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Research in Space Physics at the University of Iowa

ANNUAL REPORT 1972

Prepared by

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Department of Physics and Astronomy

22 September 1972

1. General Nature of the Work

Our broad objective is the extension of knowledge of the energetic particles in outer space and of their relationships to electric, magnetic, and electromagnetic fields associated with the earth, the sun, the moon, the planets, and the interplanetary medium.

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 the moon and on planetary and interplanetary spacecraft and (b) on phenomenological analysis and interpretation.

Secondary emphasis is on closely related observational work by ground based radio-astronomical and optical techniques and on basic theoretical problems in plasma physics.

Specific fields 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 (e.g., solar flares, interplanetary magnetic fields and plasmas, aurorae, geomagnetic storms, corpuscular heating of the atmosphere, electromagnetic waves and electrostatic

fields in the magnetosphere, and the ionospheric effects of particle precipitation). This field of research was originated to a major extent by this laboratory.

(b) Galactic cosmic rays and energetic electrons, protons, alpha particles, and heavier nuclei emitted by the sun; and the interplanetary propagation of these particles, including the effects of shock waves.

(c) Radio-frequency emissions and soft X-radiation from both the quiescent and flaring sun and the implications thereof on the nature of the chromosphere and on the acceleration and emission of energetic particles in solar flares.

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

(e) Shock waves in the interplanetary medium.

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

(g) Dekametric radio emissions from Jupiter and the relationships of same to its magnetosphere.

(h) The magnetosphere and magnetic field of Jupiter and the search for magnetospheres of Saturn, Uranus, Neptune, and Pluto.

2. Current Projects

(a) Injun V (Explorer 40)

Study and analysis of nearly 22 months of data from our low-altitude polar satellite Injun V (primary operating period 8 August 1968 -- 30 May 1970) continue to be a major activity of our research staff and students. Injun V has already provided (i) the most complete observational and theoretical understanding of the polar aurorae that now exists; (ii) the first comprehensive survey of d.c. electric fields in the magnetosphere; (iii) the discovery of C,N,O nuclei trapped in the radiation belts of the earth; (iv) a massive body of observations on VLF radio waves in the magnetosphere and ionosphere; (v) new data on the spectra of low energy electrons and protons in the magnetosphere; (vi) several studies of the access of solar energetic particles into the magnetosphere; and (vii) a detailed study of the distribution and time variations of the intensity of geomagnetically trapped alpha-particles. An extensive bibliography of published papers based on Injun V already exists.

Injun V was further operated from 19 February 1971 -- 7 June 1971 in collaboration with the Max Planck Institut für Stratasphaerenphysik, Lindau/Harz, Germany. The data from this secondary period are the subject of collaborative work.

On 9 August 1972, Injun V was commanded on successfully in response to a developing interest in conducting further work on

VLF radio transmission in the earth's ionosphere. The spacecraft was found to be in a good state-of-health and the VLF experiment was operating normally. Other experiments were not exercised in this brief test. The spacecraft has been in orbit for four years.

(NASA support for Injun V work terminates on 30 September 1972; continuing data reduction, analysis, and publication are being supported by ONR.)

[Van Allen, Frank, Gurnett, Ackerson, Randall, Shaw, Rodriguez, and supporting personnel at the University of Iowa; Krimigis and Verizariu at the Applied Physics Laboratory of Johns Hopkins University; Fennell at Aerospace Corporation; Sagalyn and Wildman at Air Force Cambridge Research Center; and Pfotzer, Rosenberg, and others at Max Planck Institut]

(b) Explorers 33 and 35

The in-flight operation of Explorer 33 was terminated on 1 November 1971 after 5 years 4 months in orbit.

Explorer 35 completed its fourth year in orbit around the moon in July 1972. The University of Iowa experiment on this spacecraft continues to function flawlessly, though progressive degradation in the S/C power supply now limits the duty cycle of useful data acquisition to about 45%. NASA has made a provisional commitment to continue in-flight operations, data acquisition, and orbit determination until 31 December 1972.

