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The Return of Magnetic Flux to the Inner Saturnian Magnetosphere

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The addition of plasma to the rotating inner Saturnian magnetosphere drives the circulation of the magnetic flux. The magnetic flux is loaded with cold plasma originating from Enceladus and its plasma torus. It then convects outward to the tail region, is emptied of plasma during reconnection events, and returns buoyantly to the inner magnetosphere. Returning flux tubes carry hot and tenuous plasma that serves as a marker of this type of flux tube. The plasma inside the tubes drifts at different rates depending on energy in the curved and inhomogeneous magnetosphere when the tubes convect inward. This energy dispersion can be used to track the flux tube. With data from MAG and CAPS, we model the energy dispersion of the electrons to determine the age and the point of return of the 'empty' flux tubes. The results show that even the 'fresh' flux tubes are several hours old when seen and they start to return at $\sim$19 Saturn radii, near Titan's orbit. This supports the hypothesis that returning flux tubes generated by reconnection in the far-tail region are injected directly into the inner magnetosphere.