First Investigation of Geomagnetic Micropulsation, Pi 2, in Egypt

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Abstract We present first investigation of Pi 2 pulsations observed from MAGnetic Data Acquisition System (MAGDAS) at Fayum and Aswan stations (FYM and ASW) in Egypt. MAGDAS is an important component of the International Space Weather Initiative (ISWI). We carried out our analysis through a visual inspection comparing our events with burst in AE index during the period from November 2008 to October 2009. We used two different methods: (i) Fourier transformations and (ii) Wavelet power spectrum. Pi 2 events of H component, at FYM and ASW, have the same waveform and the same frequency, and some times the same amplitude, but in some cases FYM has relatively higher amplitude than ASW

Keywords: Pi 2 pulsation, MAGDAS, ISWI, Wavelet.

Introduction

Pi 2 pulsation is magnetic fluctuations with period [40:150 seconds]. It considers the most common pulsations used in substorm research [1]. Pi 2 pulsations at low latitude are a good indicator to substorm onset because it observed not only in the nightside but also in the dayside [2]. With some cautions due to gradual increase in the Pi 2 amplitude and the onset delay within 1 - 3 minute from the auroral breakup [3] and [4], Pi2 pulsation is considered the result from hydromagnetic disturbances driven by sudden change in magnetspheric convection or reconfiguration in the magnetotail during the substorm expansive phase, so that it considered a better proxy of substorm onset than it's counterpart at middle and high latitude [5]. Furthermore the low latitude Pi 2 is sensitive to small substorms even extremely ones that hardly detectable with the AE index [6] and [7]. [8] showed that the low latitude Pi 2 appear with beginning part of positive bays H component, but Pi 2 at lower latitudes have the same waveform and amplitude might be associated with the sudden formation of substorm current wedge and/or the magnetospheric compressional cavity waves.

[9] suggested that low-latitude Pi 2 caused by global plasmaspheric cavity resonance, enhanced during fast mode waves emitted at the substorm onset and trapped in the inner plasmasphere, then compressing the plasmapause causing radial oscillation of the field lines. Many observations at middle and low showed Pi 2 frequency has Kp dependence [10] and [11]. In this work we present the first investigation of Pi 2 pulsation observed from MAGDAS stations in Egypt.

Data Sets

Data were obtained from two stations in Egypt (FYM and ASW) belong to MAGDAS project (Fig. 1). The PI of the MAGDAS Project and the Director of Space Environment Research Center (SERC) is Professor K. Yumoto of Kyushu University, Japan [12]. This system is one of many tools are now being deployed in order to carry out space weather studies in the Space Weather Monitoring Center (SWMC) in Egypt [13]. The geomagnetic and geographic locations of both stations are given in Table (1).

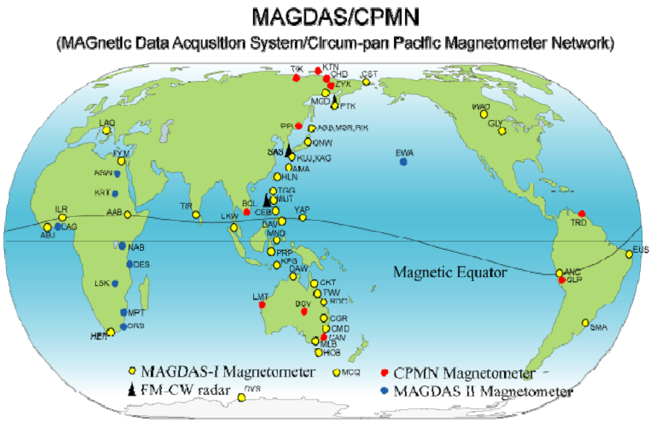

Fig.1: MAGDAS/CPMN (MAGnetic Data Acquisition System/Circum-pan Pacific Magnetometer Network) system of the SERC, Kyushu University. Yumoto and MAGDAS group (2006)

TABLE 1. The geomagnetic and geographic locations of both stations

Station	Code	G.G Lat.	G.G Long.	G.M Lat.	G.M Long.
Fayum	FYM	29.30	30.88	21.13	102.38
Aswan	ASW	23.59	32.51	15.20	104.24

Analysis method

Pi 2 pulsations in the period range of November 2008 up to October 2009 have been studied. We identified Pi 2 pulsations through its waveform, and local time appearance, using second order Butterworth band-pass filter. But because Pc4 pulsations share the same frequency band of Pi 2 we had set rules for choosing Pi 2 event according to [14] with little modifications.

Pi 2 pulsations are limited around local time 19 PM: 5 AM.

Correlated the chosen events with dramatic megnetospheric disturbance identified by Auroral Electrojet index (AE), with some cautions have to be applied according to [15], the magnetic positive-bay caused by substorm current wedge in the nighttime sector.

