two University of Iowa investigations have been selected and confirmed for the early scientific program with the NASA Shuttle/Spacelab.

2.13.1 "An Ejectable Plasma Diagnostics Package (PDP) for the Spacelab 2 Mission"

S. D. Shawhan, Principal Investigator	(U. of Iowa)
L. A. Frank, Co-Investigator	(U. of Iowa)
D. A. Gurnett, Co-Investigator	(U. of Iowa)
N. D'Angelo, Co-Investigator	(U. of Iowa)
N. H. Stone, Co-Investigator	(MSFC)
D. L. Reasoner, Co-Investigator	(MSFC)
H. Brinton, Co-Investigator	(GSFC)

2.13.2 "An Ejectable Plasma Diagnostics Package (PDP) for the Space Shuttle Orbital Flight Test (OFT) Missions"

[Investigators, same as for 2.13.1]

The University of Iowa has designed and constructed a complete subsatellite including all scientific instrumentation for preliminary flight on the OSS-1 mission scheduled for 30 January 1982. The subsatellite unit is positioned in and around the Orbiter by the Remote Manipulator System but is not released into orbit. On the later Spacelab 2 flight (November 1984) it is planned to release the PDP into a close companion orbit with the Orbiter craft. The objectives of these investigations are to determine the electromagnetic and plasma environments of the Spacelab as a basis for designing future experiments and for studying Orbiter wake, electron beam-plasma, and plasma depletion phenomena stimulated by the Orbiter. In both cases the acquisition of the in-flight data will extend over a time period of eight days. The subsatellite will be powered by storage batteries. The scientific instrumentation is similar to that on Hawkeye 1. The subsatellite was completed and initially delivered to GSFC/NASA in May 1980 for integration and system tests. After initial tests, the subsatellite was installed in the JSC Plasma Chamber along with the Utah State University Fast Pulse Electron Gun to conduct basic electron beam-plasma research and to simulate the OSS-1 mission conditions. The University of Iowa's North Liberty Radio Observatory will be used for data acquisition.

(Proposal and preliminary design support for ONR and NASA Headquarters)

(Hardware support by Marshall Space Flight Center/NASA)

(NLRO support by the Office of Naval Research)

2.13.3 Recoverable Plasma Diagnostic Package for Shuttle/Spacelab (MSFC NAS8-33770)

Principal Investigator:

Stanley D. Shawhan	(U. of Iowa)

Co-Investigators:

K. L. Ackerson	(U. of Iowa)
R. R. Anderson	(U. of Iowa)
J. D. Craven	(U. of Iowa)
N. D'Angelo	(U. of Iowa)
L. A. Frank	(U. of Iowa)
D. A. Gurnett	(U. of Iowa)
R. R. Shaw	(U. of Iowa)
L. P. Block	(Royal Institute of Technology)
C.-G. Fälthammar	(Royal Institute of Technology)
M. Sugiura	(GSFC)
J. H. Hoffman	(U. of Texas, Dallas)
W. W. L. Taylor	(TRW)
T. Obayashi	(U. of Tokyo)
P. M. Banks	(Utah State U.)
N. H. Stone	(MSFC)
U. Samir	(U. of Michigan)

For the past year a definition of the Recoverable Plasma Diagnostics Package (RPDP) has been conducted. The RPDP is to be a fully instrumented spacecraft (more sophisticated than the Plasma Diagnostics Package for OSS-1 and Spacelab-2) which is to be carried into orbit and recovered from orbit by the Shuttle. When deployed into orbit, the RPDP measures the ambient plasma conditions and the perturbations caused by the injection of energetic particles (via SEPAC), the emission of waves (WISP), or the release of chemical tracers by Shuttle-borne equipment. The Orbiter establishes the experimental geometry with respect to the magnetic field. RPDP data are transmitted back to the Orbiter for display to the crew to allow interactive adjustment of experiment parameters.

2.13.4 Participation in Other Spacelab Active Experiment Definitions

Stanley D. Shawhan is the co-investigator for the following programs:

(a) Waves in Space Plasmas (WISP)
Principal Investigator: Dr. Robert Fredricks, TRW.
Other U. of Iowa Co-Investigator: Dr. Wynne Calvert.
Responsibility: Accommodate WISP instrumentation on the RPDP; provide FLV instruments on RPDP.

(b) Shuttle Experiments with Particle Accelerators (SEPAC)
Principal Investigator: Professor Tats Obayashi, U. of Tokyo.
Responsibility: Accommodate SEPAC instrumentation on the RPDP; provide VLF and particle detector instruments on RPDP.

