Space plasma physics from Moon orbit: opportunities provided by the Lunar Gateway

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The Moon is a unique location to study the deep space plasma environment. During most part of its orbit around the Earth it is directly exposed to the solar wind. Due to the absence of a substantial intrinsic magnetic field and of a collisional atmosphere, solar wind and solar energetic particles (SEPs) arrive almost without any deviation or absorption and impact directly on its surface, interacting with the lunar regolith and the tenuous lunar exosphere. Energetic particles arriving at the Moon's surface can be absorbed, or scattered, or can remove another atom from the lunar regolith by sputtering or desorption. The same phenomenon occurs also with the galactic cosmic rays (GCRs), which present fluxes and energy spectra typical of interplanetary space. During 5 - 6 days every orbit, however, the Moon crosses the tail of the terrestrial magnetosphere. It then offers the possibility to study in-situ the terrestrial magnetotail plasma environment as well as atmospheric escape from the terrestrial ionosphere, in the form of heavy ions accelerated and streaming downtail. The lunar environment offers thus a unique opportunity to study the interaction of the solar wind, the cosmic rays and the terrestrial magnetosphere with the surface and the surface-bounded exosphere of an unmagnetized planetary body, constituting a complex multi-scale interacting system. The Lunar Gateway is an orbital crewed platform that will be assembled and operated in the vicinity of the Moon by NASA and international partner organizations, including ESA, starting from the mid-2020s. It will offer new opportunities for fundamental and applied scientific research. In this presentation we we examine the opportunities provided by externally mounted payloads on the Gateway in the field of space plasma physics, heliophysics and space weather, and also the impact of the deep space environment on an inhabited platform in the vicinity of the Moon. We will then present the conceptual design of a model payload we undertook for ESA, required to perform these space plasma measurements and observations. It results that the Gateway is very well-suited for space plasma physics research. It allows a series of scientific objectives with a multi-disciplinary dimension to be addressed.