Through those two rules we have got 152 Pi 2 events. To investigate the dominant frequency of Pi 2 pulsations, we used two methods [i] Discrete Fourier Transformations (DFT) and [ii] Wavelet power spectrum. The DFT analysis is considers a transformation of an input signal (function) defined in the time (space) domain to an output signal (function) defined in the temporal (spatial) frequency domain.

This transformation of the signal (function) from the time or the space domain to the temporal (spatial) frequency domain can be used to solve many complex problems, especially in data analysis, which enables us to view hidden details in the raw signal. In our analysis we had used Meyer wavelet to map the variability of the time series on different wavelength using different scales, as this base function is finite in frequency and infinite in time [16].

Observational result

At first we filtered our data using a Butterworth second order band pass filter in the period range of Pi 2 pulsations [40:150 Seconds] then we had performed the Fourier transformations for the filtered data to investigate the dominant frequency for a 600 data point, as the duration time of Pi 2 in the period range 5 to 7 minutes [11]. The dominant frequency is obtained by taking the frequency at the maximum amplitude in the power spectrum analysis, sometimes we normalizes the power. Figure 2 shows the power amplitude versus frequency for 27-3-2009 at FYM station. The dominant frequency for H (blue dashed line) and D (red solid line) component are 9.7 and 10.7 mHz respectively. This method is applied to all events observed at FYM and ASW stations.

We also applied the wavelet power spectrum method (Fig. 3), which is considers a powerful tool. The wavelet power spectrum is more useful method deals no stationary signals (transient variation) which is considers a promising method in atmospheric science. Pi 2 events of H component, at FYM and ASW, have the same waveform and the same frequency, and some times the same amplitude.

In some cases FYM has relatively higher amplitude than ASW (fig 4) which are expected to be related to different modes that are excited coherently from lower to higher latitudes [8]. Figure 5 shows that the dominant frequency of all recorded events (152 events) is approximately 9.7 mHz. The majority of Pi 2 events observed during the nightside time without any activities detected in the AE index, this result is consistent with the result derived by [17].

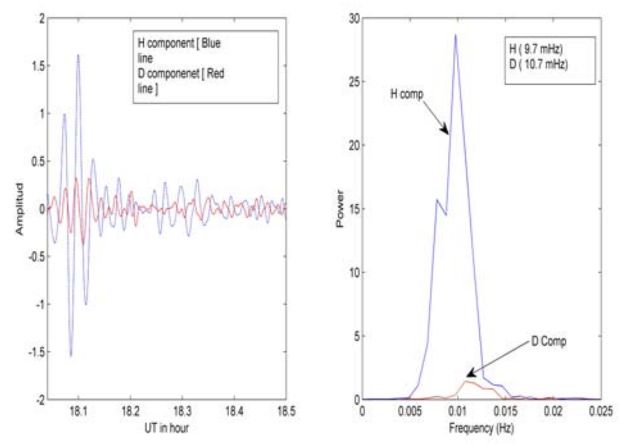

Fig.2: Pi 2 event at FYM station on 27-3-2009, (left panel) shows the H and D component filtered data, (right panel) shows the power spectra at 18.02:18.27h UT.

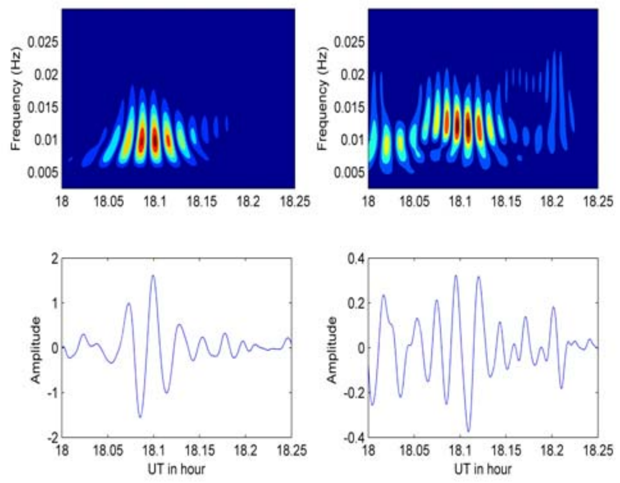

Fig.3: Wavelet power spectrum for the same event at Fig.2. Left panel shows H component but the D component in the right panel.

Also, Pi 2 event observed at the Kp index = -1 and AE less than 50nT as shown in Fig.(6) during 26-12-2008, the events have the same waveform and frequency band of Pi 2s of H component at both stations, two successive Pi 2 events showed frequency 10.7 and 11.7 mHz respectively at both stations.

Figure 7 shows a relationship between the K index and the frequency of all 152 events. This result shows that the Pi 2 has higher frequency with high Kp index. When Kp index was 2, the frequency was 5.7 mHz but when Kp index become 4 the frequency raised to the maximum value, 21.8 mHz. This positive result is consistent with the result derived by [10].

