NOTICE

SPACE RADIATION LABORATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY
Pasadena, California 91125

SEMI-ANNUAL STATUS REPORT

for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Grant NGR 05-002-160*
"RESEARCH IN PARTICLES AND FIELDS"

for

1 April 1985 - 30 September 1985

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(NASA-CR-176361) RESEARCH IN PARTICLES AND FIELDS Semiannual Status Report, 1 Apr. - 30 Sep. 1985 (California Inst. of Tech.) 17 p HC A02/MF A01 CSCL 03B

N86-15237

Unclas
G3/93 04876

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TABLE OF CONTENTS

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Space Radiation Laboratory (SRL)
California Institute of Technology

1 April 1985 - 30 September 1985

This report covers the research activities in Cosmic Rays, Gamma Rays, and Astrophysical Plasmas supported under NASA Grant NGR 05-002-160. The report is divided into sections which describe the activities, followed by a bibliography.

This group's research program is directed toward the investigation of the astrophysical aspects of cosmic rays and gamma rays and of the radiation and electromagnetic field environment of the Earth and other planets. We carry out these investigations by means of energetic particle and photon detector systems flown on spacecraft and balloons.

1. Cosmic Rays and Astrophysical Plasmas

This research program is directed toward the investigation of galactic, solar, interplanetary, and planetary energetic particles and plasmas. The emphasis is on precision measurements with high resolution in charge, mass, and energy. The main efforts of this group, which are supported partially or fully by this grant, have been directed toward the following two categories of experiments.

1.1. Activities in Support of or in Preparation for Spacecraft Experiments

These activities generally embrace prototypes of experiments on existing or future NASA spacecraft or they complement and/or support such observations.

1.1.1. The High Energy Isotope Spectrometer Telescope (HEIST)

HEIST is a large area (0.25 m^2sr) balloon-borne isotope spectrometer designed to make high-resolution measurements of isotopes in the element range from neon to nickel ($10 \le Z \le 28$) at energies of about 2 GeV/nucleon. The instrument consists of a stack of 12 NaI(Tl) scintillators, two Cerenkov counters (C1 and C2), and two plastic scintillators (S1 and S2) as illustrated in Figure 1. Each of the 2-cm thick NaI disks is viewed by six 1.5-inch photomultipliers whose combined outputs measure the energy deposition in that layer. In addition, the six outputs from each disk are compared to determine the position at which incident nuclei traverse each layer to an accuracy of ~2 mm. The Cerenkov counters, which measure particle velocity, are each viewed by twelve 5-inch photomultipliers using light integration boxes. This experiment is a collaborative effort with the Danish Space Research Institute.

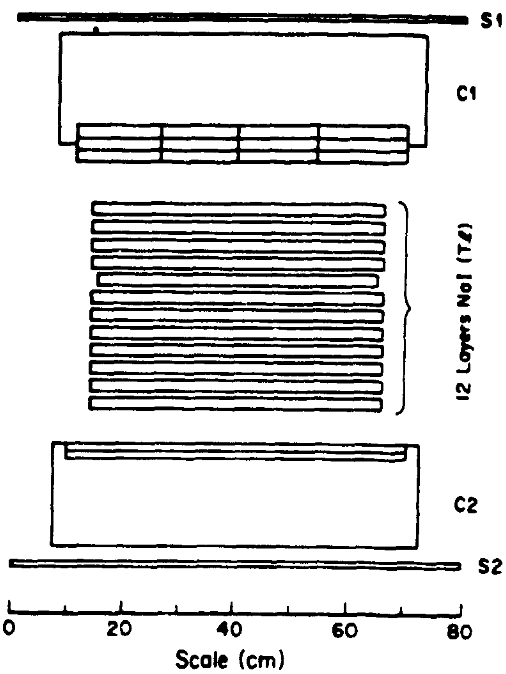

Figure 1

HEIST determines the mass of individual nuclei by measuring both the change in the Lorentz factor ($\Delta\gamma$) that results from traversing the NaI stack, and the energy loss (ΔE) in the stack. Since the total energy of an isotope is given by $E = \gamma M$, the mass M can be determined by $M = \Delta E/\Delta\gamma$. The instrument is designed to achieve a typical mass resolution of 0.2 amu.

