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THE ADVANCED COMPOSITION EXPLORER MISSION

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ABSTRACT

The Advanced Composition Explorer, to be launched in August of 1997, will include six high resolution spectrometers that will measure the composition of interplanetary nuclei with $2 \leq Z \leq 28$ from <1 keV/nuc to $\sim$500 MeV/nuc. Three additional instruments will provide the interplanetary context for these measurements. We give a brief introduction to the ACE mission, its instrumentation, and its goals.

INTRODUCTION

The Advanced Composition Explorer, ACE, will perform comprehensive studies of the elemental, isotopic, and ionic charge-state composition of energetic nuclei in interplanetary space (Stone et al., '90). ACE's six high-resolution spectrometers will make measurements at energies ranging from <1 keV/nucleon (solar wind) to $\sim$0.5 GeV/nucleon (cosmic radiation) including elements from He to Ni ($2 \leq Z \leq 28$). These studies will be performed near the L1 point, $\sim$0.01 astronomical units sunward of the Earth, with a launch planned for August 1997. ACE also includes three monitoring instruments that will characterize the interplanetary solar wind, magnetic field, and energetic particle environment of protons, alphas, and electrons. Following launch in August of 1997, ACE will take $\sim$3 months to reach L1. It is then scheduled for a 2-year (minimum) mission with a goal of five years. A brief description of the ACE Science Center and the data available from ACE is given in a companion paper (Garrard et al. '97); detailed descriptions of the ACE instruments and spacecraft will appear in a special issue of Space Science Reviews to be published shortly after launch.

MISSION GOALS

The prime objective of ACE will be to determine and compare the elemental and isotopic composition of several distinct samples of matter, including the solar corona, the interplanetary medium, the local interstellar medium, and galactic matter. Figure 1 shows examples of typical energy spectra from various components of energetic nuclei observed in interplanetary space. Matter from the Sun will be studied directly by measuring the composition of the solar wind, of coronal mass ejections, and of solar energetic particles. Matter from the local interstellar medium is observed as interstellar neutral particles which enter the heliosphere, are ionized and picked up by the solar wind ("pick-up" ions), and accelerated to cosmic ray energies ("anomalous" cosmic rays). Galactic cosmic rays provide a sample of matter from other regions of the Galaxy that is believed to be accelerated by supernova shock waves. Each of these samples has a distinctly different history: the pick-up ions and anomalous cosmic rays sample the present day interstellar medium; galactic cosmic rays were accelerated roughly 10 million years ago; and solar material has been stored in the Sun for the last 4.6 billion years.

The comparison of these samples will be used to study the origin and subsequent evolution of solar and galactic material by isolating effects of fundamental processes that include nucleosynthesis, charged and neutral-particle separation, bulk plasma acceleration, and acceleration of suprathermal and high-energy particles.

In addition, real time telemetry of a limited subset of the ACE data will allow "space-weather" predictions by the National Oceanic and Atmospheric Agency, NOAA, since these data will reach the Earth about an hour ahead of the solar wind plasma passing ACE on the way to Earth.