(c) Magnetospheric Multiprobes
Principal Investigator: Dr. James L. Burch, Southwest Research Institute.
Responsibility: Provide RF antennas, telescoping booms, wire antennas, dc electric field instruments, and plasma wave instruments.

2.13.5 Pending Proposal

"Design and Development Phase Proposal: A Recoverable Diagnostics Package for Spacelab", May 1981

Principal Investigator:
Stanley D. Shawhan (U. of Iowa)

Co-Investigators:
[Same as RPDP Definition Phase]

This proposal is for building a RPDP for a possible flight opportunity in 1986 in support of the SEPAC and WISP active experiments.

2.14 Very-Long Baseline Radio-Interferometry (VLBI)

The ONR 60-ft parabolic antenna at the North Liberty Radio Observatory has been converted from a spacecraft telemetry facility to a VLBI receiving station operating at a wavelength of 18 cm (OH line). It has been adopted as an element of the national VLBI network at this frequency. A substantial program of observations is underway, in collaboration with other VLBI observatories in the United States, Puerto Rico, and Germany.

[Mutel, Fix et al., and observers from other laboratories]

(Principal current support by the National Science Foundation)

2.15 Theory

Theoretical studies are continuing on the propagation and acceleration of solar protons, alpha particles, and electrons in the interplanetary medium; on the emission of x rays and radio noise by the sun; on the generation and propagation of very low frequency radio waves in the magnetosphere and the relationship of such waves to particle acceleration, diffusion, and precipitation; on shock waves in the interplanetary medium; and on the physical dynamics of the magnetospheres of Jupiter and Saturn.

[Goertz, Barbosa, Calvert, Grabbe, Borovsky, Huang, Randall, Omidi, Thomsen et al.]

(Support by the Office of Naval Research, the National Science Foundation, and NASA Headquarters)

2.16 International Solar Polar Mission [Formerly called Out-of-Ecliptic Mission]

As originally planned and authorized, this NASA/ESA mission contemplates a single launch of two instrumented spacecraft which will then be separated for independent flight. Both will be targeted to fly by Jupiter in such a way that their subsequent orbits will be in a plane approximately perpendicular to the equatorial plane of the sun. After their respective encounters with Jupiter, the two spacecraft will be counter-revolving in this plane with one passing over the north pole of the sun as the other passes over the south pole (both at ~ 1.8 AU) and vice versa as their orbital motions continue. The unique objectives of this mission are to measure the properties of the interplanetary medium at high solar latitudes, to measure the intensity of galactic cosmic rays and the propagation of solar energetic particles, also at high solar latitudes, and to observe activity in the polar caps of the sun by x-ray and coronal imaging and radio receivers and the relationships of this activity to the interplanetary conditions.

Gurnett at Iowa has been confirmed as a co-investigator on the Radio Astronomy Experiment (RAE) team and plans to build the Plasma Wave Assembly as one component of the RAE instrument.

Substantial delays in the schedule and the possibilities of subdividing the mission into two separate launches and/or cancelling the NASA portion of the mission are being considered. It is not likely that any launch will occur before 1986.

3.0 Pending Proposals for Future Flight Missions

3.01 International Comet Mission

An Announcement of Opportunity (AO No. OSS-2-79) entitled "International Comet Mission" was issued by NASA on 23 October 1979. The plan of the mission was that it be carried out jointly by the National Aeronautics and Space Administration of the United States and the European Space Agency (ESA). The following is quoted from the A.O.: "It is currently contemplated that, if authorized, this mission will be launched in 1985 and will include a rendezvous with a short period comet and a flyby of a second, more active, comet for comparative measurements. Primary candidates under consideration at this time include Comet Tempel 2 (rendezvous) and Comet Halley (flyby)."