On May 14, 1984, the HEIST instrument was launched from Palestine, Texas on its first balloon flight. It reached altitude successfully and floated over the state of Texas for approximately 38 hours at a typical atmospheric depth of $\sim$5.5 g/cm^2, and at geomagnetic cutoffs ranging from $\sim$4.5 to 5.5 GV. During the flight more than 4 x 10^5 events were recorded, including $\sim 10^5$ events with charge $Z \geq 6$ and kinetic energy $E \geq 1.4$ GeV/nucleon. Although only a subset of these are suitable for isotope analysis, the others are being used for in-flight mapping and stability checks. The various HEIST subsystems operated near-perfectly during the flight.

The primary focus of our data analysis activities during the last six months has been the development and optimization of methods to determine the position and energy-loss of ions traversing the NaI stack. These algorithms depend on detailed maps of the response of each PMT viewing the NaI which are being derived from the

^{55}Mn Bevalac calibration of HEIST. To date we have mapped and analysed the first 8 layers using a 1-cm grid. Maps for layers 9 and 10 and the top scintillator are now in progress.

We have developed a position-determining algorithm that minimizes the differences between the measured and mapped response for ratios of six different combinations of tubes in each of the NaI layers. An example of such a response ratio is the sum of the outputs of the three tubes on one half of the disk divided by the sum of the three tubes on the opposite half. Using this algorithm we now achieve a typical position resolution of 4 mm (FWHM) for ^{55}Mn ions from the Bevalac, in each of the first eight layers. We find good agreement between the positions in adjacent layers so that accurate trajectories can be derived. To determine the energy loss of an ion in a NaI layer we obtain a separate measure of ΔE from maps of each of the six tubes in that layer, and then calculate a weighted mean of these six values. The measured energy resolution for ^{55}Mn is ~2.5% (FWHM) in each of the first eight NaI layers. These results are averaged over the entire area of the disks, and are consistent with the design goals for isotope resolution in the instrument.

We have recently started applying these new maps and analysis methods to the flight data. As an example, Figure 2 shows the trajectory and energy loss profile for an event determined to be silicon (Z=14). The rms deviation of the x and y positions from the best-fit straight-line trajectory for this event is $\sigma \simeq$ 2.5 mm, typical for events with this charge. The resolution improves for heavier nuclei and decreases for lighter species.

