Plasma loss mechanisms from Saturn's magnetosphere

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Saturn. Photo: NASA

Since the first up-close observations of Saturn, made by the Pioneer 11 probe in 1979, a great deal has been learned about the dynamics of the gas giant's magnetosphere. In-depth observations made by the Cassini orbiter, which has been circling Saturn since 2004, have revealed fundamental differences between the behavior of Saturn's magnetosphere and that of the Earth's magnetosphere.

Earth's magnetospheric plasma is largely populated by ions captured from the solar wind, whereas Saturn's plasma comes predominantly from water vapor that spews from massive geysers on the southern end of its icy moon Enceladus. Ionized water vapor from Enceladus streams out at 12 to 250 kilograms (27 to 551 pounds) per second, yet observations show that the concentration of plasma in Saturn's magnetosphere is at a relatively steady level. This discrepancy has left researchers searching

for potential plasma loss mechanisms. In a review, Thomsen highlights the progress made in recent years in understanding this question.

According to the author, the main force driving plasma from Saturn's magnetosphere derives from the planet's fast rotation, which takes just 10.7 hours and produces currents in the magnetosphere that drive the plasma outward. These currents do not produce a uniform outflow—observations have shown interlocking fingers of cold inner magnetospheric plasma flowing outward and hot outer magnetospheric plasma flowing inward to take its place. Once it reaches the outer magnetosphere, the author says, the plasma can be lost to the solar wind, either crossing through the magnetopause or being swept down the magnetotail.

Observations made using the Cassini orbiter have shown mass loss through magnetic reconnection in the magnetotail, but current estimates suggest that this mechanism is inadequate to remove all of the plasma emerging from the inner magnetosphere.

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