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Giant magnetospheres - small moons: Who's in the driver's seat?

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In Galileo's day, the most interesting aspect of the Medicean moons was that they moved in quasi-circular orbits around Jupiter. Four hundred years later, we are far more interested in the evidence that these moons, and their cousins orbiting Saturn, are not inert objects moving in endless circles. They are scarred on their surfaces by magnetospheric particle fluxes and their interiors respond to the changing magnetic fields imposed upon them. Of particular interest are the ways in which these small bodies modify their environments, imposing distinctive features upon the magnetospheres that envelope them. Moons serve as plasma sources through localized jets of neutral gas, known to be present at Io and Enceladus and possibly yet to be discovered at other moons. Magnetospheric particle fluxes are both enhanced and reduced by interactions with moons, which may serve as sources (sputtering) or sinks (micro- and macro signatures of absorption). To a considerable degree, it is their moons that make the magnetospheres of Jupiter and Saturn truly unique. Without Io, Jupiter's magnetosphere would take the form of a bloated terrestrial magnetosphere. It is the plasma source linked to Io that exerts stresses on the confining magnetic field, distorting and enlarging Jupiter's magnetosphere so that it does not resemble a scaled-up version of Earth's. The plumes of Enceladus fill Saturn's magnetospheric cavity with neutrals that cause the properties of plasma near Saturn to differ markedly from properties of plasma near Earth. Other moons are less important as plasma sources but they, too, modify the distribution of magnetospheric plasma. Many anticipated that Titan, enveloped in a dense atmosphere rich in nitrogen, would serve a major plasma source for Saturn, but no Titan torus is observed; the plasma is probably swept away by magnetosheath or boundary layer flows because Titan's orbit lies either just within or even outside of the magnetopause on the day side. Although this talk will emphasize some idiosyncratic aspects of the moon-magnetosphere systems at Jupiter and Saturn and emphasize the powerful influences of a few small bodies embedded within immense spatial domains, we should not overlook the many ways in which our understanding of the terrestrial magnetosphere is validated by applying familiar insights to interpretation of the behavior of fields and particles in a significantly different range of parameter space.