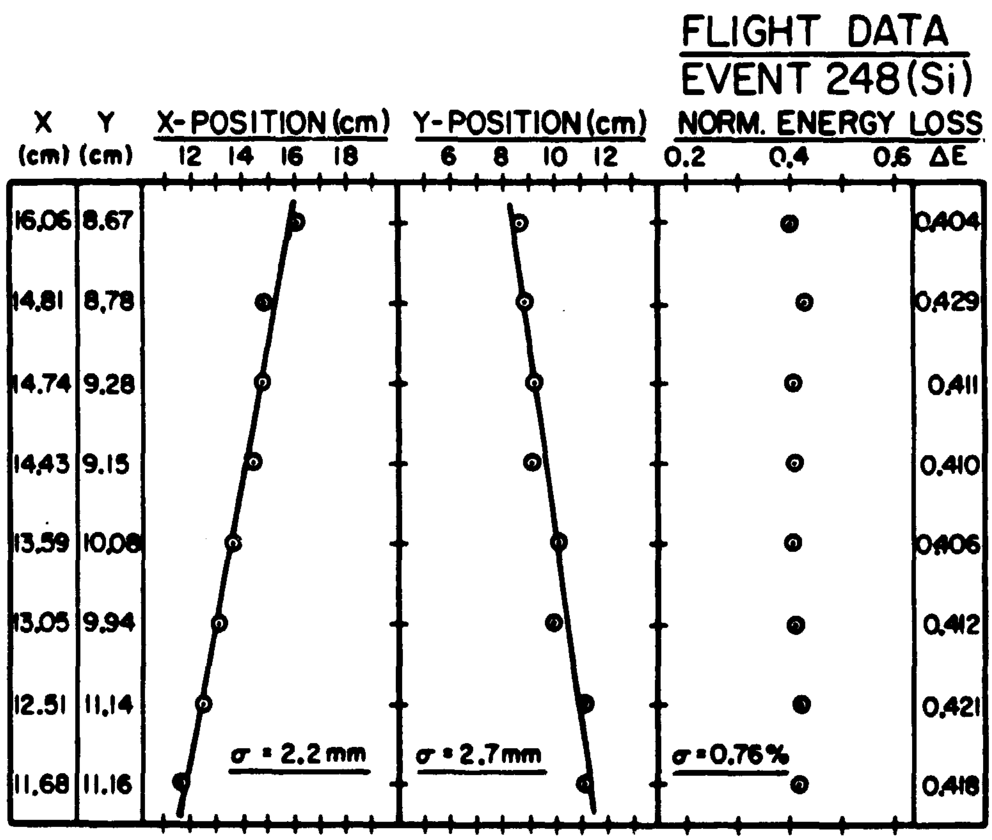

Figure 2

In Figure 3 we show a histogram of the square-root of the mean energy-loss response summed over layers 1 to 8, based on ~10,000 penetrating events obtained during the flight. Clearly visible are well-resolved peaks due to elements from B to Si ($5 \leq Z \leq 14$), and an Fe peak at a response of ~1.03.

Our collaborators at the Danish Space Research Institute have been focusing their efforts on mapping and calibration of the response of the Cerenkov counters. They have recently obtained improved maps of the individual blocks of the top Cerenkov counter using a subset of the ^{55}Mn calibration data that was selected using our maps of the NaI stack. It is planned to apply the Cerenkov maps to the flight data in the near future.

