EPSC Abstracts
Vol. 8, EPSC2013-11, 2013
European Planetary Science Congress 2013

Planetary period magnetic field oscillations in Saturn’s magnetosphere: Post-equinox abrupt non-monotonic transitions to northern system dominance

G. Provan (1), S. W. H. Cowley (1), J. Sandhu (1), D. J. Andrews (2) and M. K. Dougherty (3)

(1) Department of Physics and Astronomy, University of Leicester, Leicester, UK, (gp3@ion.le.ac.uk), (2) Swedish Institute of Space Physics, Uppsala, Sweden (3) Blackett Laboratory, Imperial College, London, UK.

Abstract

We examine the ‘planetary period’ magnetic field oscillations observed in the ‘core’ region of Saturn’s magnetosphere (dipole L<12), on 56 near-equatorial Cassini periapsis passes that took place between vernal equinox in August 2009 and November 2012. Previous studies have shown that these consist of the sum of two oscillations related to the northern and southern polar regions having differing amplitudes and periods, that had reached near-equal amplitudes and near-converged periods ~10.68 h in the interval to ~1 year after equinox. The present analysis shows that an interval of strongly differing behavior then began ~1.5 years after equinox, in which abrupt changes in properties took place at ~6 to ~8 month intervals, with three clear transitions occurring in February 2011, August 2011, and April 2012, respectively. These are characterized by large simultaneous changes in the amplitudes of the two systems, together with small changes in period about otherwise near-constant values of ~10.63 h for the northern system and ~10.69 h for the southern (thus not reversed post-equinox), and on occasion jumps in phase. The first transition produced a resumption of strong southern system dominance unexpected under northern spring conditions, while the second introduced comparably strong northern system dominance for the first time in these data. The third resulted in suppression of all core oscillations followed by re-emergence of both systems on a time scale of ~85 days, with the northern system remaining dominant but not as strongly as before. This behavior poses interesting questions for presently-proposed theoretical scenarios.

Figures

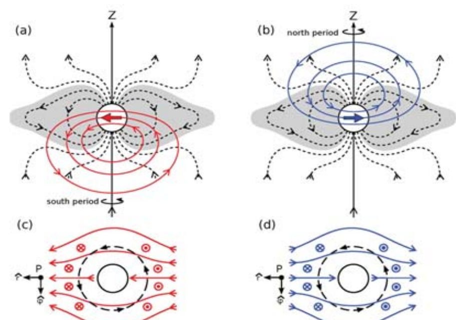

Figure 1

Figure 1 presents sketches of the spatial structure of (a) southern and (b) northern magnetic perturbations inferred from Cassini MAG data. The colored lines show the perturbation fields in the principal meridian of the perturbation at any instant (Z axis represents the spin/magnetic axis). The black dashed lines show the quasi-static ‘background’ magnetospheric field. The perturbation fields out of the meridian can be obtained approximately by displacing the colored loops directly into and out of the plane of the figure. These field patterns then rotate approximately rigidly around the axis at the southern and northern periods, giving rise to magnetic field oscillations at those periods. Sketches of the corresponding perturbation fields in the equatorial plane are shown in panels (c) and (d), viewed from the north. The solid lines indicate the quasi-uniform equatorial field. The colored circled dots and crosses represent the direction of the north-south field perturbation (the θ component positive southward) at this instant.

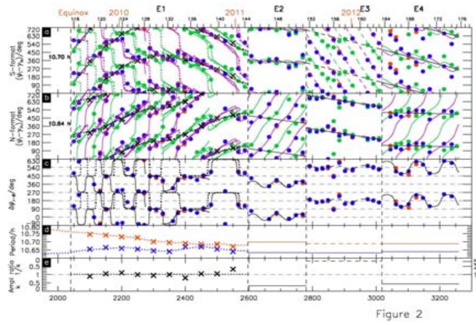

Figure 2 presents phase data and derived oscillation parameters plotted versus time over the interval of the study. The panels show (a) phase data (solid circles) plotted in S-format for the r (red), θ (green), and φ (blue) field components using a guide phase corresponding to a fixed period of 10.70 h, together with model values shown by the black crosses and black, purple, and green lines (b) the same phase data plotted in N-format using a guide phase corresponding to a fixed period of 10.64 h, together with model values (c) phase difference data (solid circles) $\Delta\psi_{r-\theta}$ (red) and $\Delta\psi_{\varphi-\theta}$ (blue) together with model values shown by black solid, dotted, and dashed lines, (d) southern (red) and northern (blue) oscillation periods corresponding to the gradients of the modeled phases shown by crosses and solid, dotted, and dashed lines and (e) north/south amplitude ratio k values shown by black crosses and solid, dotted, and dashed lines, where in the lower half of the panel the scale is linear in k from zero to unity, while in the upper half it is linear in between unity and zero. In interval E1 the dotted lines in each panel show the model parameters derived by Andrews et al. [2012], where in panels (a) and (b) the black dotted lines show the southern and northern phase models, respectively, while the purple and green dotted lines show models for the observed combined phase data for the (r, φ) and θ components, respectively. The crosses and solid lines in interval E1 similarly show the values derived from 5-parameter fits to 150 day data segments computed every 50 days centered on the times indicated by the crosses. In E2 and E4 the solid lines show results from linear fits to the S- and N-format phase data within those intervals. In E3 the dashed lines indicate values determined using a southern phase that is linearly interpolated between the E2 and the beginning of E4 as shown in panel (a).

6. Summary and Conclusions

We present the first indication of variability in the post-equinox planetary period oscillation amplitudes on several-month time scales. In the ~22 month post-equinox interval analyzed here, the oscillations are found to exhibit major abrupt changes in properties on such time scales, quite unlike the steady behavior observed previously during post-solstice southern summer conditions. The changes principally involve abrupt variations in the amplitudes of the two systems, together on occasion with small but clear changes in the period and/or phase. The changes themselves occurred between one periapsis pass and the next, thus on time scales of ~20 days or less. Three such changes have been documented here, occurring in February 2011, August 2011, and April 2012, with lesser changes being noted in November 2011. At the first of these transitions in February 2011 strongly southern-dominant conditions were unexpectedly resumed for a ~6 month interval, with northern amplitude decreasing by a factor of ~2.5 to values lower even than during southern summer, while the southern amplitude increased by a factor of ~1.3 back to southern summer values. At the second transition occurring ~2 years after equinox (August 2011) strong northern-dominant oscillations were abruptly established for the first time with northern amplitude increasing by a factor ~3, while the previously near-constant southern amplitude simultaneously decreased by a factor of ~6 such that the presence of the southern system could hardly be discerned in the phase data. These conditions were maintained for the following ~8 months to April 201, when the final transition took place. The dominant northern oscillations present were suppressed from one Rev to the next to values below a few tenths of a nT. The emergent oscillations were again dominated by the northern system, but to a lesser extent than prior to April 2012, with the amplitude of the southern oscillations increasing.

References

[1] Andrews, D. J., S. W. H. Cowley, M. K. Dougherty, L. Lamy, G. Provan, and D. J. Southwood (2012), Planetary period oscillations in Saturn's magnetosphere: Evolution of magnetic oscillation properties from southern summer to post-equinox, J. Geophys. Res., 117, A04224, doi: 10.1029/2011JA017444.