The body of data from Explorers 33 and 35 continues to be a valuable one for study of (a) solar protons, electrons, alpha particles, and $Z > 2$ nuclei, (b) particle bombardment of the moon and the production of short-lived radioisotopes in the lunar

surface material, (c) solar X rays and their effects on the earth's ionosphere, (d) the magnetospheric tail, (e) shock waves in the interplanetary medium, (f) access of solar particles into the magnetosphere, and (g) the solar-cycle modulation of galactic cosmic ray intensity.

(Data reduction, analysis, and publication since 1968 supported by ONR)

[Van Allen, Shawhan, Innanen, Oliven, Sentman, Sarris, Spangler, Randall, and Sheats at University of Iowa; Krimigis at Applied Physics Laboratory of Johns Hopkins University; Armstrong at University of Kansas; Venkatesan and Venkatarangan at University of Calgary]

(c) Explorer 43 (IMP-I)(1971-019A)

This spacecraft and two separate University of Iowa experiments thereon continue to operate properly after some 18 months in an eccentric earth-orbit.

(Support jointly by GSFC/NASA and ONR)

[Gurnett, Pfeiffer, Anderson, and Shaw on VLF Radio Experiment]

[Frank, Yeager, Ketterer, and Callahan on Low Energy Particle Experiment]

(d) Small Scientific Satellite (S^3-A)

This GSFC/NASA satellite was launched at 05^h UT on 15 November 1971 from the San Marco launching facility (Italian) off the coast of Kenya. The initial orbit had an inclination of 3.5°, a perigee altitude of about 200 km, a radial distance to apogee of 5.23 R_E (earth radii), and a period of 7.79 hours.

The principal objective of this mission is to study the physics of magnetic storms. One of the instruments on board was developed by the VLF radio group at the University of Iowa in collaboration with corresponding groups at the University of Minnesota and the Goddard Space Flight Center. This instrument has performed properly throughout the mission, continuing at the present date. The data flow has been rather slow but a number of important new results on the plasmasphere of the earth have been obtained already. Part of the early telemetry acquisition was performed at the North Liberty Radio Observatory of the University of Iowa.

(Support by GSFC/NASA)

[Gurnett, Anderson, and Shaw]

(e) IMP-H and IMP-J

The launch of IMP-H is imminent at the date of writing. This GSFC/NASA satellite carries a system of University of Iowa low energy proton electron differential analyzers (LEPEDEA) for studying particle phenomena in the outer magnetosphere of the earth, including the magnetotail.

(Support by GSFC/NASA)

[Frank et al.]

The University of Iowa has both electrostatic analyzers and VLF radio receivers on IMP-J. The construction work is largely finished. Launch is tentatively scheduled for mid-1973.

(Support by GSFC/NASA)

[Frank et al. on electrostatic analyzers]

[Gurnett et al. on VLF radio receivers]

(f) German American Solar Probe (Helios)

VLF radio equipment is being built at the University of Iowa for this interplanetary spacecraft. One mission is now scheduled for launch in 1974 and the second in 1975. The planned solar orbit will make it possible to measure interplanetary (solar-wind) and solar generated radio emissions (10 Hz to 15 kHz) from 1.0 to 0.3 A.U. from the sun. The prototype apparatus has been completed and delivered.

(Support by GSFC/NASA)

[Gurnett, Pfeiffer, Odem, and Clark]

(g) British-American Near Earth Satellite (UK-4)

This satellite was launched on a 4-stage Scout vehicle from Vandenburg Air Force Base in California at 20:47 UT on 11 December 1971. The initial orbit had perigee altitude of 472 km, apogee altitude of 587 km, inclination of 85°, and period of 95.5 minutes. The data flow has been very slow and work has been done mainly with quick-look data from the University of Iowa experiment up to the present date.

Low energy particle measurements similar to those on Injun V are being made in this mission, with emphasis on the angular distributions in the auroral zone.

(Support by GSFC/NASA)

[Frank, Craven, Enemark, Ketterer, and Callahan]

(h) Pioneers F and G (Asteroid/Jupiter Missions)

The first of these two missions began on 3 March 1972 with the successful launch of Pioneer F (= Pioneer 10) from Cape Kennedy.

This ARC/NASA spacecraft is intended to fly outwards from the earth, through the asteroid belt, and past the planet Jupiter at a closest distance of approach of 2.9 planetary radii. After encounter, it will continue on a trajectory such as to eventually escape from the solar system. The encounter date with Jupiter is 4 December 1973. It may be possible to receive useful telemetry for as long as ten years.