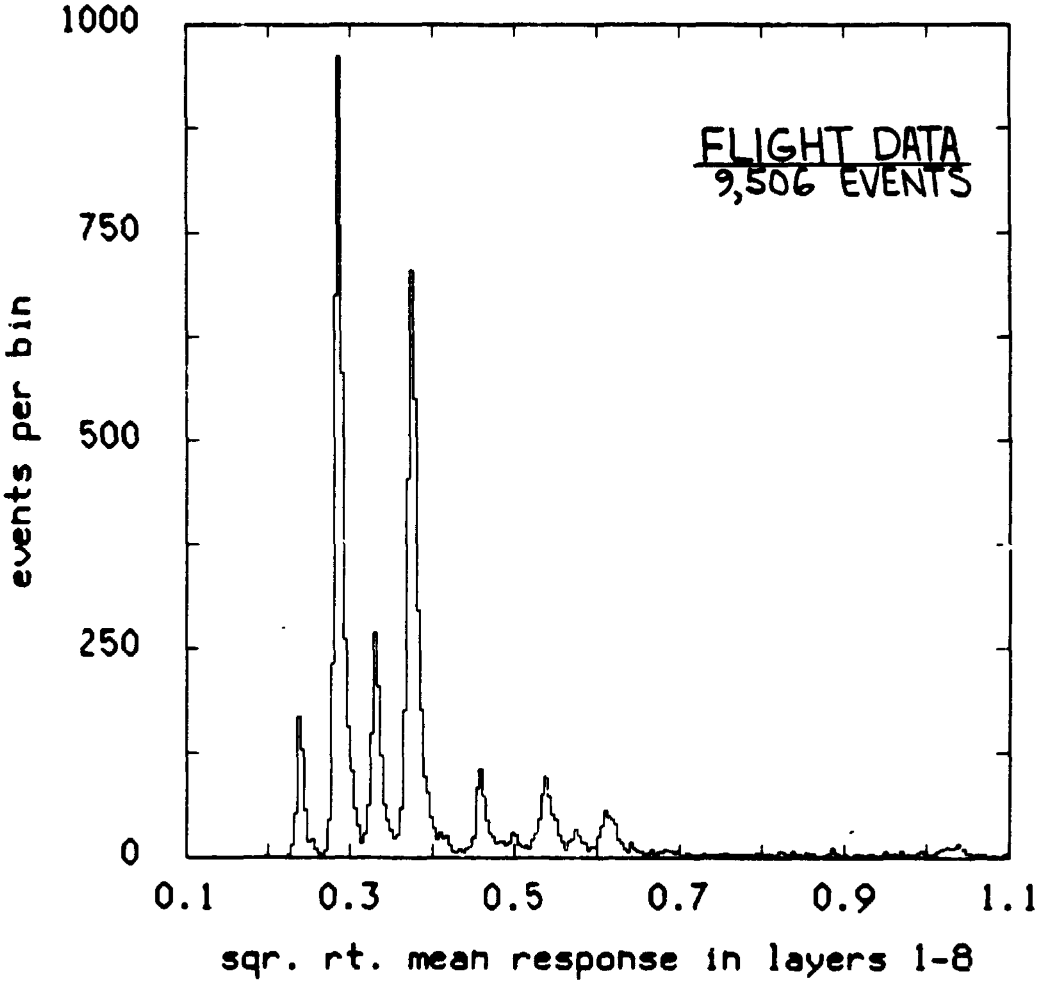

Figure 3

The following recent talks and papers have resulted from this work:

- "Measurements of Cosmic Ray Isotopes from a Space Station Platform," R. A. Mewaldt Experiments for the Space Station Era, *Pro. of The Workshop on Cosmic Ray and High Energy Gamma Ray*, 267-274 (1985).

- "Initial Results from the Caltech/DSRI Balloon-Borne Isotope Experiment," S. M. Schindler et al., *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA.*

1.1.2. Low Energy Isotope Spectroscopy

In August of 1984 we completed a successful calibration of solid-state detectors at the Lawrence Berkeley Laboratory Bevalac, in which we studied several problems important to isotope spectrometers based on silicon solid-state detectors. One of the areas of investigation during this calibration was the extension of our mass spectroscopy capabilities to nuclei beyong the Fe (Z=26) peak. We have now shown that solid-state detector isotope spectrometers of the type we flew on ISEE-3 can resolve isotopes up through Kr (Z=36) with a r.m.s. mass resolution of $\sigma_m \simeq 0.25$ amu or better. Work is continuing on other aspects of this investigation.

1.2. Experiments on NASA Spacecraft

The SR&T grant program of the Space Radiation Laboratory is strengthened by and contributes to the other programs described here. Activities related to these programs are primarily funded by mission-related contracts but grant funds are used to provide a general support base and the facilities which make these programs possible.

1.2.1. An Electron/Isotope Spectrometer (EIS) Launched on IMP-7 on 22 September 1972 and on IMP-8 on 26 October 1973

This experiment is designed to measure the energy spectra of electrons and positrons (0.16 to ~6 MeV), and the differential energy spectra of the nuclear isotopes of hydrogen, helium, lithium, and beryllium (~2 to 50 MeV/nucleon). In addition, it provides measurements of the fluxes of the isotopes of carbon, nitrogen, and oxygen from ~5 to ~15 MeV/nucleon. The measurements from this experiment support studies of the origin, propagation, and solar modulation of galactic cosmic rays; the acceleration and propagation of solar flare and interplanetary particles; and the origin and transport of energetic magnetospheric particles observed in the plasma sheet, adjacent to the magnetopause, and upstream of the bow shock.

The extensive EIS data set has been utilized in comprehensive studies of solar, interplanetary, and magnetospheric processes. Correlative studies have involved data from other IMP investigations and from other spacecraft, as well as direct comparisons of EIS data from IMP-7 and IMP-8.

Our studies of IMP data have resulted in the following recent talks and papers:

- "Solar Cycle Variations of the Anomalous Cosmic Ray Component," R. A. Mewaldt and E. C. Stone, *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* **5**, 167 (1985).

- "Cosmic Ray ^{3}He Measurements," R. A. Mewaldt, *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* **2**, 64 (1985).