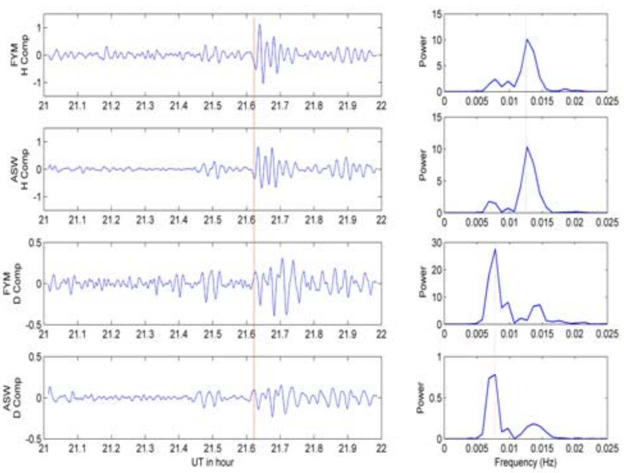

Fig.4: Pi 2 event at 2-1-2009, filtered H and D component at the left column and the power spectra at the right. Vertical line shows the onset of Pi 2 pulsation

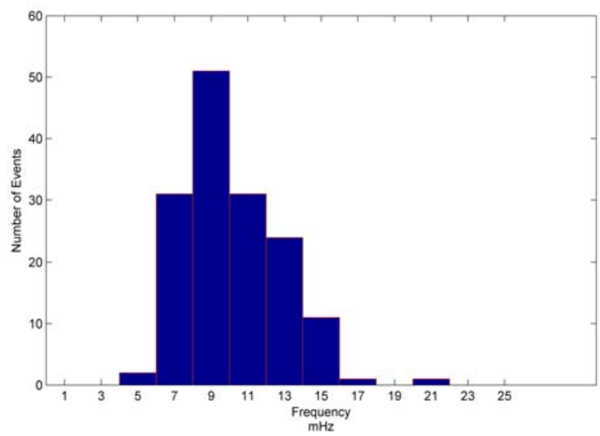

Fig. 5: Number of all events versus frequency of H component.

Summary and Conclusion

We presented first investigation of Pi 2 pulsations observed at Fayum and Aswan (FYM and ASW) stations in Egypt. This study showed that, Pi 2 pulsations at FYM and ASW have the same waveform, the same frequency and comparable amplitude at both stations. In this study the magnetic activity dependence with the frequency of Pi 2 pulsation was investigated and found that the Pi 2 has a positive relationship with Kp index. This result is consistent with the result derived by [10].

Acknowledgments

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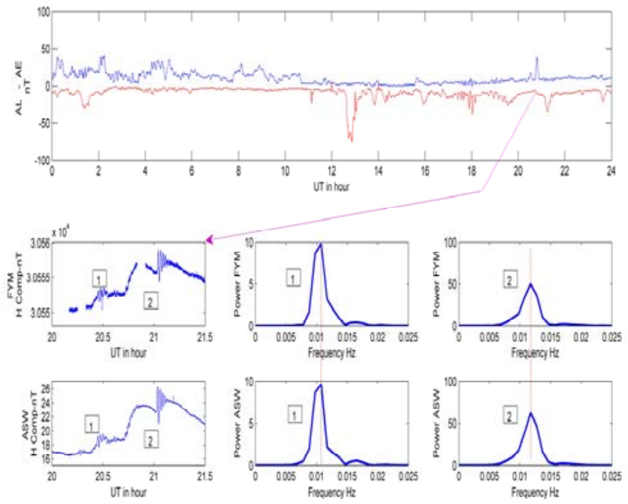

Fig.6: Pi 2 pulsations during 26-12-2008, Kp=-1, Without AE activity the middle and the most right column show the fast Fourier transformation of two successive substorm events in the left column. Vertical lines show maximum frequencies.

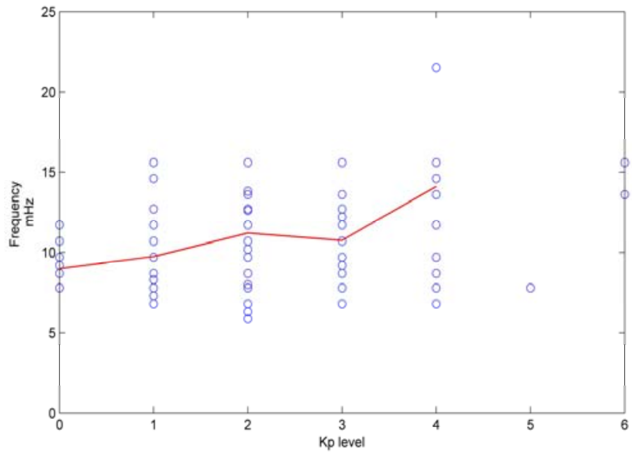

Fig. 7: The relation between the K index and the frequency of all events.

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