ACE (ADVANCED COMPOSITION EXPLORER)

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Advanced Composition Explorer (ACE or Explorer 71) is a NASA Explorer program satellite and space exploration mission to study matter comprising energetic particles from the solar wind, the interplanetary medium, and other sources.

Real-time data from ACE are used by the National Oceanic and Atmospheric Administration (NOAA) Space Weather Prediction Center (SWPC) to improve forecasts and warnings of solar storms.[1] The ACE robotic spacecraft was launched on 25 August 1997, and entered a Lissajous orbit close to the L1 Lagrange point (which lies between the Sun and the Earth at a distance of some 1,500,000 km (930,000 mi) from the latter) on 12 December 1997.[2] The spacecraft is currently operating at that orbit. Because ACE is in a non-Keplerian orbit, and has regular station-keeping maneuvers, the orbital parameters in the adjacent information box are only approximate.

As of 2023,[3] the spacecraft is still in generally good condition.[4] NASA Goddard Space Flight Center managed the development and integration of the ACE spacecraft.[5]

History

ACE during assembly

The Advanced Composition Explorer (ACE) was proposed in 1986 as part of the Explorer Concept Study Program. ACE is designed to make coordinated measurements of the elemental and isotopic composition of accelerated nuclei from H (Hydrogen) to Zn (Zinc) spanning six decades in energy per nucleon, from solar wind to galactic cosmic ray energies, with sensitivity and with charge and mass resolution much better than heretofore possible. Following a Phase-A definition study, ACE was selected for development in 1989, and began construction in 1994. On 25 August 1997, ACE was successfully launched from Cape Canaveral Air Force Station by a Delta II launch vehicle. The August 1997 launch was originally scheduled back in 1993.[6]

Science objectives

Scientific instruments on ACE

ACE observations allow the investigation of a wide range of fundamental problems in the following four major areas:[7]

Elemental and isotopic composition of matter

A major objective is the accurate and comprehensive determination of the elemental and isotopic composition of the various samples of "source material" from which nuclei are accelerated. These observations have been used to:

Generate a set of solar isotopic abundances based on a direct sampling of solar material;

Determine the coronal elemental and isotopic composition with greatly improved accuracy;

Establish the pattern of isotopic differences between galactic cosmic ray and Solar System matter;

Measure the elemental and isotopic abundances of interstellar and interplanetary "pick–up ions";

Determine the isotopic composition of the "anomalous cosmic ray component", which represents a sample of the local interstellar medium.

Origin of the elements and subsequent evolutionary processing

Isotopic "anomalies" in meteorites indicate that the Solar System was not homogeneous when formed. Similarly, the Galaxy is neither uniform in space nor constant in time due to continuous stellar nucleosynthesis.

ACE measurements have been used to:

Search for differences between the isotopic composition of solar and meteoritic material;

Determine the contributions of solar wind and solar energetic particles to lunar and meteoritic material, and to planetary atmospheres and magnetospheres;

Determine the dominant nucleosynthetic processes that contribute to cosmic ray source material;

Determine whether cosmic rays are a sample of freshly synthesized material (e.g., from Supernova) or of the contemporary interstellar medium;

Search for isotopic patterns in solar and galactic material as a test of galactic evolution models.

Formation of the solar corona and acceleration of the solar wind

Solar energetic particles, solar wind, and spectroscopic observations show that the elemental composition of the solar corona is differentiated from that of the photosphere, although the processes by which this occurs, and by which the solar wind is subsequently accelerated, are poorly understood. The detailed composition and charge–state data provided by ACE are used to:

Isolate the dominant coronal formation processes by comparing a broad range of coronal and photospheric abundances;

Study plasma conditions at the source of solar wind and solar energetic particles by measuring and comparing the charge states of these two populations;

Study solar wind acceleration processes and any charge or mass-dependent fractionation in various types of solar wind flows.

Particle acceleration and transport in nature

Particle acceleration is ubiquitous in nature and understanding its nature is one of the fundamental problems of space plasma astrophysics. The unique data set obtained by ACE measurements has been used to:

Make direct measurements of charge and/or mass-dependent fractionation during solar energetic particle and interplanetary acceleration events;

Constrain solar flare, coronal shock, and interplanetary shock acceleration models with charge, mass, and spectral data spanning up to five decades in energy;

Test theoretical models for 3He–rich solar flares and solar γ–ray events.