1.2.2. An Interstellar Cosmic Ray and Planetary Magnetospheres Experiment for the Voyager Missions Launched in 1977.

This experiment is conducted by this group in collaboration with F. B. McDonald and J. H. Trainor (Goddard Space Flight Center), W. R. Webber (University of New Hampshire), and J. R. Jokipii (University of Arizona), and has been designated the Cosmic Ray Subsystem (CRS) for the Voyager Missions. The experiment is designed to measure the energy spectra, elemental and (for lighter elements) isotopic composition, and streaming patterns of cosmic-ray nuclei from H to Fe over an energy range of 0.5 to 500 MeV/nucleon and the energy spectra of electrons with 3 - 100 MeV. These measurements will be of particular importance to studies of stellar nucleosynthesis, and of the origin, acceleration, and interstellar propagation of cosmic rays. Measurements of the energy spectra and composition of energetic particles trapped in the magnetospheres of the outer planets are used to study their origin and relationship to other physical phenomena and parameters of those planets. Measurements of the intensity and directional characteristics of solar and galactic energetic particles as a function of the heliocentric distance will be used for *in situ* studies of the interplanetary medium and its boundary with the interstellar medium. Measurements of solar energetic particles are crucial to understanding solar composition and solar acceleration processes.

The CRS flight units on both Voyager spacecraft have been operating successfully since the launches on August 20, 1977 and September 5, 1977. The CRS team participated in the Voyager 1 and 2 Jupiter encounter operations in March and July 1979, and in the Voyager 1 and 2 Saturn encounters in November 1980 and August 1981. The Voyager data represent an immense and diverse data base, and a number of scientific problems are under analysis. These investigation topics range from the study of galactic particles to particle acceleration phenomena in the interplanetary medium, to plasma/field energetic particle interactions, to acceleration processes on the sun, to studies of elemental abundances of solar, planetary, interplanetary, and galactic energetic particles, and to studies of particle/field/satellite interactions in the magnetospheres of Jupiter and Saturn.

The following publications and papers for scientific meetings, based on Voyager data, were generated:

- "Solar Coronal and Photospheric Abundances from Solar Energetic Particle Measurements," H. Breneman and E. C. Stone, *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* 4, 217 (1985).

- "Precision Measurements of Solar Energetic Particle Elemental Composition," H. Breneman and E. C. Stone, *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* 4, 213 (1985).

- "Differential Measurement of Cosmic-Ray Gradient with Respect to Interplanetary Current Sheet," S. P. Christon et al., *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* 4, 445 (1985).

- "Changes in the Energy Spectrum of Anomalous Oxygen and Helium During 1977-1985," A. C. Cummings et al., *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* 5, 163 (1985).

• "Radial and Latitudinal Gradients of Anomalous Oxygen During 1977-1985," W. R. Webber et al., *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* **5**, 172 (1985).

• "Solar Photospheric and Coronal Abundances from Solar Energetic Particle Measurements," H. H. Breneman, Ph.D Thesis, California Institute of Technology (1985).

• "Changes in the Energy Spectrum of Anomalous Oxygen During 1977-1985," A. C. Cummings et al., *J. Geophys. Res.* **To be published in special issue on results of Cosmic-Ray Modulation Workshop** (1985).

• "Cosmic Ray Modulation, 1980: Particle and Field Observations," A. J. Lazarus et al., AGU Spring Meeting (1985).

1.2.3. A Heavy Isotope Spectrometer Telescope (HIST) Launched on ISEE-3 in August 1978

HIST is designed to measure the isotope abundances and energy spectra of solar and galactic cosmic rays for all elements from lithium to nickel ($3 \leq Z \leq 28$) over an energy range from several MeV/nucleon to several hundred MeV/nucleon. Such measurements are of importance to the study of the isotopic constitution of solar matter and of cosmic ray sources, the study of nucleosynthesis, questions of solar-system origin, studies of acceleration processes and studies of the life history of cosmic rays in the galaxy.

HIST was successfully launched on ISEE-3 and provided high resolution measurements of solar and galactic cosmic ray isotopes until December 1978, when a component failure reduced its isotope resolution capability. Since that time, the instrument has been operating as an element spectrometer for solar flare and interplanetary particle studies.

Our work on solar flare, interplanetary, and galactic cosmic ray isotopes has resulted in the following recent papers.

• "A Cerenkov-ΔE-Cerenkov Detector for High Energy Cosmic Ray Isotopes and an Accelerator Study of ^{40}Ar and ^{56}Fe Fragmentation," K. H. Lau, Ph.D Thesis, California Institute of Technology (1985).

• "Measurements of Fe and Ar Fragmentation Cross Sections," K. H. Lau et al., *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* **3**, 91 (1985).

• "Cosmic Ray ^3He Measurements," R. A. Mewaldt, *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* **2**, 64 (1985).