The University of Iowa experiment is designed to make an exploratory survey of the intensities, energy spectra, and distribution of energetic electrons and protons in the radiation belts of Jupiter; to study the interplanetary propagation of solar electrons and protons to large heliocentric radial distances; and to study the heliocentric radial dependence of galactic cosmic rays to great distances from the sun. The experiment is operating properly in all respects after some 200 days into the mission. Present distance from the sun exceeds 2.5 astronomical units. A good flow of quick-look data has been maintained, though the flow of final data has been rather slow. One paper on the heliocentric radial gradient of galactic cosmic ray intensity from 1.0 to 2.0 a.u. has been submitted and accepted for publication. Others are in progress.

The launch window for the second mission (Pioneer G) is 5-18 April 1973. University of Iowa flight and back-up units have been delivered and are awaiting launch. The mission objectives are similar to those of Pioneer 10. A number of targeting options at Jupiter are being considered. One possibility is to fly by Saturn about 20 months after the Jovian encounter.

(Support by Ames Research Center/NASA)

[Van Allen, R. Randall, Baker, Owens, Flindt, and Fluckey]

(i) Hawkeye Satellite (Formerly called Injun F)

The construction of Hawkeye is the major hardware project at the University of Iowa at the present date and will continue to be for another 18 months, or thereabouts. The spacecraft as well as two of the three scientific instruments are being designed, built, and tested at the University of Iowa. The third instrument -- the magnetometer -- is being purchased to our specifications. This mission is for the investigation of magnetospheric phenomena in the polar magnetosphere at large radial distances and in particular in the vicinity of the "neutral point" in the polar magnetic field.

The satellite will carry three basic scientific instruments for the investigation of the particles and the electric and magnetic fields associated with the earth's polar magnetosphere in the vicinity of the hypothetical magnetic neutral point.

(a) A four-range, three-axis Schonstedt flux-gate magnetometer to measure the vector magnetic field. (Presently planned full scale ranges on each axis are as follows: $\pm$ 100 gammas, $\pm$ 600 gammas, $\pm$ 3,000 gammas, and $\pm$ 10,000 gammas -- selectable by ground command.)

(b) A Low-Energy Proton and Electron Differential Electrostatic Analyzer (LEPEDEA) to measure the differential energy spectra of protons and electrons, separately and simultaneously, over the energy range 4 eV to 40,000 eV for a wide range of intensities and the integral intensities of $\geq$ 40 keV electrons and/or > 600 keV protons.

(c) An ELF-VLF Electric and Magnetic Fields apparatus to study the characteristics and origin of naturally occurring radio noises and plasma instabilities in the earth's polar magnetosphere and magnetosheath. The electric antenna (100 ft. tip-to-tip) and associated receiver depend on the successful experience with similar apparatus on Injun V and will operate over the frequency range 1 Hz to 30 kHz. The magnetic antenna (a search coil magnetometer) and its associated receiver cover the frequency range 1 Hz to 3 kHz.

Following extensive design studies beginning in late 1968, the construction contract for Hawkeye was awarded by Langley Research Center/NASA on 21 March 1972. The period of performance

is $30\frac{1}{2}$ months from 1 February 1972. Launch is planned for the first or second quarter of 1974.

(Support by Langley Research Center/NASA)

[Van Allen, Frank, Gurnett, Rogers, Enemark, Craven, Oliven, Randall, Clark, Brechwald, Jagnow, Luthey, et al.]

(j) Theory

Theoretical studies are continuing on the propagation of solar protons, alpha particles, and electrons in interplanetary space; 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 on the relationship of such waves to particle acceleration, diffusion, and precipitation; on shock waves in the interplanetary medium; and on the radiation belts of Jupiter and Saturn.

(Support by ONR and NASA)

[Gurnett, Shawhan, Taylor, Luthey, and Sarris]

(k) Solar Radio Noise

Solar radio noise at 1.95 cm is being observed routinely by a radiometer-polarimeter at the North Liberty Radio Observatory. Observations are also being made with the 60 ft dish at 136 MHz on a selected basis and with a 15 km baseline interferometer.

