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Foreword

Acceleration Reconnection Turbulence and Electrodynamics of Moon's Interaction with the Sun (ARTEMIS) mission

C.T. Russell · V. Angelopoulos

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The Moon's space environment, tenuous neutral exosphere, wake, surface and interior have been studied with single spacecraft missions since the beginning of the space age: The Apollo missions extended not only the human experience to the lunar surface but also carried our extended eyes and ears to the lunar surface and into lunar orbit to study for the first time how the solar wind interacts with airless bodies and, using magnetic induction, to probe the interior core properties. Since then, the US Clementine, Lunar Prospector and Lunar Reconnaissance Orbiter missions, ESA's SMART-1, the Japanese Kaguya, the Indian Chandrayaan and the Chinese Chang'e I and II missions have revealed with greater detail properties of lunar crustal magnetism and surface composition, while analysis of Apollo samples have rewritten textbooks regarding the formation of the Earth-Moon system and Solar System evolution. It has become apparent recently that to make further progress in understanding the complex interaction of the Moon's surface with its space environment, as well as to better probe the Moon's interior with natural electromagnetic signals from above, single point measurements are inadequate. The solar wind buffeting the surface never stays constant: it varies on the time-scales that correspond to deep electromagnetic sounding and on spatial scales comparable to several lunar radii, rendering distant spacecraft (e.g., ones at the Earth-Sun Lagrange point) ineffective monitors of the local drivers.

At a distance of 55–65 Earth radii, the Moon spends most of its time upstream of Earth's bow shock, and is thus exposed to either the pristine solar wind or to showers of particles emitted by the solar wind-magnetosphere interaction. Once per lunar month the Moon traverses Earth's magnetotail at a woefully undersampled region where magnetic reconnection, plasma turbulence and particle acceleration are commonplace and have far-reaching consequences for magnetospheric plasma circulation. Lunar orbits, therefore, are ideal platforms for observation and study of the pristine solar wind that impacts Earth, distant effects at shocks, and the dominant method of energy release in the magnetosphere, namely distant magnetotail reconnection. Typical studies of these phenomena have, again, been con-

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ducted only with single spacecraft missions. Thus, spatial extent, spatio-temporal ambiguities, three-dimensional effects and dynamical evolution could only be loosely inferred in the past but not duly explored.

Recognizing the scientific return from a two-point investigation from the Moon and of the Moon, the NASA/THEMIS team embarked upon a bold initiative to use the excess fuel capacity of two of the five spacecraft in the THEMIS constellation orbiting Earth and send them via low-thrust trajectories in orbit about the Moon. From those stable, yet scientifically optimal orbits, the two spacecraft would conduct unprecedented observations of the solar wind driver and its interaction with the lunar exosphere, crustal magnetism, lunar surface (wake), and lunar interior, as well as perform two-point observations of the solar wind, its interaction with the magnetosphere, and magnetotail reconnection and their effects (plasmoids, particle acceleration and turbulence) in the distant magnetotail. Hence the ARTEMIS mission was born out of THEMIS.

ARTEMIS has been a mission of several “firsts”. It is the first mission to employ two identical coordinated spacecraft at the Moon, the first mission to conduct prolonged (9 month) observations and station-keeping at an Earth-Moon Lagrange point, the first to provide DC electric field measurements at the lunar space environment, and the first to provide comprehensive in-situ measurements in the lunar space environment from a high altitude lunar orbit.

In the compendium of papers in this volume V. Angelopoulos describes the ARTEMIS mission, and T. Sweetser and colleagues present its circuitous, mission-enabling, low thrust trajectory design. Its broad scientific objectives spanning heliophysics and planetary goals are described by D. Sibeck and colleagues, and the first results from the mission, obtained during a lunar flyby enroute to a translunar orbit injection by the ARTEMIS P1 spacecraft are presented by J. Halekas and colleagues. The latter provides an exposition of the scientific potential from the instrumentation aboard that has been operating nominally five years after launch of the ARTEMIS hardware into space. The spacecraft and instrumentation, including salient features of calibration and generic data interpretation, have been described in the THEMIS Space Science Reviews volume (Angelopoulos 2008).

We hope that the present volume will be useful to researchers in both heliophysics and planetary physics for understanding published scientific results from the mission and in order to aid their own analysis and data interpretation efforts from these publicly available datasets.

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