1.2.4. A Heavy Nuclei Experiment (HNE) Launched on HEAO-C in September 1979

The Heavy Nuclei Experiment is a joint experiment involving this group and M. H. Israel, J. Klarmann, W. R. Binns (Washington University) and C. J. Waddington (University of Minnesota). HNE is designed to measure the elemental abundances of relativistic high-Z cosmic ray nuclei ($17 \leq Z \leq 130$). The results of such measurements are of significance to the studies of nucleosynthesis and stellar structures, the existence of extreme transuranic nuclei, the origin of cosmic rays, and the physical properties of the interstellar medium. HNE was successfully launched on HEAO-3 and operated until late May 1981.

The following talks and papers were presented during the reporting period:

- "Lead, Platinum, and Other Heavy Elements in the Primary Cosmic Radiation--HEAO-3 Results," W. R. Binns et al., *Ap. J.* **To be published in Oct. 1985 issue.** (1985).

- "The Response of Ionization Chambrs to Relativistic Heavy Nuclei," B. J. Newport et al., *Bull. Am. Phys. Soc.* **30**, 778 (1985).

- "Interactions of Relativistic Heavy Nuclei (Kr to U) in Light Targets," M. P. Kertzman et al., *Bull. Am. Phys. Soc.* **30**, 779 (1985).

- "Platinum, Lead, and Other Elements in the Primary Cosmic Radiation--HEAO-3 Results," C. J. Waddington et al., *Bull. Am. Phys. Soc.* **30**, 763 (1985).

- "Energy Spectra of Iron-Secondary Elements Between 5 and 300 GeV/amu," M. D. Jones et al., *Bull. Am. Phys. Soc.* **30**, 764 (1985).

These papers were presented at the 19th International Cosmic Ray Conference in August:

- "Elemental Abundances of Cosmic Rays with $Z > 33$ as Measured on HEAO-3," B. J. Newport et al., *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* **2**, 123 (1985).

- "The Response of Ionization Chambers to Relativistic Heavy Nuclei," B. J. Newport et al., *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* **3**, 287 (1985).

- "Energy Spectra of Elements with $18 \leq Z \leq 28$ Between 10 and 300 GeV/amu," M. Jones et al., *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* **2**, 28 (1985).

- "Lead, Platinum, and Other Heavy Elements in the Primary Cosmic Radiation--HEAO-3," C. J. Waddington et al., *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* **To be published in Late Volume** (1985).

- "Interactions of Heavy Nuclei, Kr, Xe and Ho, in Light Targets," M. P. Kertzman et al., *Proceedings of 19th International Cosmic Ray*

Conference, La Jolla, CA **3**, 95 (1985).

• "Abundances of 'Secondary' Elements Among the Ultra Heavy Cosmic Rays - Results from HEAO-3," J. Klarmann et al., *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* **2**, 127 (1985).

• "Implications of Source Abundances of Ultraheavy Cosmic Rays," W. R. Binns et al., *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* **3**, 13 (1985).

1.2.5. Proposal for an Advanced Composition Explorer (ACE)

This investigation, proposed jointly by this group, and by W. D. Arnett and J. A. Simpson (University of Chicago), L. F. Burlaga (GSFC), R. E. Gold and S. M. Krimigis (APL/JHU), W. C. Feldman (LANL), G. Gloeckler and G. M. Mason (UMd), and J. V. Hollweg (UNH), is for the study of an Advanced Composition Explorer (ACE). This Explorer-class mission would make comprehensive measurements of the elemental and isotopic composition of accelerated nuclei with increased sensitivity of several orders of magnitude, and with improved mass and charge resolution. ACE would observe particles of solar, interplanetary, and galactic origins, spanning the energy range from that of the solar wind (~ 1 keV/nucleon) to galactic cosmic ray energies (several hundred MeV/nucleon). Definitive studies would be made of the abundance of essentially all isotopes from H to Zn ($1 \leq Z \leq 30$), with exploratory isotope studies extending to Zr ($Z=40$), and element studies extending to U ($Z=92$).

