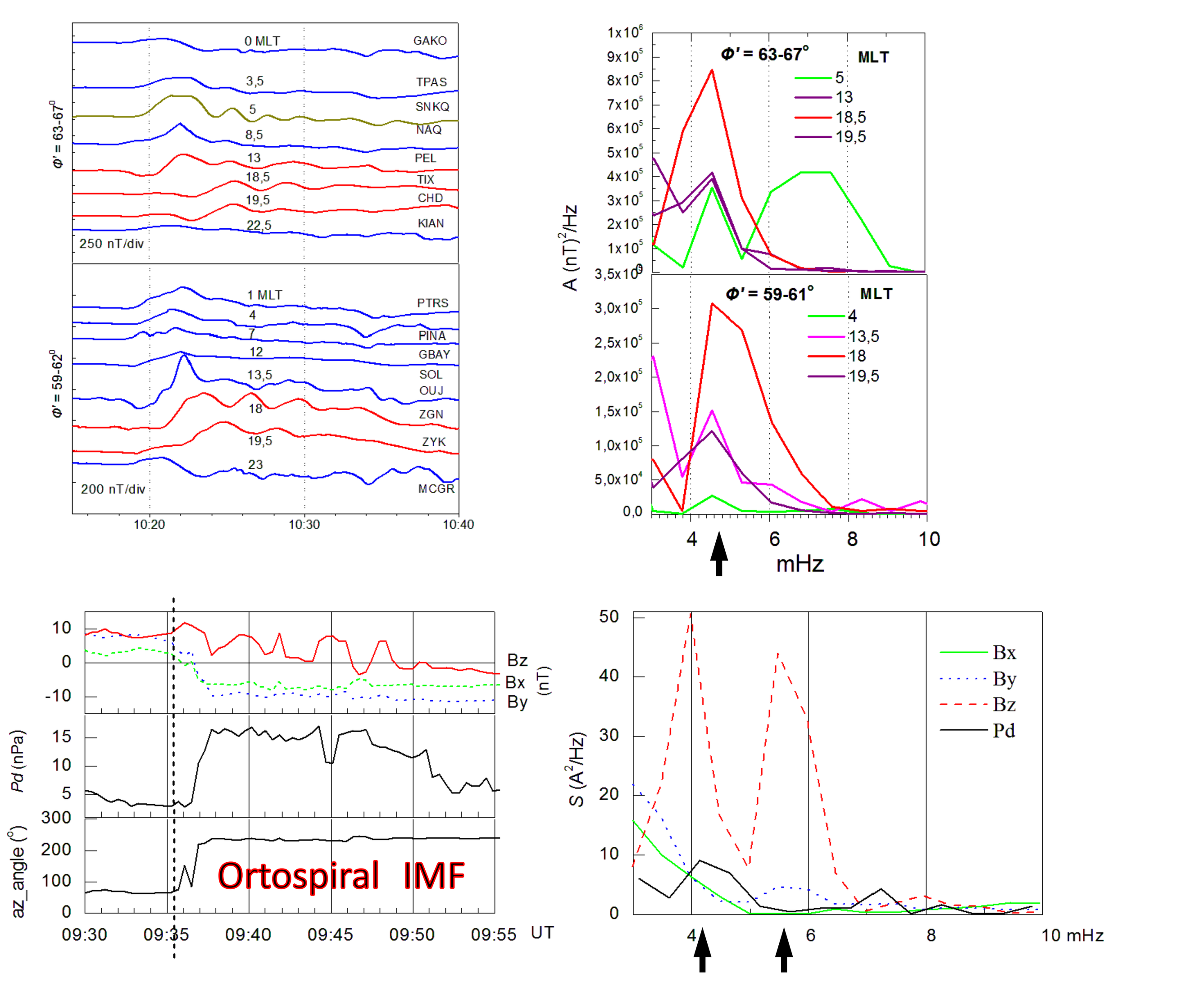
Features of geomagnetic pulsations in the Pc5 range, penetrating from the interplanetary medium during an impact of interplanetary shock on the Earth's magnetosphere

Moiseev A. [1], Baishev D. [1], Yoshikawa A. [2], Yumoto K. [2]

