

## 「太陽活動期における月面帯電シミュレーション」

九州工業大学 工学部 宇宙システム工学科 機械宇宙システム工学コース

221A5021 尾崎雅仁

指導教員 Necmi Cihan Orger

月面基地の建設や長期滞在の実現に向けては、月面の帯電環境を正確に把握し、安全性を確保することが不可欠である。ミッションが行われる昼側で生じる正の帯電は、精密機器の誤作動や月塵の付着を引き起こし、探査活動の障害となる。現在は第 25 期太陽活動期にあり、突発的な太陽イベントの観測データが高時間分解能で得られる状況にある。

本研究の目的は、太陽活動期における通常の太陽風から、太陽フレアやコロナ質量放出といった突発的なイベントに至るまで、幅広い太陽環境が昼側の月面の帯電に与える影響を定量的に明らかにすることである。この際、多くの先行研究で過小評価されてきた光電子電流値について、太陽光の 1 平方メートル当たりのエネルギーを表した太陽放射フラックスをモデル化した FISM (Flare Irradiance Spectral Model) モデルを用いて計算を行った先行研究の結果や FISM モデルの最新版である FISM2 を用いた計算結果を用いることで帯電状況をシミュレーションした。

### **Simulation of Lunar Dayside Charging during Solar Maximum**

Kyushu Institute of Technology, Department of Space Systems Engineering

School of Engineering, Mechanical and Space Systems Engineering Course

221A5021 Masahito Ozaki

Supervisor: Assistant Professor Necmi Cihan Orger

To realize the construction of lunar bases and long-term stays, it is essential to accurately understand the charging environment of the lunar surface and ensure safety. Positive charging occurring on the dayside, where missions take place, causes malfunctions of precision instruments and the adhesion of lunar dust, which hinders exploration activities.

The purpose of this study is to quantitatively clarify the impact of a wide range of solar environments—from normal solar wind during active solar periods to sudden events such as solar flares and Coronal Mass Ejections (CME)—on the charging of the lunar dayside. In doing so, this study simulates charging conditions using the results of previous studies that calculated photoelectron current values—which have been assumed and undervalued in many previous studies—using the Flare Irradiance Spectral Model (FISM), and the results calculated using FISM2, the latest version of the FISM model.

## TABLE OF CONTENTS

TABLE OF CONTENTS .....	v
ABBREVIATIONS .....	vii
LIST OF SYMBOLS.....	ix
LIST OF TABLES .....	xi
LIST OF FIGURES .....	xiii
SUMMARY.....	xv
要約 .....	xvii
1.Introduction.....	1
1.1. Research Background .....	1
1.1.1. Overview .....	1
1.1.2. Solar Activity .....	2
1.2. Previous Study.....	3
1.2.1. Lunar Surface Charging Variability using the Current Balance Method [1] .....	3
1.2.2. Photoelectron Current Density Calculations using FISM2 and Experimental Photoelectric Yield Data [2] .....	4
1.3. Research Objectives .....	5
2. Lunar Dayside Charging Simulations.....	7
2.1. Lunar Surface Charging Principle.....	7
2.2. Current Balance Method [1] .....	8
2.3. Lunar Surface Charging Model .....	10
2.4. Solar Wind Cases Simulation.....	12
2.4.1. Solar Wind Cases Simulation Parameter .....	12
2.4.2. Solar Wind Cases Simulation Method.....	13
2.4.3. Solar Wind Cases Simulation Result .....	13
2.5. Time Synchronization of OMNI and WIND Data.....	15
2.5.1. Time Synchronization Principle.....	15
2.5.2. Time Synchronization Method.....	17
2.5.3. Time Synchronization Result .....	19
2.6. Case Study of Lunar Surface Charging without Solar Flare Impacts.....	20
2.6.1. Selection of Representative Days and Simulation Parameters .....	20
2.6.2. Simulation of a Quiet Day (August 1, 2025).....	24
2.6.3. Simulation of an Active Day (May 11, 2024) .....	27
2.7. Saturation Photoelectron Current Density $Jp0$ Calculations.....	30

2.7.1. Saturation Photoelectron Current Density $J_{p0}$ Principle .....	30
2.7.2. Saturation Photoelectron Current Density $J_{p0}$ Method .....	30
2.7.3. Saturation Photoelectron Current Density $J_{p0}$ Result.....	32
2.8. Case Study for 1 CME with Saturation Photoelectron Current Density $J_{p0}$ .....	34
2.8.1. CME Case Simulation Parameter .....	34
2.8.2. CME Case Simulation Method.....	34
2.8.3. CME Case Simulation Results.....	36
3. Discussions .....	39
4. Conclusions .....	41
5. Future Study .....	43
6. Acknowledgements .....	45
7. References .....	47