The mass of Saturn's plasma sheet

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Observations by Pioneer 11 and the two Voyager spacecraft indicated the presence of an essentially quasi-dipolar magnetosphere with a well-defined ring current extended between 8 and $16R_S$ in Saturn's equatorial plane. McNutt (1983) showed that the dynamical driver of this current system was the centrifugal force caused by (sub)-corotating cold ions. Using Cassini Magnetometer data we show that outside of approximately $15R_S$ the magnetic field stretches radially outward forming a thin current sheet. Near noon the solar wind stress helps to oppose additional stretching of the magnetic field and maintains a quasi-dipolar configuration, but at dawn the field lines stretch out. Thus the observations describe a magnetodisc tailward of approximately $9\ SLT$.

Using magnetometer data, and electron densities from the CAPS/ELS instrument we investigate the stress balance in this current sheet. Extending an earlier study based on only three orbits of Cassini [*Arridge et al. 2005, Eos Trans. AGU 86(52)*], we use transient encounters with this magnetodisc current sheet to calculate the Maxwell stresses and hence to evaluate the MHD stress balance. The $\mathbf{j} \times \mathbf{B}$ force and an estimation of the plasma pressure gradient force are balanced with the centrifugal force and the required mass density is determined. We find a reasonable agreement between the required ion number density and the electron number density, thus showing that our approximations are reasonable and the mass density profile is accurate. We find that the centrifugal force is the dominant source of mechanical stress in the region $15 - 40R_S$. For many different orbits of Cassini we present the determined mass density profile and show that this is remarkably stable.