DUst and plaSma environmenT survEyeR (DUSTER) in the Lunar South Polar Region. X. Wang[1], M. Horanyi[1], D. Malaspina[1], L. Andersson[1], J. Deca[1], H.-W. Hsu[1], P. Chamberlin[1], P. Metzger[2], L. Liuzzo[3], C. Fisher[1], A.J. Gemer[4], and DUSTER Team[1], [1]Laboratory for Atmospheric and Space Physics, University of Colorado Boulder (xu.wang@colorado.edu), [2]University of Central Florida, [3]UC Berkeley, and [4]Lunar Outpost Inc.

DUSTER Mission Goals: Under the Artemis program, NASA is going back to and build long-term presence on the Moon. To safeguard the crew safty and exploration, we need to have a good understanding of the environment on the lunar surface in order to mitigate any potential hazards. The dust and plasma environment is cruicial to human activities and the operations of equipment and instruments, including in-situ resource utilization (ISRU).

The DUst and plaSma environmenT survEyoR (DUSTER) instrument suite was recently selected as part of NASA's Artemis IV mission to characterize the dust and plasma environment over an extended area around the landing site in the lunar south polar region. The DUSTER investigation will, for the first time, achieve a comprehensive understanding of the near-surface plasma, electrostatically lofted dust, micrometeoroid impacts, and dust ejecta generated due to lander liftoff. The DUSTER investigation will provide crucial results to help evaluate dust and electrostatic discharge hazards to gauge the safety and ensure the success of crewed Artemis missions and the sustained human presence on the lunar surface.

DUSTER Science Questions: DUSTER will quantitatively answer the following science questions: SQ1 - What is the surface electron density and its spatial and temporal variability in the lunar south polar region? SQ2 -What are the size, charge, velocity distributions, and flux of electrostatically lofted dust and its spatial and temporal variability in the lunar south polar region? SQ3 - What is the flux of micrometeoroid impacts in the lunar south polar region? and SQ4 - What is the flux of dust ejecta generated during lander liftoff? The DUSTER investigation addresses multiple Moon-to-Mars science objectives: LPS-2, HS-1, HS-3, HBS-3, and PPS-2, as well as LI-9 and AS-1. Additionally, the DUSTER investigation directly addresses goals 7k, 7l, 7m, 5b-1, and 6g prioritized in the Artemis III Science Definition Team report.

DUSTER Instruments and ConOps: DUSTER will carry the Electrostatic Dust Analyzer (EDA [1]) and RElaxation SOunder and differentiaL VoltagE (RESOLVE [2]) instruments accommodated on the Mobile Autonomous Prospecting Platform (MAPP) rover (Fig. 1, left). DUSTER will be deployed on the lunar surface by a single crew member (Fig. 1, right), then operates autonomously for the rest of the mission. Both baseline and extended investigations will be performed for maximized science return. The baseline investigation has a duration of ~6.5 Earth days. DUSTER will traverse over an extended area to characterize the variability of the dust and plasma environment to answer SQ1-SQ3. If an orbiting relay satellite is available during the mission, DUSTER will traverse further from the landing site to perform the extended investigation with the total duration up to ~14 days. DUSTER will characterize dust ejecta generated during lander liftoff to answer SQ4.

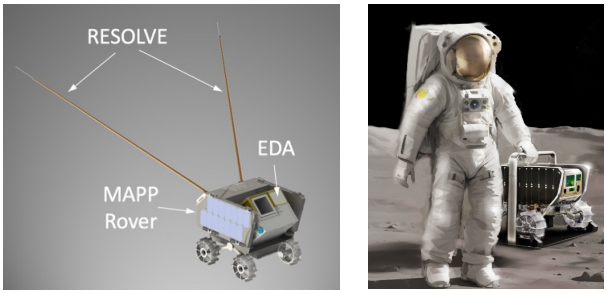

Fig. 1 Left: DUSTER instruments (EDA and RESOLVE) accommodated on the MAPP rover; Right: Artist rendering showing an astronaut carring DUSTER for deployment on the lunar surface.

EDA measures electrostatically lofted dust, including its charge, size, velocity, and flux [1]. RESOLVE consists of two antennas to characterize the electron density above the lunar surface via plasma sounding [2]. Combined with solar UV irradiance and upstream plasma data available from operating orbital missions as well as numerical modeling, full plasma and electric field profiles along the rover's path will be revealed. Additionally, RESOLVE measures the flux of micrometeoroid impacts or high-speed dust ejecta generated during lander liftoff via impact-generated plasma plume on the DUSTER payload or nearby lunar regolith. These in-situ measurements, combined with the state-of-the-art modeling, will achieve a self-consistent understanding of the dust and plasma environment in the lunar south polar region, and critically evaluate their interplay with human presence.

Summary: DUSTER will provide in-situ measurements of the dust and plasma environment in the lunar south polar region over different local times and locations. These information will provide important guidance for mitigation strategies and solutions to ensure long-term exploration and operations, including ISRU, on the lunar surface.

References: [1] Wang et al (2024), PSJ, 5, 41. [2] Malaspina et al (2023), AGU Fall Meeting Abstract.