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Comparisons of Pi pulsations and substorm developments observed on the ground and in the near-earth magnetotail

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We present unique results of recent work for comparisons of Pi pulsations and their relation to substorm developments observed on the ground and in the night-side magnetotail. The observations of Pi pulsations and aurora on the ground and of the magnetic field oscillations at the geosynchronous orbit and in the near-earth magnetotail are examined in detail. The expansion onset of a substorm examined was registered at 0512 UT on 4th April 2009. Pi pulsations appeared to oscillate from 0502 UT about 10 minutes earlier than the expansion onset. The Pi pulsations initiated with a small amplitude oscillation in association with faint appearance of auroral luminousity oscillations concurrently to the Pi 2 oscillations. The auroral luminousity oscillations became clear from 0506 UT in association with the clear appearance of the Pi 2 oscillations, particularly in the magnetic field D component oscillations. The large amplitude Pi 2 oscillations began to appear suddenly from 0509 UT accompanied with a slight poleward movement of the auroral activity, and then the aurora began to move suddenly poleward from 0512 UT with the auroral luminosity enhancement, which is the expansion onset. For about 3 minutes after the expansion onset the aurora continued to activate at the poleward site. Then the aurora became weak and moved gradually to the lower latitude side from 0515 UT, but the Pi 2 oscillations still continued to oscillate. During this substorm activity Pi 2 oscillations were clearly observed simultaneously at the geosynchronous orbit by GOES 11 and GOES 12 in the pre and post midnight sector, respectively, which provided very interesting oscillation signatures, i.e., the antiphase oscillations in the horizontal components of the magnetic field, implying that the polarization of the magnetic field horizontal components was opposite each other, suggesting the opposite flow direction of the field-aligned currents (FACs), that is upward and downward in the pre and postmidnight sector. Thus these observations at the synchronous orbit represent clear evidence of Pi 2 oscillations as substorm current wedge FAC oscillations. While, the observations by the THEMIS satellites located in the near-earth magnetotail at the radial distance from – 10 Re to – 13 Re provided a very important indication concerning to the growth of Pi oscillations and substorm processes in the near-earth magnetotail. For the most earthward satellite, THEMIS A (THA) observed small amplitude magnetic field perturbations from 0505 UT almost simultaneous to the clear appearance of the Pi 2 oscillations on the ground and at the geosynchronous orbit, and then the magnetic field perturbations became to oscillate gradually in the amplitude, which continued until 0513UT, when the dipolarization signature appeared at this site. While, the THEMIS E (THE) satellite located a little tailward nearest to the THA observed the gradual increase of the magnetic field intensity from 0504 UT and then observed the field decrease from 0507 UT associated with the plasma pressure increase. The dipolarization and associated plasma depression appeared at 0512UT. Thus, the dipolarizations observed at the THEMIS satellites was almost coincident to the expansion onset on the ground. These are summaries in this work, which indicate the close relation between Pi oscillations observed on the ground and substorm processes in the ionosphere, at the synchronous orbit and in the near-earth magnetotail.

Keywords: Pi oscillations, substorm, magnetosphere