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Diamagnetic depressions in the inner magnetosphere of Saturn: Evidence for strong magnetosphere-ionosphere coupling

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A most unexpected feature was observed in the initial Cassini magnetometer data inside the orbit of Dione: isolated depressed fields with very sharp boundaries. These depressions signal regions where there must be an additional component of hot plasma, with energy densities up to hundreds of eV per cc. It is tempting to associate this phenomenon with the interchange instability because Saturn has a rapidly rotating magnetosphere. A plasma density gradient is observed at the inner edge of the plasma sheet but this phenomenon is unlikely to be associated with that gradient because it is observed far from it and because the denser plasma sheet should be stable to interchange with the magnetospheric plasma if both are corotating. A second candidate region of instability is the outer edge of the cold E ring torus. This region may mark the point where the ionosphere can no longer maintain corotation of plasma produced by the E ring as it moves outward to its eventual deposition in the tail. Nevertheless, these isolated "tubes" of depressed field occur significantly inside of that boundary as well. Thus we are left without an obvious source for these diamagnetic depressions. In this paper we examine the statistical properties of these tubes, including evidence for their evolution with time and their geometrical configuration.