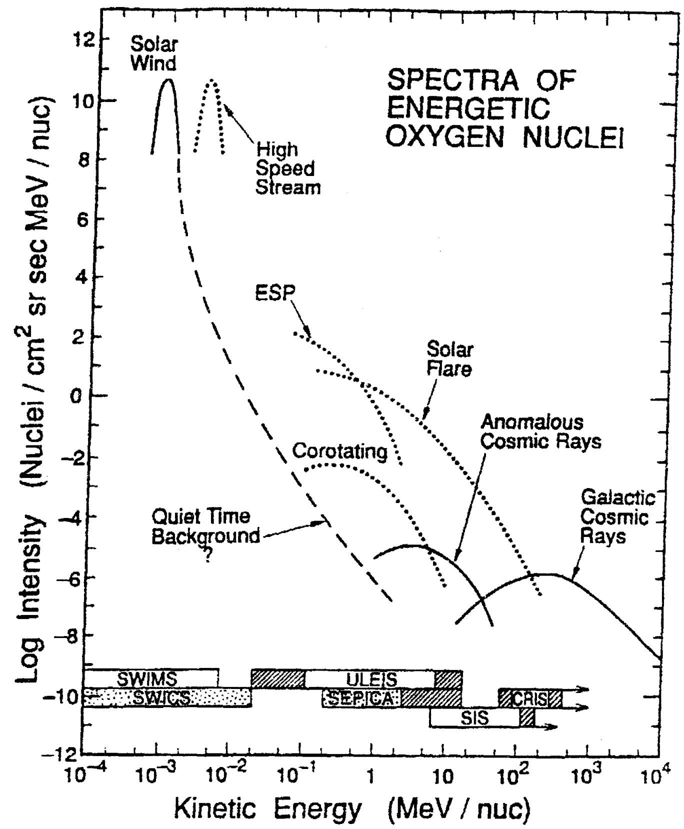

Figure 1: *Typical energy spectra of various sources of energetic oxygen nuclei are shown, along with energy coverage for various ACE instruments. Other nuclear species tend to have similar specta. Solid curve = steady-state components; light dashed = transient phenomena; heavy dashed = postulated quiet-time supra-thermal solar particles. Energy ranges: blank = isotopes resolved; cross-hatched = elements resolved; stippled = ionic charge states resolved.*

INSTRUMENTATION

Addressing the objectives summarized above requires coordinated, high-precision measurements of elemental, isotopic, and ionic-charge-state composition of energetic nuclei over a broad energy range with good time resolution. The instruments that will provide the composition measurements are listed below. They cover the charge range from H to Ni. Energy ranges are indicated in both figures.

The Cosmic Ray Isotope Spectromenter (CRIS, from Caltech, Goddard Space Flight Center, Jet Propulsion Laboratory, and Washington University) will measure elemental and isotopic composition using an optical-fiber trajectory system to track nuclei that are stopped in one of four co-aligned stacks of large-area silicon detectors.

The Solar Isotope Spectrometer (SIS, from Caltech, Goddard Space Flight Center, and Jet Propulsion Laboratory) will measure elemental and isotopic composition of energetic nuclei using two stacks of large-area silicon detectors with trajectories measured by silicon matrix detectors.

The Ultra Low Energy Isotope Spectrometer (ULEIS, from University of Maryland and Johns Hopkins University Applied Physics Laboratory) measures mass and kinetic energy of nuclei based on time of flight and total kinetic energy.

The Solar Energetic Particle Ionic Charge Analyzer (SEPICA, University of New Hampshire and Max Planck Institut) measures charge state, energy, and nuclear charge of ions based on electro-