(Support by ONR)

[Shawhan, Chen, and Sarris]

(l) Electron Density in the Solar Corona

The occultation of the pulsar NP 0532 by the solar corona (closest approach of line of sight to center of the sun: 5 solar radii) has been observed in mid-June of four successive years 1969, 1970, 1971, and 1972 at the Arecibo Radio Observatory at three different radio frequencies (111.5, 196.5, and 430.0 MHz). The observations of dispersion measure as a function of time as the occultation proceeds yield absolute values of coronal electron density over the range 5 to 20 solar radii in an entirely new way and with much improved accuracy over existing values.

(Support by NASA)

[Rankin and Weisberg]

(m) Spectro-Photometry of Planets

A program of absolute spectro-photometry of the planets Jupiter, Saturn, Uranus, Neptune, and Pluto and satellites of the major planets is underway, using the U. of Iowa 24" optical telescope. The object is to increase knowledge of the nature of their surfaces and atmospheres. The current work on Jupiter is of special interest to the space physics group.

(Support by NSF)

[Neff and Fix]

(n) Very-Long-Base-Line Radio-Interferometry

A program of VLBI observations is being developed at NLRO in collaboration with Iowa State University/Ames, NOAA/Boulder, GSFC, and the National Radio Observatory in Greenbank, W. Va. In contrast to most other VLBI experiments, a low frequency, 26.5 MHz, has been selected in order to study the dekametric emissions from Jupiter and the structure of the interplanetary plasma and to search for dekametric emissions from Saturn. A preliminary series of observations has been completed and is being reduced with the cooperation of GSFC.

(Support by NASA)

[Shawhan, Taylor, Cronyn, et al.]

(o) Large Area Interferometer

During the summer of 1972 the University of Iowa collaborated with NOAA/Boulder and GSFC in constructing the largest area radio interferometer in the northern hemisphere. Both area and angular resolution exceed those of the Arecibo facility. The array is located at Clark Lake, California. The operating frequency is 34 MHz. The construction will be completed in November 1972. Preliminary observations are already being obtained. The special objectives of this array are to study the propagation of solar wind streams through interplanetary space; to observe dekametric radio emissions from Jupiter; and to search for dekametric radio emissions from Saturn.

(Support by NASA, GSFC/NASA, and NOAA)

[Shawhan, Cronyn, et al.]

3. Senior Academic Staff in Space Physics
[July 1972]

Van Allen, James A., Professor of Physics and Head of Department of Physics and Astronomy

Frank, Louis A., Professor of Physics

Gurnett, Donald A., Associate Professor of Physics
[Professor of Physics effective September 1972]

Shawhan, S. D., Assistant Professor of Physics

Craven, John D., Research Associate

Oliven, Melvin N., Research Associate

Rankin, John M., Research Associate

Luthey, Joe L., Research Associate

Ackerson, Kent L., Research Associate

Randall, Bruce A., Research Associate

Also in closely related work
(astronomy and plasma physics)

Montgomery, David C., Professor of Physics

Knorr, Georg, Associate Professor of Physics

Swift, Daniel F., Visiting Associate Professor of Physics
[September 1971 -- June 1972]

Joyce, Glenn R., Assistant Professor of Physics
[Associate Professor of Physics effective September 1972]

Neff, John S., Associate Professor of Astronomy

Fix, John D., Assistant Professor of Astronomy

4. Senior Engineering and Administrative Staff
[July 1972]

Enemark, Donald C., Research Assistant Professor of Physics

Brechwald, Robert L., Senior Computer Programmer and Systems Analyst

Rogers, John E., Project Manager

Robertson, Thomas D., Contracts Administrator

Anderson, Roger R., Research Physicist

Gabel, Ronald H., Research Engineer

Pfeiffer, G. William, Research Engineer

Yeager, David M., Research Physicist

Randall, Roger F., Research Engineer

Henry, Kaye, Drafting Shop Supervisor

Freund, Edmund A., Supervisor, Departmental Machine Shop

Robison, Evelyn D., Publications Supervisor

Swails, James K., Data Reduction Supervisor (to 8 September 1972)

Odem, Dan, Research Engineer

Kelso, James P., Data Reduction Supervisor (after 8 September 1972)

