ISSI International Research Team on

Plasma - Surface Interactions with Airless Bodies in Space and the Laboratory

Final Report

Team members:

J. Deca (PI), X. Wang (Co-PI), R. Bamford, G. L. Delzanno, Y. Futaana, N. Gilet (Young Scientist), J. Halekas, P. Henri, M. Horányi , R. Jarvinen, C. Lue (Young Scientist), M. Nishino, A. Poppe, S. Ratynskaia, E. Roussos, and L. Vignitchouk (Young Scientist).

Team meetings:

1. February 1-5, 2016 at ISSI, Bern - 12 team members attended.
2. June 19-23, 2017 at ISSI, Bern - 8 team members attended.

In addition to the two official meetings held in Bern, smaller team meetings were organized at the AGU, EGU, and AOGS conferences in 2016 - 2018.

Scientific highlights:

The scientific accomplishments of our team have thus far cumulated into 15 peer-reviewed publications (listed below) and numerous presentations at local and international conferences. In addition, several new collaborations that sprouted from the two workshops have won grants that support instrument development (NASA-DALI), data analysis (NASA-LDAP/RDAP), and numerical efforts (PRACE).

- *Lunar science.* Combining the modeling and observational expertise within the team, the correlation between the Reiner Gamma swirl and the co-located magnetic anomaly has been explained and characterized through the solar wind standoff mechanism. Part of the work has been published in **Nature** Communications Physics.
- *Lunar science.* Using ARTEMIS observations and empirical models, proton scattering processes on the lunar surface have been investigated. The team defined relationships in function of the impact and exit speeds. In addition, lessons learned **from the Moon** have been extrapolated **to the Hermean environment.**
- *Dust charging.* Combining experimental and theoretical/modeling efforts, we have characterized the mechanisms for dust hopping/transport on regolith surfaces: **the patched charge model**.
- *Cometary science.* Within our team we have produced the very first fully kinetic simulations of the solar wind interaction with a weakly outgassing comet (67P/Churyumov-Gerasimenko), self-consistently identifying the origins of the different electron populations observed by Rosetta. The work has thus far resulted in **2 publications in Physical Review letters.**
- *Cometary science.* The expertise within our team has been a significant contribution to help analyze the results produced by the Mutual Impedance Probe (MIP) on board the Rosetta spacecraft.

Publications:

1. Deca J. and A. Divin, Reflected Charged Particle Populations around Dipolar Lunar Magnetic Anomalies, *The Astrophysical Journal*, **829**, 60 (2016).
2. Deca J., A. Divin, X. Wang, et al., Three-dimensional Full-kinetic Simulation of the Solar Wind Interaction with a Vertical Dipolar Lunar Magnetic Anomaly, *Geophysical Research Letters*, **43**, 4136 (2016).
3. Wang X., J. Schwan, H.-W. Hsu, et al., Dust Charging and Transport on Airless Planetary Bodies, *Geophysical Research Letters*, **43**, 6103 (2016).
4. Beadles R., X. Wang, and M. Horányi, Floating Potential Measurements in Plasmas: From Dust to Spacecraft, *Physics of Plasmas*, **24**, 023701 (2017).
5. Deca J., A. Divin, P. Henri, et al., Electron and Ion Dynamics of the Solar Wind Interaction with a Weakly Outgassing Comet, *Physical Review Letters*, **118**, 205101 (2017).
6. Gilet N., P. Henri, G. Wattieaux, et al., Electrostatic Potential Radiated by a Pulsating Charge in a Two-Electron Temperature Plasma, *Radio Science*, **52**, 1432 (2017).
7. Lue C., Y. Futaana, S. Barabash, et al., Solar Wind Scattering from the Surface of Mercury: Lessons from the Moon, *Icarus*, **296**, 39 (2017).
8. Schwan J., X. Wang, H.-W. Hsu, et al., The Charge State of Electrostatically Transported Dust on Regolith Surfaces, *Geophysical Research Letters*, **44**, 3059 (2017).
9. Behar E., B. Tabone, M. Saillenfest, et al., Solar Wind Dynamics around a Comet. A 2D Semi-analytical Model, *Astronomy & Astrophysics*, **620**, A35 (2018).
10. Deca J., A. Divin, C. Lue, et al., Reiner Gamma Albedo Features Reproduced by Modeling Solar Wind Standoff, *Nature Communications Physics*, **1**, 12 (2018).
11. Lue C., J Halekas, A. R. Poppe, et al., ARTEMIS Observations of Solar Wind Proton Scattering off the Lunar Surface, *Journal of Geophysical Research: Space Physics*, **123**, 5289 (2018).
12. Myllys M., P. Henri, M. Galand, et al., Plasma Properties of Suprathermal Electrons near Comet 67P/Churyumov-Gerasimenko with Rosetta, *Astronomy & Astrophysics*, **630**, A42 (2019).
13. Deca J., The Plasma Environment of the Moon, Book chapter in the *Encyclopedia of Lunar Science*, edited by B. Cudnik, Springer, in production.
14. Deca J., D. J. Hemingway, A. Divin, et al., Simulating the Reiner Gamma Swirl: the Long-term Effect of Solar Wind Standoff, *Journal of Geophysical Research: Planets*, submitted.
15. Horányi M., J. Deca, O. Havnes, et al. Charging effects on Rosetta Dust Measurements, *Monthly Notices of the Royal Astronomical Society*, submitted.