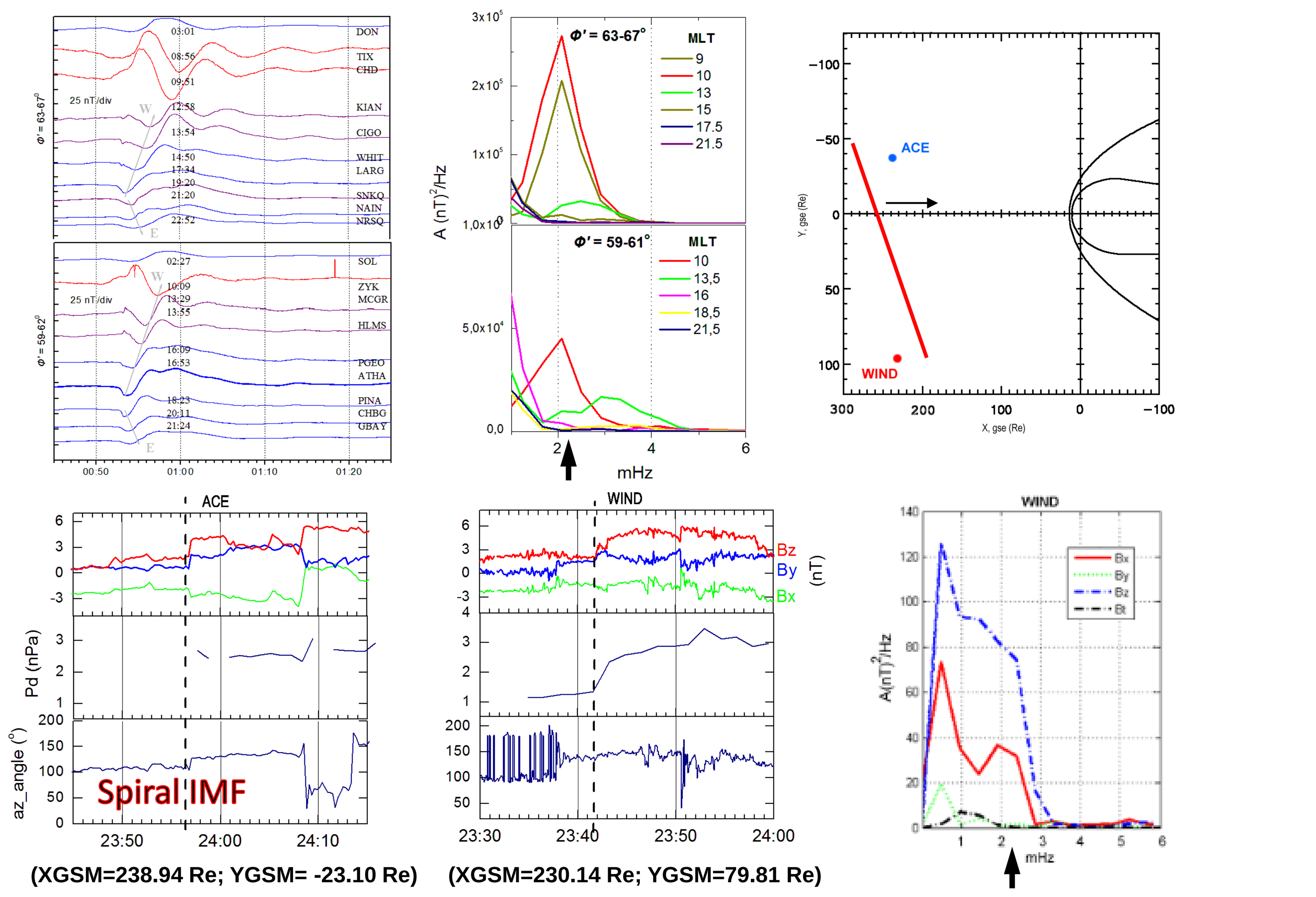
[1]Yu.G.Shafer Institute of Cosmophysical Research and Aeronomy, SB RAS, Yakutsk, Russia
[2]International Center for Space Weather Science and Education, Kyushu University, Fukuoka, Japan

During interplanetary shock (IPS) interaction with the magnetosphere the Psi pulsations can be also generated as the result of direct wave penetration from the solar wind into the magnetosphere. In this case variations of the solar wind dynamic pressure and (or) IMF have the same spectrum as the Psi pulsations in the magnetosphere.
By the analysis of a number of events of Psi in the Pc5 range, we have found that in the case of direct wave penetration, the Psi oscillation frequency was independent of a magnetic latitude and the maximum of Psi amplitude was asymmetrically distributed in the longitude relative to the noon meridian (i.e. it was registered on the dawn or dusk side).