In collaboration with other laboratories, the University of Iowa prepared and submitted two proposals:

3.01.1 "Comprehensive Plasma Instrumentation for Measurements of Plasmas in the Vicinity of Comets (International Comet Mission)"

Principal Investigator:

Louis A. Frank	(U. of Iowa)

Co-Investigators:

Ferdinand V. Coroniti	(UCLA)
D. Asoka Mendis	(UCSD)
George L. Siscoe	(UCLA)
James A. Van Allen	(U. of Iowa)

The plasma instrument proposed for the International Comet Mission consists of a solar wind ion analyzer, an electrostatic analyzer for measurements of the three-dimensional velocity distributions of hot positive ions and electrons and an analyzer for determining the (M/Q) composition of ions over the entire 4π-steradian solid angle for positive-ion velocity vectors at the spacecraft. These plasma analyzers are capable of providing definitive observations of cometary plasma environments during either a fast flyby or a rendezvous with a comet, and from either a spin-stabilized or fixed-axis spacecraft. The hot plasma and solar wind analyzers are straightforward extensions of the designs for similar electrostatic analyzers on the ISEE spacecraft, i.e., the quadrispherical Lepedeas. The three-dimensional ion composition analyzer has been developed recently in our laboratory. It employs a quadrispherical-plate electrostatic analyzer with miniature mass spectrometers of new design at the analyzer exit aperture. These mass analyzers employ a magnetic spectrometer for M/Q dispersion and micro-channel plates, phosphors, and photodiode arrays as sensors. The mass range is $1 \leq M/Q \leq 200$ with a resolution $(M/Q)/(\Delta M/Q) \geq 15$ in 330 simultaneously sampled channels.

3.01.2 "A Plasma Wave Investigation for the Halley/Tempel 2 Comet Mission"

Principal Investigator:

D. A. Gurnett	(U. of Iowa)

Co-Investigators:

A. H. Delsemme	(U. of Toledo)
F. M. Neubauer	(Tech. Univ. Braunschweig, W. Germany)
F. L. Scarf	(TRW)
C. F. Kennel	(U. Cal., Los Angeles)
H. Oya	(Tohoku U., Japan)
E. J. Smith	(JPL)

The objectives of this investigation are to determine the role of plasma waves in the interaction between the solar wind and the cometary atmosphere and to make very accurate measurements of the electron density profile in the cometary ionosphere using a plasma sounder. The measurements obtained will provide a direct indication of turbulent heating processes near and upstream of the bow shock, at the contact discontinuity, and in the cometary ionosphere. The electron density measurements provide the profile of a fundamental parameter needed to compute ionization rates and other basic properties of the ionosphere-atmosphere interaction.

Nearly identical instruments are proposed for both the probe and rendezvous spacecraft to provide comparative measurements during the Halley flyby. Both electric and magnetic field measurements are made to distinguish electrostatic and electromagnetic waves. The electric field measurements extend from 3.1 Hz to 3 MHz, and the magnetic field measurements extend from 3.1 Hz to 3.1 kHz. These frequency ranges include all of the characteristic electrostatic and electromagnetic emission frequencies expected during the cometary encounters. The electric field sensor consists of an extendible dipole antenna with a tip-to-tip length of 30 meters. On the probe spacecraft the electric antenna is provided by the project, whereas on the rendezvous spacecraft it is provided by the experimenter. The magnetic field sensor consists of a search coil magnetometer mounted on the end of a boom to reduce interference from the spacecraft. The main instrument package consists of (1) a multichannel spectrum analyzer for very high time resolution measurements, (2) a sweep frequency receiver for providing high resolution frequency spectrums, (3) a sounder for local plasma density measurements, and (4) on the rendezvous spacecraft only, a wideband waveform receiver for dynamic spectral studies. Except for the sounder and the search coil magnetometer, the design, construction, and testing of the instrument will be performed at the University of Iowa. The sounder will be provided by The University of Tokyo in collaboration with Tohoku University. The search coil will be constructed by the Technical University of Braunschweig. This investigation incorporates well proven instrumentation which has been flown on numerous spacecraft, including Helios 1 and 2, Voyager 1 and 2, ISEE 1 and 2, and Exos-B. The investigators involved all have a wide range of experience in the study of space plasma physics and can be expected to work closely with other members of the comet science team to provide a timely and knowledgeable interpretation of the results obtained.

3.01.3 Status as of July 1981

NASA has not yet obtained approval for U. S. participation in this mission. Meanwhile ESA has decided to proceed independently on a fast flyby of Comet Halley with a launch in July 1985 and an encounter in March 1986, soon after the comet's perihelion passage.

The possibilities of some U. S. participation in the ESA mission or of a separate U. S. flyby of Halley are still under consideration. Meanwhile, the review of scientific proposals is being conducted by NASA in preparation for either or both of these possibilities.

(The astronomy group at the University of Iowa (Neff et al.) is developing a new system of photometric filters for ground based observation of cometary spectra.)