ACE would be a coordinated experimental and theoretical effort, designed to investigate a wide range of fundamental problems. In particular, ACE would provide the first extensive tabulation of solar *isotopic* abundances based on direct sampling of solar material and would establish the pattern of *isotopic differences* between galactic cosmic ray and solar system matter. These composition data would be used to investigate basic dynamical processes that include the formation of the solar corona, the acceleration of the solar wind, and the acceleration and propagation of energetic nuclei on the Sun, in interplanetary space, and in cosmic ray sources. They would also be used to study the history of solar system material and of galactic cosmic ray material, and to investigate the differences in their origin and evolution.

The ACE study payload includes four high resolution spectrometers, each designed to provide the ultimate charge and mass resolution in its particular energy range, and each having a collecting power 1 to 3 orders of magnitude greater than previous or planned experiments. Included in the study would be two spectrometers, a Solar Isotope Spectrometer (SIS) and a Cosmic Ray Isotope Spectrometer (CRIS), for which Caltech would play a leading role. These spectrometers would make use of the proven mass-resolution techniques and large-area detectors that were developed and tested by this laboratory over the past decade, partly through the support of this grant.

1.2.6. Galileo Heavy Ion Counter

This experiment, being constructed by this group in collaboration with N. Gehrels at Goddard Space Flight Center, has been added to the Galileo mission as an engineering subsystem. It will monitor penetrating (~ 10 to ~ 200 MeV/nucleon) sulfur, oxygen, and other heavy elements in the Jovian magnetosphere with the sensitivity needed to warn of potential "single-event upsets" (SEU) in the attitude control system computer. (SEUs are state changes induced by ionizing radiation.) Caltech is responsible for management, detector testing, and calibration of the experiment, which is based on repackaging the Voyager CRS prototype unit (the PTM). Although the primary purpose is engineering support, the data will allow us to continue our investigation of spectra of trapped ions in the Jovian magnetosphere and their relation to the Jovian aurora. In addition, during cruise phase and in the outer Jovian magnetosphere, we will use the instrument to measure the elemental composition of solar flare events and of the anomalous cosmic ray component, beginning in 1986 and continuing through ~ 1991.

The instrument was delivered on schedule to JPL in June. It has been integrated onto the spacecraft and tested. Calibrations were done at CIT in early September and the instrument was re-delivered and re-tested afterwards. Current efforts are directed mainly to planning mission operations and data processing.

2. Gamma Rays

This research program, which has received significant support from Caltech, is directed toward the investigation of galactic, extragalactic, and solar gamma rays with spectrometers of high angular resolution and moderate energy resolution carried on spacecraft and balloons. The main efforts have been directed toward the following two categories of experiments.

2.1. Activities in Support of or in Preparation for Spacecraft Experiments

These activities generally embrace prototypes of experiments on existing or future NASA spacecraft and they complement and/or support such experiments.

2.1.1. A Balloon-Borne Gamma Ray Imaging Payload (GRIP)

The GRIP instrument is a balloon-borne imaging gamma-ray telescope for galactic and extragalactic astronomy observations. A shielded NaI Anger camera will be used in combination with a 2-cm thick, lead, rotating, coded-aperture mask to achieve an imaging capability of 1000 0.6° pixels in a 20° field of view and a localization capability of 3 arc minutes for 10σ sources. This performance represents more than an order of magnitude improvement over previous balloon and satellite instrumentation. The 16" x 2" NaI Anger camera plate will have an energy range of 30 keV to 3 MeV and achieve a continuum sensitivity of $6x10^{-7}/cm^2 s$ keV at 1 MeV.

Integration of the GRIP instrument was completed during July, 1985 and the instrument was shipped to Palestine, Texas for a launch during the Fall turnaround period. A 35 hour flight was desired which included observations of the Crab and Cygnus regions, as well as measurements of γ-ray emission from NGC4151 and the Galactic Center region. Because the telescope has a 20° field of view, multiple objects can be observed simultaneously. For instance, the same field of view that contains the Crab pulsar also contains the cyclotron line source A0535+26 and the high-energy γ-ray source Geminga. In the Cygnus field of view, both Cyg X-1 and Cyg X-3 are simultaneously observable.