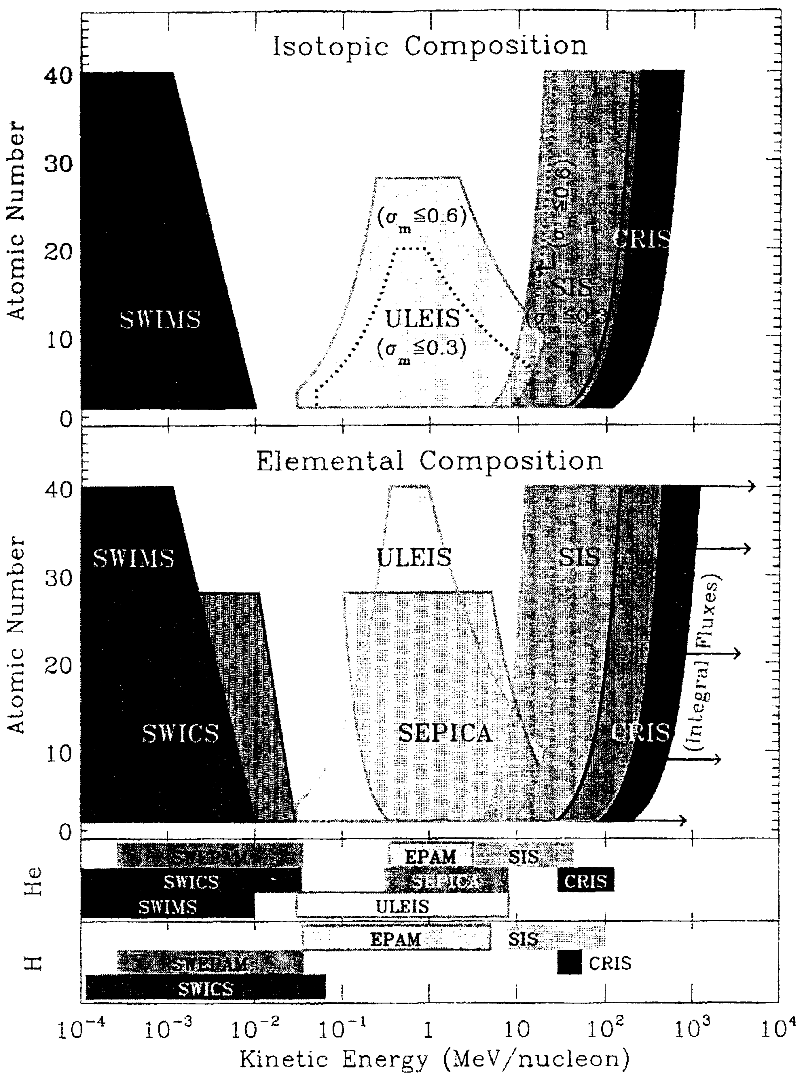

Figure 2: *Energy coverage of the ACE instruments is shown as a function of atomic number and for H and He. The upper panel shows regions in which isotopic composition is resolved, the lower panel shows energy intervals for which elemental composition is resolved.*

static deflection, energy loss, and residual energy.

The Solar Wind Ion Mass Spectrometer (SWIMS, from University of Maryland and University of Bern) will measure mass-to-charge ratios for solar wind and pick-up ions, using time of flight through a specially designed electrostatic potential.

The Solar Wind Ion Composition Spectrometer (SWICS, from University of Maryland and University of Bern) determines elemental and ionic-charge-state composition using electrostatic deflection, post-acceleration, time of flight, and energy measurements.

The Electron, Proton, and Alpha-Particle Monitor (EPAM, from Johns Hopkins University Applied Physics Laboratory) characterizes electron and ion fluxes using range, energy loss, residual energy, and magnetic deflection.

The Solar Wind Electron, Proton, and Alpha-Particle Monitor (SWEPAM, from Los Alamos National Laboratory) uses electrostatic deflection to measure the three-dimensional characteristics of solar wind and suprathermal electrons from about 1 to 900 eV and ions from 0.26 to 35 KeV.

The Magnetometer (MAG, from University of Deleware/Bartol Research Institute and Goddard Space Flight Center) is a dual, triaxial flux-gate device that will measure the dynamic behaviour of the vector magnetic field, including high-time-resolution snapshots and Fourier transforms for studying shocks and waves.

The spacecraft, built by Johns Hopkins University Applied Physics Laboratory, will be spin stabilized for attitude control, with the spin axis roughly aligned along the Sun-Earth line. Many of the instruments take advantage of the spacecraft's spin to measure distributions of particle arrival directions. The location of the spacecraft at the L1 Lagrangian point allows measurements free of "contamination" from the Earth's magnetosphere and it facilitates ACE's utility for monitoring solar wind conditions affecting the Earth, for both measuring input to the magnetosphere and for space weather purposes. The instruments generate data at a rate of 6944 bits per second. Data are stored on board in a Solid state recorder with a capacity of 52 hours. The recorder contents are transmitted to the Deep Space Network, nominally scheduled for 3 hours each day.

SUMMARY

The data from the instruments listed above will be analyzed in a coordinated fashion by the instrument teams, and will be made available to the community through the ACE Science Center, the Space Physics Data System, and the National Space Science Data Center. These coordinated studies, with a suite of instruments designed to obtain definitive measurements over as broad an energy range as possible, will lead to new and interesting results on a wide range of topics related to the origin and evolution of elements, one of the quests important to understanding the structure and evolution of the Universe.

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