



## **Flying a spacecraft through a Lunar Magnetic Anomaly: Measurement Requirements as Defined by Fully Kinetic Modelling**

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The Reiner Gamma swirl formation, co-located with one of our Moon's strongest crustal magnetic anomalies, is one of the most prominent lunar surface features. Due to Reiner Gamma's fairly moderate spatial scales, it presents not only an ideal test case to study the solar wind interaction with its magnetic topology from an ion-electron kinetic perspective, but also a relatively simple albeit realistic scenario to define measurements requirements for plasma instruments onboard a spacecraft flying through the region.

Using the fully kinetic particle-in-cell code, iPIC3D, we model the solar wind interaction with Reiner Gamma for two different scenarios: (1) an idealised one-dipole approximation of the strongest component of Reiner Gamma's magnetic topology, and (2) a realistic setup, in which we couple our code with a surface vector mapping magnetic field model based on Kaguya and Lunar Prospector observations.

We constrain both the reflected and incident flux patterns to the lunar surface. These are in good agreement with, e.g., Chandrayaan and Artemis results. A virtual probe moving through the simulated anomaly observes in high resolution various physical quantities, such as density, the electromagnetic fields, and the differential energy distributions at altitudes representative for a typical spacecraft orbit, we find that high-cadence low-orbit observations are required to capture the fine-scale structures of the interaction. In addition, the solar wind speed and direction are the determining factors that shape the surface weathering pattern and the structure of the fields and particle distributions. Comparing with a pure electron/proton solar wind plasma, adding 5% He<sup>2+</sup> particles to the simulation has a negligible effect on the overall structure of the electromagnetic fields.

In conclusion, this study will help analyse plasma measurements of the near-surface lunar plasma environment, and might help to develop/constrain the requirements for future (lunar) plasma instruments.