3.02 Origin of Plasmas in the Earth's Environment (OPEN)

NASA's Announcement of Opportunity AO-OSS-1-79 describes a multi-spacecraft mission for the comprehensive investigation of the origin and physical dynamics of plasmas in the earth's environment, as the major element of its continuing program in magnetospheric physics during the late 1980's. Four instrumented spacecraft, in quite different orbits, are contemplated, viz.

(a) Interplanetary Physics Laboratory (IPL) -- upstream solar unit measurements near the earth-Sun Lagrangian point (L1) at 235 R_E sunward of the earth.

(b) Geomagnetic Tail Laboratory (GTL) -- apogee at 80 to 250 R_E with lunar swing-by orbit adjustment to maintain the apogee in the earth's magnetotail (perigee at $\leq 2\ R_E$).

(c) Polar Plasma Laboratory (PPL) -- inclination $\sim 90°$ to the earth's equator with apogee 4 to 15 R_E and low perigee.

(d) Equatorial Magnetosphere Laboratory (EML) -- equatorial orbit, apogee at $\sim 12\ R_E$, perigee at $\sim 2\ R_E$ with the possibility of a deep magnetotail penetration late in the mission.

As of mid-1981, the OPEN mission has not been authorized but is still an element of NASA planning.

In response to the AO, the University of Iowa prepared and submitted four major proposals. A fifth proposal has been recently revised and submitted. These and other OPEN proposals have been under review but because of delays in the program the selection of investigations has been postponed repeatedly.

3.02.1 "Comprehensive Plasma Instrumentation for Measurements of Plasmas in the Earth's Magnetotail (OPEN Mission)"

(For GTL and for PPL if comparable instrumentation is not proposed for PPL by others)

Principal Investigator:
Louis A. Frank (U. of Iowa)

Co-Investigators:
Ferdinand V. Coroniti (UCLA)
George L. Siscoe (UCLA)

A plasma instrument similar to that for the International Comet Mission (q.v.) was proposed for the Geomagnetic Tail Laboratory (GTL) spacecraft of the OPEN Mission. This plasma instrumentation is sufficiently comprehensive that no other complementary plasma instrumentation is required for this spacecraft. The observational objectives of four of the eight strawman instruments are achieved with this single compact set of interactive plasma analyzers. Selection of flight instruments for the mission is expected in July/August 1981.

3.02.2 "Advanced Auroral Instrumentation for Visible and Ultraviolet Wavelengths for the OPEN Mission"

(for PPL)

Principal Investigator:
Louis A. Frank (U. of Iowa)

Co-Investigators:
Kent L. Ackerson (U. of Iowa)
John D. Craven (U. of Iowa)
Paul B. Hays (U. of Michigan)
William E. Sharp (U. of Michigan)

An imaging instrument suitable for viewing the global auroral emissions at visible and vacuum-ultraviolet wavelengths from the great altitudes of the Polar Plasma Laboratory (PPL) spacecraft of the OPEN mission was designed and proposed. The design guidelines included significant improvements in sensitivity, spatial resolution and temporal resolution (frame rate) relative to those for the DE imaging instruments, and sufficient stray light rejection to observe auroras at an altitude of 14 R_E. At these altitudes, the apparent angular diameter of the earth is only $\sim 8°$ so that a collimator of sufficient dimensions to exclude viewing of the earth's sunlit surface by the primary optics is not practical. A catoptric primary optics system constructed from an off-axis section of a parabolic mirror was found with computer software to yield sufficient angular resolution and stray light rejection for this difficult imaging task. The sensors are microchannel plate/ charge collecting diode arrays capable of single-pulse resolution.

Wavelength selection is provided by narrow-band interference filters mounted on rotating drums. The maximum angular resolution for this proposed instrument is 45 μrad; the frame rate is ~ 2 seconds. Corresponding angular and temporal resolutions for the DE imaging instruments are 4400 μrad and 432 seconds, respectively. Selection of flight instruments for this mission is expected in July/August 1981.

