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Seven Years (2004-2011) of Cassini Measurements Reveal Strong Local Time Asymmetry of the Saturnian Ring Current

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The Saturnian ring current, initially inferred from magnetic field and particle measurements after the Voyager 1 and 2 flybys, has been studied in substantial detail via in-situ and remote measurements since the July 2004 Cassini orbit insertion. The ring current of Saturn, located between 7 and 15 R_S and primarily composed of O+ ions, is characterized by increased suprathermal ($>$ 3 keV) particle pressure with high ($>$ 1) plasma β values and intense dynamic behavior, as revealed by the analysis of combined particle data from the Cassini Magnetospheric Imaging Instrument (MIMI) and the Cassini Plasma Spectrometer instrument (CAPS), and magnetic field measurements from the Cassini magnetometer (MAG). Among the most important findings so far is that the azimuthal ring current flows primarily to balance inertial centrifugal forces inside $\sim$8 R_S, but increasingly it is driven by the non-thermal pressure gradient beyond its maximum region (8-12 R_S, 100–150 pA/m^2) and certainly it dominates farther out. Beyond $\sim$ 10R_S, the non-thermal pressure decreases with radial distance faster than the previously assumed 1/r rate and results in a magnetic perturbation of 10-15 nT. In this work we present the most complete (2004-2011) and up-to-date results, focusing on the local time asymmetry of the ring current properties (e.g. particle pressure, current density), and the relative contribution of different components to the radial force balance. The comprehensive spatial and local time coverage provided by the Cassini orbits has revealed that the suprathermal pressure and its corresponding pressure gradient is higher by a factor of 3 to 8 on the night side, in agreement with the observed distribution of energetic particle injections and energetic neutral atom (ENA) emissions. In addition to in-situ measurements, ENA images from the Ion and Neutral Camera (INCA) of Cassini, offer a unique overview of large parts of the Saturnian magnetosphere, depicting the rotation and dynamics of the ring current.