EPSC Abstracts
Vol. 9, EPSC2014-420, 2014
European Planetary Science Congress 2014

Quasi-periodic injections of relativistic electrons in Saturn's outer magnetosphere

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Abstract

Quasi-periodic, short-period injections of relativistic electrons have been observed in both Jupiter's and Saturn's magnetospheres, but understanding their origin or signifcance has been challenging, primarily due to the limited number of in-situ observations of such events by past flyby missions. Here we present the first survey of such injections in an outer planetary magnetosphere using almost nine years of energetic charged particle and magnetic field measurements at Saturn. We focus on events with a characteristic period of about 60-minutes (QP60), which we find to be very common in the outer magnetosphere (mapping outside Titan's orbit). QP60 are present over a very wide range of local times and latitudes and their distribution is asymmetric. The local time asymmetry is the most striking feature, with higher frequency of QP60 observations at dusk compared to dawn. The events at dusk reside on closed field lines and are distributed over a wide range of distances from the magnetopause. The ones at dawn map either on open field lines or along the magnetopause boundary. Those asymmetries indicate that the origin of QP60 is not unique. We suggest that a subset of the injections at the post-dusk sector may be signatures of the Vasiliunas reconnection cycle, while magnetopause reconnection or KH-instability may be invoked to explain all other events around dusk. Injections at the dawnside magnetosphere, which occur preferentially at the southern hemisphere, may result from solar-wind induced storms. We also observe that electrons in a QP60 can be accelerated at least up to 6 MeV, suggesting that these injections can be an efficient source process of energetic electrons for the saturnian magnetosphere. The distribution of QP60 appears also to trace well the aurora's local time structure, an observation that could have implications about high-latitude electron acceleration. Despite these new findings, it is still unclear what determines the rather well-defined 60 minute period of the electron bursts and how electrons can reach rapidly up to energies of several MeV.