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Numerical and laboratory studies of magnetic enhancements produced by solar wind interaction with Lunar crustal magnetic fields

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In this study, we use a combination of 3D Particle-in-Cell (PIC) simulations and a laboratory experiment to investigate the dynamics of solar wind - Moon interaction. It is known that the Moon has no global magnetic field, but there exist areas of intense remanent magnetization of the lunar crust which are strongly non-dipolar. Performed simulations indicate that the localized crustal fields are capable of scattering solar wind ions, efficiently heat electrons, and produce magnetic field perturbations in the upstream plasma. Numerical study of reflected ion flux compares well to the laboratory experiment performed at induction discharge theta-pinch "KI-1" facility (Novosibirsk). The plasma flow interacts with a magnetic field source (dipolar or quadrupolar), producing a minimagnetosphere with typical scales comparable to (or less than) a few ion inertial lengths. Our numerical and laboratory study concludes that the magnetic field should drop faster than r^{-3} with the distance in order to reproduce the spacecraft observations. In this case, gyroradii of the reflected ions are considerably larger than the scale of the minimagnetosphere density cavity. Reflected ions generate enhancements in the upstream magnetic field, supposedly seen as LEMEs (lunar external magnetic enhancements) in spacecraft data above the Moon crustal fields.