3.02.3 "A Plasma Wave Investigation for the OPEN Geomagnetic Tail Laboratory"

(for GTL)

Principal Investigator:

Donald A. Gurnett	(U. of Iowa)

Co-Investigators:

Joseph K. Alexander	(GSFC)
Christoph K. Goertz	(U. of Iowa)
Hiroshi Matsumato	(Kyoto University)
Robert R. Shaw	(U. of Iowa)
Roger R. Anderson	(U. of Iowa)
Michael L. Kaiser	(GSFC)
Frederick L. Scarf	(TRW)
Stanley D. Shawhan	(U. of Iowa)
Bruce T. Tsurutani	(JPL)

3.02.4 "A Plasma Wave Investigation for the OPEN/Polar Plasma Laboratory (PPL)"

(for PPL)

Principal Investigator:

Stanley D. Shawhan	(U. of Iowa)

Co-Investigators:

Roger R. Anderson	(U. of Iowa)
Christoph K. Goertz	(U. of Iowa)
Donald A. Gurnett	(U. of Iowa)
William S. Kurth	(U. of Iowa)
Joseph K. Alexander	(GSFC)
Michael L. Kaiser	(GSFC)

Co-Investigators (continued)

Robert W. Fredricks	(TRW)
Michael C. Kelley	(Cornell)
Paul M. Kintner	(Cornell)
Chung G. Park	(Stanford)
Bruce T. Tsurutani	(JPL)
Michael Temerin	(Berkeley)
Hiroshi Matsumoto	(Kyoto)

3.02.5 "Duct Sounder: Revised Proposal for the Polar Plasma Laboratory and Equatorial Magnetospheric Laboratory OPEN Spacecraft"

(for PPL and EML)

Principal Investigator:

Wynne Calvert	(U. of Iowa)

Co-Investigators:

R. F. Benson	(GSFC)
S. A. Gross	(Polytechnic Institute of NY)
R. C. Maehl	(RCA Astro-Electronics)
D. B. Muldrew	(Communications Res. Center Canada)
S. A. Curtis	(GSFC)
L. C. Lee	(U. of Alaska)
K. Maeda	(GSFC)
C. S. Wu	(U. of Maryland)
D. L. Carpenter	(Stanford U.)
H. Oya	(Tokohu U., Japan)
S. D. Shawhan	(U. of Iowa)
W. W. L. Taylor	(TRW)

3.03 Active Magnetospheric Particle Tracer Experiment (AMPTE)

A proposal has been made to the Office of Naval Research for support of a plasma wave electric and magnetic field instrument for the NASA Active Magnetospheric Particle Tracer Experiment.

Principal Investigator:
D. A. Gurnett (U. of Iowa)

The basic scientific objective of the AMPTE mission is to use a series of large lithium and barium ion releases in the solar wind, magnetosheath, and distant magnetotail, to study the diffusion and transport of charged particles in the Earth's magnetosphere. The investigation consists of two spacecraft: the Charge Composition Explorer (CCE) which is to be provided by Johns Hopkins Applied Physics Laboratory (S. M. Krimigis, principal investigator) and the Ion Release Module (IRM) which is to be provided by the Max-Planck-Institut für Extraterrestrische Physik (G. Haerendel, principal investigator). The AMPTE launch is currently scheduled for August 1984.

The University of Iowa has been invited by Dr. Haerendel to provide a plasma wave instrument on the German IRM for the purpost of studying plasma instabilities which develop in the barium and lithium ion clouds after their release near the IRM. The basic instrumentation for this investigation is to consist of a spare electric antenna and spectrum analyzer from the Hawkeye and Helios projects, plus certain specialized instrumentation which is being constructed specifically for the IRM application.

4.0 Senior Academic Staff in Space Physics
[31 December 1980]

Van Allen, James A.	Carver Professor of Physics and Head of Department of Physics and Astronomy
D'Angelo. Nicola	Professor of Physics
Frank, Louis A.	Professor of Physics
Gurnett, Donald A.	Professor of Physics
Shawhan, Stanley D.	Professor of Physics
Goertz, C. K.	Associate Professor of Physics
Ackerson, Kent L.	Associate Research Scientist [Research Associate]
Anderson, Roger R.	Associate Research Scientist [Research Associate]
Craven, John D.	Associate Research Scientist [Research Associate]
Cronyn, Willard M.	Associate Research Scientist [Research Associate] [Terminated 30 September 1980]
Eastman, Timothy E.	Associate Research Scientist [Research Associate]
Randall, Bruce A.	Associate Research Scientist [Research Associate]
Shaw, Robert R.	Associate Research Scientist [Research Associate]
Thomsen, Michelle F.	Associate Research Scientist [Research Associate] [Terminated 30 June 1980]
Barbosa, David D.	Assistant Research Scientist [Research Associate] [Terminated 30 June 1980]

Kurth, William S.	Assistant Research Scientist [Research Associate]
Pécseli, Hans L.	Assistant Research Scientist [Research Associate] [Terminated 16 November 1980]
Rickard, James J.	Assistant Research Scientist [Research Associate] [Terminated 31 July 1980]
Mehta, Naresh C.	Research Investigator [Research Associate] [Terminated 30 June 1980]