Aug. 4, 2010 (wave activity in the dusk sector)



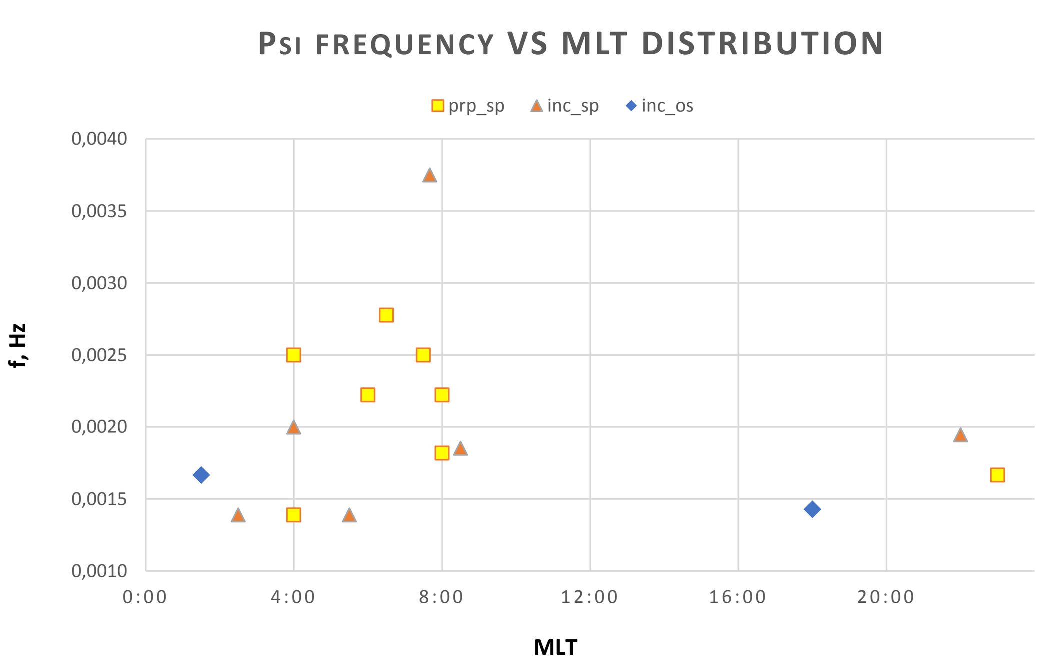
Apr. 24, 2009 (wave activity in the dawn sector)



Two events with the opposite distribution of ULF activity relative to the noon meridian are presented. On Top: geomagnetic field variations at high latitudes and their spectra. At bottom: conditions in the interplanetary medium aboard WIND and ACE satellites and their spectra. For the Apr. 24, 2009 event the satellite position in XY-plane is shown.

We have selected events from IPS list (http://www.cfa.harvard.edu/shocks/) with the vertical normal component near the zero (Nz~0) and cone angle > 45°. Several types of events were selected: perpendicular spiral shock (prp_sp - 8 events), inclined spiral shock (inc_sp – 5 events) and inclined ortospiral shock (inc_os – 2 event). Then the spectra both of interplanetary medium parameters (IMF Bz, Bx, By-components and solar wind dynamic pressure (Pd)) and H-component of ground stations distributed longitudinally at latitude 63-66° was calculated. If the spectra be the same we selected such events for further analysis. (Please see the table below)

N	Date	Time, UT	Shock normal Nx	Shock normal Ny	Shock normal Nz	Nxy azimuth angle	Phi	Bx GSE [nT] (d/stream)	By GSE [nT] (d/stream)	Bz GSE [nT] (u/stream)	Bz GSE [nT] (d/stream)	cone angle	Plasma Beta (d/stream)	Vx GSE [km/s] (d/stream)	ΔPd/Pdd	Shock type
1	08/22/2007	0434	-0,96	0,20	-0,03	101,77	342,90	0,80	-2,60	0,90	1,20	74,39	0,867	-332,70	0,416432	inc_sp
2	04/30/2008	1502	-0,96	0,19	0,04	101,20	339,91	1,50	-4,10	-0,40	-0,80	70,25	1,036	-405,70	0,484202	inc_sp
3	06/24/2009	0952	-0,88	-0,26	-0,06	196,46	166,50	-1,80	7,50	1,00	0,70	76,56	0,537	-305,00	0,539386	prp_sp
4	08/30/2009	0033	-0,96	-0,14	-0,03	188,30	326,98	2,60	-4,00	0,00	2,00	59,83	1,071	-370,70	0,499943	prp_sp
5	02/14/2011	1506	-0,68	-0,22	0,05	197,93	337,38	2,00	-4,80	-1,70	-3,90	72,08	1,141	-382,90	0,760166	prp_sp
6	05/21/2012	1831	-0,90	0,31	-0,06	109,01	229,76	-2,20	-2,60	1,60	5,00	68,68	0,944	-383,00	0,748802	inc_os
7	06/16/2012	1934	-0,64	-0,09	0,09	188,01	82,04	1,30	9,30	7,80	12,60	85,25	0,437	-460,10	0,526387	inc_sp
8	02/16/2013	1123	-0,80	0,29	-0,05	109,93	83,46	1,10	9,60	1,80	2,10	83,61	0,184	-394,80	0,671937	inc_os
9	04/30/2013	0852	-0,93	0,10	0,04	96,14	318,95	2,70	-3,10	2,90	6,40	69,21	0,258	-395,40	0,444147	inc_sp
10	05/05/2013	1511	-0,70	0,19	-0,07	105,19	311,99	1,00	-0,90	3,80	1,50	60,25	6,771	-395,50	0,643143	inc_sp
11	06/02/2013	0233	-0,68	-0,02	-0,12	181,69	108,44	-1,20	0,40	-10,00	-4,40	74,80	0,897	-726,20	-0,52673	prp_sp
12	10/29/2013	0933	-0,80	-0,41	0,08	207,14	205,91	-3,50	-1,70	-5,30	-9,60	70,25	0,107	-336,80	0,553954	prp_sp
13	01/14/2014	0739	-0,92	-0,19	0,07	191,67	332,18	1,90	-3,60	1,80	0,40	62,32	0,800	-665,50	-0,3515	prp_sp
14	03/25/2014	1910	-0,67	-0,48	-0,04	215,62	328,43	5,90	-9,60	-2,30	-0,50	58,46	0,383	-470,80	0,789084	prp_sp
15	04/19/2014	1748	-0,95	-0,19	-0,02	191,31	124,05	-3,70	2,50	3,50	7,70	65,44	0,151	-507,30	0,486855	prp_sp



