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**Final Report**  
**on**  
**NASA Grant NAG5-727**

**“Relative to the Caltech**  
**Electron/Isotope Spectrometer - IMP”**

**Covering Activities From**  
**April 1, 1985 to September 30, 1996**

**Submitted: October 14, 1997**

**Introduction:** The Electron Isotope Spectrometers (EIS) on IMP-8 was designed to provide measurements of low energy isotopes from H to O ( $1 \leq Z \leq 8$ ) over the energy range from ~2 to ~40 MeV/nuc, as well as low energy electrons from ~0.2 to ~6 MeV. These measurements supported studies of the acceleration and transport of energetic particles originating on the Sun, in interplanetary space, in the Galaxy, and in Earth's and Jupiter's magnetosphere.

IMP-8 was launched in October 1973 and still continues to provide key particles and fields measurements from orbit about the Earth. The IMP-8 EIS continued to operate flawlessly until 8/3/92, when a partial failure was suffered in a bias supply, which reduced the ability of the instrument to measure high energy particles. The EIS was subsequently turned off in 1995. A nearly identical instrument was flown on IMP-7 from 10/92 to 7/96, and many studies combined results from both instruments. For completeness, this report summarizes scientific results and publications from the entire IMP-7&8 effort, not just from the period covered by NAG5-727. The investigators on these two instruments were E.C. Stone (Principal Investigator), and R. E. Vogt and R. A. Mewaldt (Co-investigators).

**Scientific Results:** The EIS instruments provided new results on a wide range of topics in space physics and astrophysics. A summary of some of the topics addressed is provided on the following page. For a complete summary, see the papers in the attached bibliography.

**PhD Theses:** Four Caltech graduate students based their PhD thesis work on data from the IMP-7 & 8 EIS instruments, and several additional graduate/undergraduate students and technical personnel received valuable training during the design, development, and calibration of these instruments. The PhD theses are listed in the attached bibliography.

**Bibliography:** A complete bibliography of papers and talks based on EIS data is attached.

## IMP EIS Science Highlights

### **Solar Energetic Particles**

- Discovery of heavy-ion enrichments in  $^3\text{He}$ -rich flares
- Measurements of  $^2\text{H}$  and  $^3\text{He}$  in solar energetic particles
- Measurements of solar flare electron spectra

### **Anomalous Cosmic Rays (ACRs)**

- First measurement of the isotopic composition of ACRs
- Time variations of ACR oxygen over 20 years
- Interplanetary radial gradients with Pioneer and Voyager
- Proof that ACR oxygen is singly-charged (with COSMOS)
- Evidence for ACR hydrogen at 1 AU

### **Galactic Cosmic Rays (GCRs)**

- Comparison of GCR  $^2\text{H}$  and  $^3\text{He}$  with galactic propagation models
- Composition & energy spectra of low energy  $1 \leq Z \leq 8$  nuclei
- Study of neutron and  $\gamma$ -ray induced backgrounds in silicon detectors

### **Interplanetary Particles**

- First measurement of Jovian 0.2 to 3 MeV electron spectra at 1 AU
- Discovery the particles in CIR events flow back towards the Sun
- Direct determination of interplanetary diffusion coefficients

### **Magnetospheric Electrons**

- Discovery of the magnetopause energetic electron layer
- Study of energy flow at the magnetopause and geomagnetic activity
- Evidence for sub-storm associated magnetic reconnection

**The Caltech Electron/Isotope Spectrometers  
on IMP-7 and 8; 1972-1996  
PUBLICATIONS**

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**The Caltech Electron/Isotope Spectrometers  
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