Unfortunately, high altitude and surface wind conditions were unfavorable during almost the entire turnaround period. Although the GRIP instrument was in flight ready condition for over two weeks, weather conditions did not permit a launch. The instrument is currently stored at NSBF in Palestine, Texas and we plan to take advantage of launch opportunities during the Spring, 1986 turnaround period.

The following papers were presented at the ICRC:

- "Hexagonal Uniformly Redundant Arrays for Coded-Aperture Imaging," M. H. Finger and T. A. Prince, *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* 3, 295 (1985).

- "A Balloon-Borne Imaging Gamma-Ray Telescope," W. E. Althouse et al., *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* 3, 299 (1985).

- "Balloon-Borne Video Casette Recorders for Digital Data Storage," W. E. Althouse and W. R. Cook, *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* 3, 395 (1985).

2.1.2. Development of a γ-Ray Imager with Arc Second Resolution (GRID)

We have continued work on the definition of an ultra-high resolution γ-ray imager for solar and cosmic γ-ray astronomy. Above 100 keV, past instruments have been limited to a typical angular resolution of 10° or poorer. The GRIP project described above is a significant step forward with an angular resolution of 0.5° up to energies greater than 1 MeV. It became clear during the last year that an extension of the GRIP technology allows imaging with a resolution of one second of arc. A γ-ray imaging device with 1 arc second resolution would be a 10,000 fold improvement over conventional non-imaging instrumentation and have substantial new capabilities for observations of astrophysical gamma-ray sources. With a resolution comparable to that of the VLA and the Einstein X-ray Observatory, the γ-ray imager would make significant contributions to our knowledge of solar flare physics, the galactic center, AGN, and other hard x-ray/γ-ray sources. The arc second γ-ray imager is based on two previously developed concepts: Fourier transform techniques combined with the position sensitive detector development carried out by our group for the GRIP balloon project.

Planning for the practical implementation of the high-resolution γ-ray imager has taken place within the high-energy solar physics community. This was a natural approach since the concept evolved in part from the P/OF project whose primary objectives are high-resolution studies of the sun. Initial discussions took place in October, 1984 at the Workshop for a High-Energy Facility for Solar Physics. Concurrently, the possibility of an SMM instrument changeout was being discussed for the next solar maximum. High resolution γ-ray imaging is a very attractive option for such a mission. We investigated this possibility in detail and the results were presented at two meetings at the Goddard Space Flight Center in February and April, 1985. The result was a concept for a MAX '91 mission which would include an instrument called GRID (Gamma-Ray Imaging Device). Caltech played a central role in the development of this instrument concept in close cooperation with Marshall Space Flight Center, Goddard Space Flight Center, UCSD, UC Berkeley, and European collaborators from Birmingham, U.K. and Utrecht, Netherlands.

The GRID instrument consists of two collimator grid planes viewed by a complement of x-ray and γ-ray detectors. The collimator grid planes are separated by 6.7 meters. The finest collimator grid scale is 50μ which yields an angular resolution of 1.5 arc seconds. The technique was described in:

- "A Fourier transform telescope for sub-arcsecond imaging," C. J. Crannell et al., *Proceedings of the Soc. Photo-Optical Instrumentation Engineers* **To be published in 1986** (1986).

Work has progressed on a detailed Phase A study for the Max '91 mission. The next meeting of the Max '91 Science Study Group is scheduled for late October, 1985. Study activities have received support from this grant as well as from the NSF Presidential Young Investigator Program.

3. Other Activities

R. A. Mewaldt is serving as a member of NASA's High Energy Astrophysics Management Operations Working Group (HEAMOWG), the Cosmic Ray Program Working Group (CRPWG), and the Superconducting Magnet Facility Definition Study Team. He also served as "OG" program chairman for the 19th International Cosmic Ray Conference.

T. A. Prince has received a Presidential Young Investigator Award from the National Science Foundation.

E. C. Stone continues to serve as NASA's Project Scientist for the Voyager Mission. He is also a member of the Space Science Board, the NASA University Relations Study Group, and the steering group of the SSB study, "Major Directions for Space Science: 1995-2015".

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Christon, S. P. and E. C. Stone, "Latitude Variation of Recurrent Fluxes in the Outer Solar System," *Proceedings of 19th International Cosmic Ray Conference, La Jolla, CA* **4**, 404 (1985).

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