Discussion

The distribution shows that MLT sector with maximum of the Psi amplitude by the IMF orientation in the azimuthal plane (spiral/ortospiral) is determined, as it is expected from the work [Korotova et al., 2002]. The most of the events registered in the prenoon MLT sector at spiral IMF orientation independently from shock front inclination angle (perpendicular/inclined) in azimuthal plane. Only one event was registered in the midnight sector at spiral IMF. Pulsations frequency in that event was relatively low (~2,2 mHz). Probably the waves with the such wave length (comparable with the magnetosphere size) excited on the nightside where the size of magnetospheric resonator correspond to wave length. Some tendency of wave frequency increase in the proximity of the noon is seen on the distribution.

We have found that in the most of events the IMF Bz component has spectral power stronger than other components and has peak at the same frequency as the Pd. The IMF Bz direction was positive (northward) in 10 events. So in majority of events ULF wave penetration can be related with the NBz current system [Zanetti et al., 1984] formation.

The frequency of pulsations in our events not exactly corresponds to fundamental magnetospheric resonance frequencies (1.3, 1.9, 2.6, and 3.4 mHz) [Kepko and Spence, 2003].

Median value of solar wind velocity corresponds to non-disturbed solar wind conditions, plasma beta values ~ 1 in most cases corresponds to warm solar wind plasma. Probably that ULF wave penetration in our events not related with the Kelvin-Helmholth instability excitation. But it is impossible to exclude an action of combined instability of Kelvin–Helmholtz–Rayleigh–Taylor [Potapov et al., 2012] that play the role of an amplifier of ULF waves incident on the magnetopause.

It has been demonstrated in [Sibeck, 1990] that the ratio $\Delta Pd/Pd$ ~ 1 is a necessary condition for the generation of a compression wave in the magnetosphere. In our events the median value of $\Delta Pd/Pd$ ~ 0.53 rather lower.

Conclusion

It was found, that:

1. Asymmetric appearance of pulsations relative to the noon meridian in general driven by IMF orientation in the azimuthal plane (IMF By/Bx ratio).
2. Penetrating Psi pulsations with relatively higher frequency of oscillations excited at the dayside rather than in the nightside.

ACKNOWLEDGMENTS The authors appreciate the possibility to use the data of the projects Themis (V. Angelopous, U. Auster, K.H. Glassmeier, and V. Baumjohann), Image (E. Tanskanen), and Greenland Coast Chain (C. Stolle), and to use materials of satellite observations through CDAWEB (D.J. McComas, R. Lepping, K. Ogilvi, and G. Paschmann (MPE)).

References

Kepko, L. and Spence H. E. (2003), Observations of discrete, global magnetospheric oscillations directly driven by solar wind density variations, J. Geophys. Res. V.108. P.1257. doi:10.1029/2002JA009676.

Korotova G. I., Sibeck D. G., Singer H. J. and Rosenberg T. J. (2002), Tracking transient events through geosynchronous orbit and in the high-latitude ionosphere, J. Geophys. Res. V. 107. P. 1345-1363.

Potapov, A.S., Tsegmed B. and Ryzhakova L.V. (2012) Relationship between the fuxes of relativistic electrons at geosynchronous orbit and the level of ULF activity on the Earth's surface and in the solar wind during the 23rd solar activity cycle, *Kosm. Issled.*, vol. 50, no. 2, pp. 130–146.

Sibeck, D.G. (1990) A model for the transient magnetospheric response to sudden solar wind dynamic pressure variations, *J. Geophys. Res*, V. 95, P. 3755 – 3771.