Dunlavy, D. David, Station Manager, North Liberty Radio Observatory

5. Junior Academic Staff in Space Physics [July 1972]

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

	Appointment	Principal Research Project
Anderson, Roger R.	Research Physicist	VLF Radio (S^3-A)
Baker, Dan W.	NSF Trainee and Research Assistant	Detector Calibrations (Pioneer F/G)
Baumback, Mark M.	Research Physicist	VLF Radio (IMP-J)
Callahan, Timothy	Research Assistant	Detector Calibrations (IMP-I and UK-4)
Chen, Sha-Lin H.	Research Assistant	Solar Radio Emissions
Chen, Tsan-fu	International Fellow	Particle Correlations (Mariner 5 and Venera 4)
Erskine, Fred T.	U.S. Steel Fellow	Pulsar Observations (Arecibo)
Flindt, Herbert R.	Research Assistant	Pioneer 10
Fluckey, Michelle	Teaching Assistant	Pioneer 10
Hosford, Norman	Research Assistant	VLF Radio
Ketterer, Harold E.	Research Assistant	Low Energy Magnetospheric Particles (IMP's H, I, and J)
Rodriguez, Paul	Research Assistant	VLF Radio (Injun V)
Saflekos, Nicolaos	Research Assistant	Diffusion of Particles in the Magnetosphere (Theoretical)
Sarris, Emmanuel	Research Assistant	Interplanetary Shock Waves
Sentman, Davis D.	Research Assistant	Solar Radio Emissions
Shaw, Robert R.	Research Assistant	VLF Radio (Injun V)

	Appointment	Principal Research Project
Sheats, George S.	Research Assistant	Solar X-Rays
Sheu, Yung-Hung Tso	Research Assistant	Solar Radio Emissions
Spangler, Steven	Graduate Assistant	Solar Physics
Taylor, William W. L.	Research Assistant	VLF Radio (Theoretical)
Yeager, David M.	Engineer II	Magnetospheric Particles (UK-4, IMP-I, H, and J)

6. Advanced Degrees Awarded in Space Physics at U. of Iowa 1 August 1971--31 July 1972

M.S. Degree

José M. da Costa (August 1971), "An Electron Calibration Source for Space Flight Detectors"

Emmanuel T. Sarris (August 1971), "Study of Solar Flares by the Satellites Explorers 33 and 35"

Ph.D. Degree

Kent Loy Ackerson (May 1972), "Observations of Charged Particle Precipitation Over the Auroral Zone During a Magnetic Substorm"

Charles P. Catalano (August 1971), "Height Distribution of Soft X-Ray Emission in the Solar Atmosphere"

William G. Innanen (May 1972), "Anisotropies in 0.3 MeV Solar Protons"

Bruce A. Randall (May 1972), "Time Variations of Magnetospheric Intensities of Outer Zone Protons, Alpha Particles and Ions ($Z > 2$)"

7. Research Reports and Publications
in Space Science
1 August 1971--31 July 1972

F. L. SCARF, R. W. FREDRICKS, L. A. FRANK, and
M. NEUGEBAUER
Nonthermal Electrons and High-Frequency Waves in the
Upstream Solar Wind, 1, Observations
J. Geophys. Res., 76, 5162-5171, 1971

L. A. FRANK
Plasma in the Earth's Polar Magnetosphere
J. Geophys. Res., 76, 5202-5219, 1971

J. A. VAN ALLEN
Catalog of Solar X-Rays (February 1971)
Solar-Geophysical Data [August 1971], SGD 324, Part II, 43
ESSA Environmental Data Service, U. S. Department of Commerce

J. A. VAN ALLEN
Catalog of Solar X-Rays (March 1971)
Solar-Geophysical Data [September 1971], SGD 325, Part II, 52
ESSA Environmental Data Service, U. S. Department of Commerce

S. M. KRIMIGIS, E. C. ROELOF, T. P. ARMSTRONG, and
J. A. VAN ALLEN
Low Energy ($\geq$ 0.3 MeV) Solar-Particle Observations at
Widely Separated Points ($>$0.1 AU) During 1967
J. Geophys. Res., 76, 5921-5946, 1971

DAVID P. CAUFFMAN and DONALD A. GURNETT
Double-Probe Measurements of Convection Electric Fields
with the Injun-5 Satellite
J. Geophys. Res., 76, 6014-6027, 1971

