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DESIGN & DISCOVERY
Open Days July 1990
RUTHERFORD APPLETON LABORATORY
SCIENCE AND ENGINEERING RESEARCH COUNCIL

THE CORONAL HELIUM ABUNDANCE EXPERIMENT ON SPACELAB 2

The Coronal Helium Abundance Experiment (CHASE) flew on Mission 51-F, the eighth flight of the Space Shuttle Challenger in July/August 1985. This mission, known as Spacelab 2, had a multidisciplinary payload for biology, astronomy and solar physics studies. Of the thirteen experiments, two were British. A major objective of the flight was the verification and flight test of the Instrument Pointing System (IPS), developed by the European Space Agency for NASA. The IPS was configured to be solar pointing and the four solar pointing experiments, including CHASE were mounted on it.

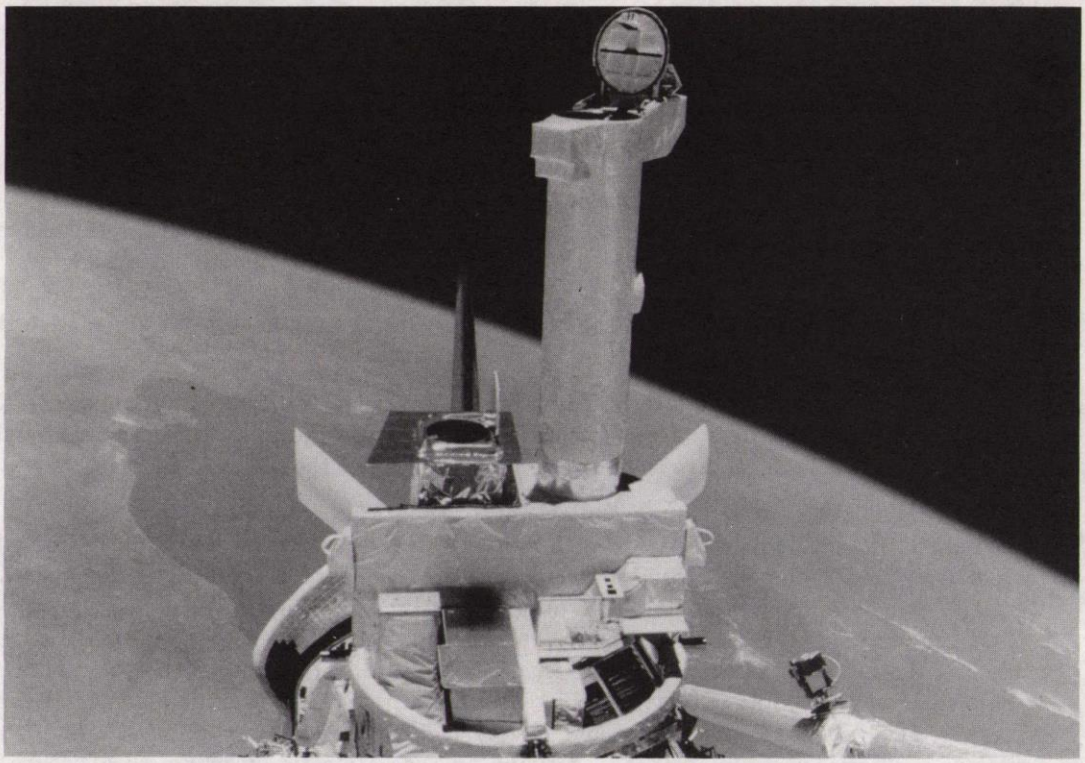
CHASE was developed jointly by Mullard Space Science Laboratory of University College London and the Rutherford Appleton Laboratory. The prime objective of CHASE was to measure the abundance of helium relative to hydrogen in the corona of the sun.

The corona is the very tenuous outer layer of the sun's atmosphere that is normally visible from earth only during total solar eclipses or with special instruments. Its lower boundary is well defined by a narrow transition zone having a steep rise in temperature of more than 1,000,000 degrees Centigrade and a correspondingly sharp drop in density. The high coronal temperature causes ionised helium, oxygen, carbon and other solar elements to radiate energy in specific wavelengths, mainly in the extreme ultraviolet (EUV) range below 120 nanometres. Ratios of the intensities of particular emission lines can yield valuable information about the composition of the solar atmosphere as well as its temperature and density. Measurements of certain helium and hydrogen emissions are particularly important in deriving an accurate ratio of helium to hydrogen in the solar corona. Because it contributes approximately 10 percent of the mass of the sun, helium plays an important role in models of the solar interior; it can be used to determine the structure of the energy generating core and the rate at which that energy is transferred to the surface. In addition, the abundance of helium is thought to have changed little since the beginning of the universe, so its measurement is significant for cosmological models. While the presence of helium in the sun is known, its abundance there has not yet been measured accurately.

Designing an instrument to measure the sun's extreme ultraviolet radiation is a difficult technical challenge. Special techniques must be used to focus the very short EUV wavelengths because they do not reflect from normal mirror surfaces and even a minute percentage of the earth's atmosphere is sufficient to absorb them. Spacelab 2 provided a research facility well above the absorbing atmosphere.

The CHASE package is a combination of a grazing incidence (shallow angle) telescope and a Rowland circle spectrometer with wavelength coverage from 15 to 135 nanometres. The 28 centimetre telescope focuses a solar image on to the entrance slit of the spectrometer. Scanning mechanisms associated with the telescope mirror and spectrometer entrance slit provide a means

of spatial scanning independently of the IPS. The spectrometer contains eleven channels for simultaneously detecting preselected emission lines of particular interest and a mechanism which rotates the spectrometer grating extends the wavelength coverage of these detectors. Another detector allows simultaneous monitoring of several wavelengths in the 15 to 22 nanometre spectral range. Two detectors measure specific hydrogen and helium lines, each directly associated with the helium to hydrogen abundance measurement. The others record emission lines of iron, carbon, oxygen and sulphur to give plasma diagnostic capability.



The picture shows the payload bay viewed from the flight deck of Challenger. The IPS and its complement of experiments are pointing at the sun.

During the flight all systems worked well and within seventeen hours mission elapsed time a solar map and several fine spectral scans were produced. Because of a software problem with the IPS tracking system, the pointing was delegated to the CHASE sun sensor and for the majority of the mission the crew routinely used this device to acquire the correct sun pointing. At every opportunity CHASE was able to gain valuable data.

The value for the abundance of helium relative to hydrogen is currently estimated to be 0.082 ± 0.012 by number. In addition to this, studies of the spectral intensities observed by CHASE have been carried out as well as investigations of limb brightening.

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