Also in Closely Related Work
(Astronomy and Plasma Physics)

Fix, John D.	Professor of Astronomy
Knorr, Georg	Professor of Physics
Hershkowitz, Noah	Professor of Physics [On Leave]
Joyce, Glenn R.	Professor of Physics [On Leave]
Neff, John S.	Professor of Astronomy
Payne, Gerald L.	Professor of Physics
Carpenter, Raymon T.	Associate Professor of Physics
Mutel, Robert L.	Associate Professor of Astronomy
Nicholson, Dwight R.	Assistant Professor of Physics
Spangler, Steven R.	Visiting Assistant Professor of Astronomy
Alport, Michael J.	Research Investigator
Sheerin, James P.	Research Investigator

5.0 Senior Engineering and Administrative Staff [31 December 1980]

Enemark, Donald C.	Adjunct Associate Professor of Physics
Brechwald, Robert L.	Manager, Systems and Programming Services
Randall, Roger F.	Senior Engineer
Robertson, Thomas D.	Administrative Associate
Anderson, Roger D.	Engineer IV
English, Michael	Engineer IV
Lee, James A.	Engineer IV
Odem, Daniel L.	Engineer IV
Owens, Harry	Engineer IV
Burek, Barbara G.	Research Assistant III [Terminated 30 September 1980]
Clausen, Terry L.	Engineer III
Knowlton, James R.	Engineer III
Kruse, Elwood A.	Engineer III [R and Q]
Markee, Robert	Engineer III [Departmental Machine Shop]
Phillips, James R.	Engineer III
Remington, Steve L.	Engineer III
Williams, R. Everett	Supervisor, Technical Services [Departmental Graphic Services]
Robison, Evelyn D.	Project Assistant [Supervisor, Publications]

6.0 Junior Academic Staff in Space Physics [31 December 1980]

All of those listed below are graduate students, engaged in research in space physics.

	Appointment	Principal Research Project
Adnan, Johari B.	Research Assistant	Hawkeye I
Baumback, Mark M.	Research Assistant	ISEE/VLBI
Bulson, Jeffry M.	Teaching Assistant	
Gallagher, Dennis	Research Assistant	VLF Radio (IMP-J)
Grosskreutz, Cynthia	Teaching Assistant	Pioneer 10/11
Omidi, Nojan	Research Assistant	Helios
Popielawska, Barbara M.	Fulbright Scholar	ISEE/Plasma
Rairden, Richard L.	Research Assistant	Pioneer 10/11
Reinleitner, Lee	Research Assistant	ISEE/Plasma Waves
Schultz, Daniel	Teaching Assistant	ISEE/VLBI
Strayer, Brian D.	Research Assistant	ISEE

7.0 Advanced Degree Awarded in Space Physics at U. of Iowa 1 January 1980 -- 31 December 1980

Ph.D. Degree

Jeffrey Lee Parish (May 1980): "The Jovian Magnetosphere"
[Goertz]

8.0 Publications and Research Reports in Space Physics 1 January 1980 -- 31 December 1980

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N. D'ANGELO
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E. W. GREENSTADT, R. W. FREDERICKS, C. T. RUSSELL, F. L. SCARF, R. R. ANDERSON, and D. A. GURNETT
Whistler Mode Waves in the Solar Wind near the Bow Shock
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C. Y. HUANG and C. K. GOERTZ
Ray Tracing Studies and Path-Integrated Growth Rates of ELF Unducted Whistler-Mode Waves in the Earth's Magnetosphere
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D. A. GURNETT and N. D'ANGELO
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R. RAIRDEN
Satellite Sweeping of Electrons and Protons in Saturn's Inner Magnetosphere

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CYNTHIA L. GROSSKREUTZ
An Estimate of the Synchrotron Radiation from Saturn

9.0 Publications and Research Reports in Related Fields 1 January 1980 -- 31 December 1980

A. PLASMA PHYSICS

NOAH HERSHKOWITZ, JAMES R. DeKOCK, PETER COAKLEY, and STEVEN L. CARTIER
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GLENN JOYCE, C.-S. LIU, and DAVID MONTGOMERY
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MARTIN V. GOLDMAN, GEORGE F. REITER, and DWIGHT R. NICHOLSON
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G. L. PAYNE and J. D. PEREZ
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