J. A. VAN ALLEN
Catalog of Solar X-Rays (April 1971)
Solar-Geophysical Data [October 1971], SGD 326, Part II, 46
ESSA Environmental Data Service, U. S. Department of Commerce

R. W. FREDRICKS, F. L. SCARF, and L. A. FRANK
Nonthermal Electrons and High-Frequency Waves in the
Upstream Solar Wind
2. Analysis and Interpretation
J. Geophys. Res., 76, 6691-6699, 1971

L. A. FRANK and D. A. GURNETT
Distributions of Plasmas and Electric Fields over the Auroral Zones and Polar Caps
J. Geophys. Res., 76, 6829-6846, 1971

J. M. RANKIN, C. C. COUNSELMAN III and D. W. RICHARDS
Crab Nebula Pulsar Radio Pulse Arrival Times at Arecibo Observatory
Astron. J., 76, 686-690, 1971

FREDERICK L. SCARF, A. M. A. FRANDSEN, D. A. GURNETT, R. A. HELLIWELL, R. E. HOLZER, P. J. KELLOGG, E. J. SMITH and E. UNGSTRUP
A Plasma Wave Instrument for the Outer Planets Grand Tour Missions
Advances in the Astronautical Sciences, Vol. 29, 517-528, 1971

J. A. VAN ALLEN
Catalog of Solar X-Rays (May 1971)
Solar-Geophysical Data [November 1971], SGD 327, Part II, 43
ESSA Environmental Data Service, U. S. Department of Commerce

J. A. VAN ALLEN
Catalog of Solar X-Rays (June 1971)
Solar-Geophysical Data [December 1971], SGD 328, Part II, 35
ESSA Environmental Data Service, U. S. Department of Commerce

D. VENKATESAN and S. M. KRIMIGIS
Observations of Low-Energy (0.3- to 1.8-MeV) Differential Spectrums of Trapped Protons
J. Geophys. Res., 76, 7618-7631, 1971

CARL HEILES and JOHN M. RANKIN
Pulsar NP 0532. Recent Results on Strong Pulses Obtained at Arecibo
Proceedings, The Crab Nebula I.A.U. Symposium No. 46, Jodrell Bank, England, 5-7 August 1970, pp. 103-108, 1971

J. M. RANKIN and J. A. ROBERTS
Time Variability of the Dispersion of the Crab Nebula Pulsar
Proceedings, The Crab Nebula I.A.U. Symposium No. 46, Jodrell Bank, England, 5-7 August 1970, pp. 114-117, 1971

A. L. BURNS and S. M. KRIMIGIS
Changes in the Distribution of Low-Energy Trapped Protons Associated with the April 17, 1965, Magnetic Storm
J. Geophys. Res., 77, 112-130, 1972

D. A. GURNETT and L. A. FRANK
VLF Hiss and Related Plasma Observations in the Polar Magnetosphere
J. Geophys. Res., 77, 172-190, 1972

J. A. VAN ALLEN
Catalog of Solar X-Rays (July 1971)
Solar-Geophysical Data [January 1972], SGD 329, Part II, 59
ESSA Environmental Data Service, U. S. Department of Commerce

J. A. VAN ALLEN
Catalog of Solar X-Rays (August 1971)
Solar-Geophysical Data [February 1972], SGD 330, Part II, 63
ESSA Environmental Data Service, U. S. Department of Commerce

J. A. VAN ALLEN
Catalog of Solar X-Rays (Descriptive Text)
Solar-Geophysical Data, SGD 330 (SUPPLEMENT), 53
ESSA Environmental Data Service, U. S. Department of Commerce

J. A. VAN ALLEN
Catalog of Solar X-Rays (September 1971)
Solar-Geophysical Data [March 1972], SGD 331, Part II, 41
ESSA Environmental Data Service, U. S. Department of Commerce

K. L. ACKERSON and L. A. FRANK
Correlated Satellite Measurements of Low-Energy Electron Precipitation and Ground-Based Observations of a Visible Auroral Arc
J. Geophys. Res., 77, 1128-1136, 1972
Correction: J. Geophys. Res., 77, 3002, 1972

S. R. MOSIER and D. A. GURNETT
Observed Correlations between Auroral and VLF Emissions
J. Geophys. Res., 77, 1137-1145, 1972

