Apollo 16 Lunar Surface Magnetometer (LSM) Experiment

Instrument Overview

The Apollo 16 Lunar Surface Magnetometer (LSM) consisted of a triaxial fluxgate magnetometer and was part of a three-station network (Apollo 12,15,16) designed to measure the magnitude and temporal variations of the lunar surface magnetic field to yield information on the internal electromagnetic characteristics of the Moon, including the lunar gross electrical diffusivity and the existence of a molten core. It was also intended to help elucidate the interaction between the solar plasma and the lunar surface, the behavior of the Earth's magnetic tail, and the nature of local magnetic anomalies.

Instrument Description

The instrument consisted of three fluxgate magnetometers (designated x-axis, y-axis, and z-axis sensors) mounted on orthogonal 100-cm booms, protruding from the top of a base box with support legs. The booms extend from the box at an angle of 35 degrees with the horizontal, with the sensors about 70-75 cm above the lunar surface and approximately 150 cm from each other. The sensors were mounted on gimbals allowing their measurement axes to be flipped for purposes of calibration and site survey. The magnetometers were capable of measuring magnetic fields in the three ranges of plus to minus 50, 100, or 200 gammas as selected by ground command, with a resolution of 0.1 gamma. Frequency response was from 0 (direct current) to 3 Hz. Sensor orientation was initially determined by the astronauts' using a bubble level and a shadowgraph, and has been subsequently monitored (with an accuracy of 0.2 degrees) by gravity-level sensors. The package was set up with the z-axis sensor pointing east and the x-axis sensor pointing towards the northwest.

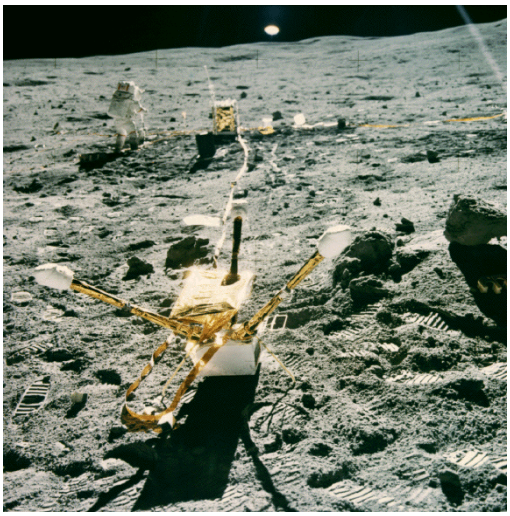

Figure 1: Lunar Surface Magnetometer

Each sensor consisted of a flattened toroidal magnetic permalloy core drive to saturation by a sinusoidal current of 6000 Hz passing through a drive winding wrapped around the core. Also wrapped around the core were sense windings and feedback windings. The sense windings measure the superposition of the drive winding magnetic field and the total local lunar surface field, a second harmonic of the driving frequency is generated in the sense winding with a magnitude proportional to the strength of the surface field. The phase of the second harmonic signal with respect to the drive signal indicates the direction of the surface field with respect to the sensor axis.

The output signal was amplified and synchronously demodulated to drive a voltage to an analog-to-digital converter and then transmitted to Earth. Magnetometer electronics were self-contained, in the base box below the booms. Thermal control was achieved by multi-layer insulation blankets, control surfaces, parabolic reflectors, radiators, and heaters. Some improvements to thermal control were made for Apollo 15 and 16 before launch after thermal problems were recognized on Apollo 12. The package had a mass of 8.9 kg and used 3.5 W average power in the daytime and 9.4 W at night. The average data rate was 116 bits/second.

Instrument Operation

The LSM was deployed at 8.98 degrees South, 15.50 degrees East on 21 April 1972 and turned on at 20:22 UT. On 24 July 1972 all three axes failed to flip, presumably due to elevated noon temperatures. There was intermittent loss of science data starting on 15 February 1973, but on 17 August 1973 the instrument returned to fully operational condition. On 3 March 1975 the z-axis sensor data became intermittently static with off-scale low temperatures during lunar night. Flip calibrations of all sensor heads were discontinued at night due to the low temperatures. The Apollo 16 LSM was turned off as part of the shutdown of all the ALSEP stations on 30 September 1977.

Explorer 35

Concurrent with the LSM operation, the ambient steady-state and time-dependent magnetic fields in the lunar environment were monitored from lunar orbit by the Explorer 35 magnetometers. The spacecraft had an orbital period of 11.5 hrs., with an apolune of 9390 km and a perilune of 2570 km. More information on these instruments can be found at NASA Space Science Data Coordinated Archive (NSSDCA):

https://nssdc.gsfc.nasa.gov/nmc/experiment/display.action?id=1967-070A-03
https://nssdc.gsfc.nasa.gov/nmc/experiment/display.action?id=1967-070A-04

References

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