DANIEL W. SWIFT
Effective Height-Integrated Conductivity of the Ionosphere
J. Geophys. Res., 77, 1279-1285, 1972

J. A. VAN ALLEN
Catalog of Solar X-Rays (October 1971)
Solar-Geophysical Data [April 1972], SGD 332, Part II, 33
ESSA Environmental Data Service, U. S. Department of Commerce

J. M. RANKIN, C. C. COUNSELMAN III, and D. W. RICHARDS
The 1969 Solar Occultation of the Crab Nebula Pulsar
Accademiia Nazionale dei Lincei, Rome [Problemi Attuali Discienza e di Sultura], Quaderno N. 162, 93-100, 1972

J. A. VAN ALLEN
Catalog of Solar X-Rays (November 1971)
Solar-Geophysical Data [May 1972], SGD 333, Part II, 38
ESSA Environmental Data Service, U. S. Department of Commerce

J. A. VAN ALLEN
Catalog of Solar X-Rays (December 1971)
Solar-Geophysical Data [June 1972], SGD 334, Part II, 37
ESSA Environmental Data Service, U. S. Department of Commerce

J. A. VAN ALLEN
Catalog of Solar X-Rays (January 1972)
Solar-Geophysical Data [July 1972], SGD 335, Part II, 38
ESSA Environmental Data Service, U. S. Department of Commerce

DONALD A. GURNETT
Sheath Effects and Related Charged-Particle Acceleration by Jupiter's Satellite Io
Astrophys. J., 175, 525-533, 1972

D. A. GURNETT and L. A. FRANK
ELF Noise Bands Associated with Auroral Arcs
J. Geophys. Res., 77, 3411-3417, 1972

J. A. VAN ALLEN, P. VENKATARANGAN, and D. VENKATESAN
Variability of the Intensity Ratios, Protons/Alphas, and Alphas/Medium Nuclei during Solar Particle Events
U. of Iowa 71-26 [August 1971]

P. VENKATARANGAN, D. VENKATESAN, and J. A. VAN ALLEN
Study of Energetic Solar Particle Events of November 18, 1968; February 25, 1969; and March 30, 1969
U. of Iowa 71-27 [August 1971]

CHARLES P. CATALANO [Ph.D. Thesis]
Height Distribution of X-Ray Emission in the Solar Atmosphere
U. of Iowa 71-34

EMMANUEL T. SARRIS [M.S. Thesis]
Study of Solar Flares by the Satellites Explorers 33 and 35
U. of Iowa 71-36

L. A. FRANK and K. L. ACKERSON
Local-Time Survey of Plasma at Low Altitudes over the Auroral Zones
U. of Iowa 71-40
J. Geophys. Res., 1972

J. A. VAN ALLEN and A. LEE BURNS
Bombardment of the Moon by Energetic Solar Particles and Production of Radioactive Nuclides
U. of Iowa 71-45 [October 1971]

DONALD A. GURNETT
Injun 5 Observations of Magnetospheric Electric Fields and Plasma Convection
U. of Iowa 71-46 [October 1971]
B. M. McCormac (ed.), Earth's Magnetospheric Processes

STANLEY D. SHAWHAN, GERALD F. DENNING, and DAVIS D. SENTMAN
2 cm Radiometer Data Catalog
29 June 1967 - 10 March 1970
U. of Iowa 71-50 [November 1971]

L. A. FRANK and D. A. GURNETT
Direct Observations of Low-Energy Solar Electrons Associated with a Type III Solar Radio Burst
U. of Iowa 72-2 [February 1972]
Submitted to Solar Physics

J. A. VAN ALLEN
Initial Flight Report on University of Iowa Experiment on Pioneer 10
U. of Iowa 72-5 [March 1972]

K. L. ACKERSON
Observations of Charged Particle Precipitation Over the Auroral Zone During a Magnetic Substorm
U. of Iowa 72-7 [April 1972]
Submitted to J. Geophys. Res.

D. A. GURNETT and L. A. FRANK
Observed Relationships Between Electric Fields and Auroral Particle Precipitation
U. of Iowa 72-8 [April 1972]
Submitted to J. Geophys. Res.

L. A. FRANK
Plasma Entry into the Earth's Magnetosphere
U. of Iowa 72-9 [May 1972]
Proceedings, 1972 COSPAR Symposium, Madrid, Spain
10-24 May 1972

DANIEL W. SWIFT
Derivation of the Electric Field and Electron Density Fluctuation Spectra for a Non-Equilibrium Magnetized Plasma
U. of Iowa 72-13 [May 1972]

D. A. GURNETT
Electric Field and Plasma Observations in the Magnetosphere
U. of Iowa 72-14 [May 1972]
Proceedings, 1972 COSPAR Symposium, Madrid, Spain, 10-24 May 1972

WILLIAM G. INNANEN and JAMES A. VAN ALLEN
Anisotropies in the Interplanetary Intensity of Solar Protons $E_p > 0.3$ MeV
U. of Iowa 72-15 [June 1972]
Submitted to J. Geophys. Res.

JOE L. LUTHEY
Possibility of Saturnian Synchrotron Radiation
U. of Iowa 72-18 [June 1972]
Submitted to Icarus

ROGER R. ANDERSON and DONALD A. GURNETT
Plasma Wave Observations Near the Plasmapause with the S^3-A Satellite
U. of Iowa 72-19 [July 1972]
Submitted to J. Geophys. Res.

8. Research Reports and Publications in Related Fields
1 August 1971--31 July 1972

JÜRGEN NÜHRENBERG
A Difference Scheme for Vlasov's Equation
ZAMP, 22, 1057-1076, 1971

DAVID MONTGOMERY
Theory of the Unmagnetized Plasma, 400 pp.
Gordon and Breach, 1971 (Research Monograph)

GLENN JOYCE, GEORG KNORR and HOMER K. MEIER
Numerical Integration Methods of the Vlasov Equation
J. Computational Phys., 8, 53-63, 1971

DAVID MONTGOMERY
Brownian Motion from Boltzmann's Equation
Phys. Fluids, 14, 2088-2090, 1971

GEORGE VAHALA and DAVID MONTGOMERY
Kinetic Theory of a Two-Dimensional Magnetized Plasma
J. Plasma Phys., 6, 425-439, 1971

DAVID MONTGOMERY and FREDERICK TAPPERT
Kubo Conductivity of a Strongly Magnetized Two-Dimensional Plasma
Phys. Rev. Letters, 27, 1419-1421, 1971

D. J. SIGMAR and G. JOYCE
Plasma Heating by Energetic Particles
Nuclear Fusion, 11, 447-456, 1971

GLENN JOYCE and GEORG KNORR
Nonlinear Evolution of the Dory-Guest-Harris Instability
Phys. Fluids, 15, 177-182, 1972

DAVID MONTGOMERY and FREDERICK TAPPERT
Conductivity of a Two-Dimensional Guiding Center Plasma
Phys. Fluids, 15, 683-687, 1972

D. MONTGOMERY
Two-Dimensional Vortex Motion and "Negative Temperatures"
Phys. Letters, 39A, 7-8, 1972

G. JOYCE and D. MONTGOMERY
Simulation of the "Negative Temperature" Instability for Line Vortices
Phys. Letters, 39A, 371-372, 1972

JOHN D. FIX
Comments on the Interior of Pluto
Icarus, 16, 569-570, 1972

DAVID MONTGOMERY, C.-S. LIU, and GEORGE VAHALA
Three-Dimensional Plasma Diffusion in a Very Strong Magnetic Field
Phys. Fluids, 15, 815-819, 1972

DAVID MONTGOMERY
Strongly Magnetized Classical Plasma Models
U. of Iowa 72-17 [July 1972]
Proceedings, Les Houches Summer School of Theoretical Physics, Les Houches, France, July 3-29, 1972

A. A. LACIS and J. D. FIX
An Analysis of the Light-Curve of Pluto
Astrophys. J., 174, 449-453, 1972

JOHN D. FIX
Comments on the Thermal Character of the Surface of Pluto
U. of Iowa 72-12 [May 1972]

LINDA J. KELSEY [M.S. Thesis]
Spectrophotometry of Pluto, 1972
U. of Iowa 72-20 [July 1972]

LARRY A. KELSEY [M.S. Thesis]
Linear Polarization Measurements of Pluto
U. of Iowa 72-21 [July 1972]