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Collisionless plasma processes at magnetospheric boundaries: Role of strong nonlinear wave interactions

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Background. Interaction of the variable solar wind (SW) plasma flow with the Earth's magnetosphere leads to the formation of the bow shock (BS), turbulent magnetosheath (MSH) downstream and magnetopause (MP = magnetospheric boundary) [1–7]. The low frequency eigen modes between BS and MP range at 0.2–10 mHz.

This study is focused on the disturbances propagating towards BS. The excitation of the **3-wave nonlinear interactions**. It was found that for the bicoherence the horizontal maximum (inferring a nonlinear cascade [1, 2]) at ∼5–6 mHz in Fig. 1 strongly dominates near MP (middle top panel). There are the horizontal bi-maxima at ∼0.3, 0.5 and 1 mHz the strongly nonlinear impulsive signal of $P_{x\mathrm{plus}}$. Right top panel demonstrates the extended reservoir of the heated MSH plasma – the PB (the stagnant outer cusp with heated MSH plasma [2]). For ∼3 and 0.1 mHz, the left and right top panels display more similarities, inferring the global influence of PB on the SW plasma streaming around the magnetosphere. C4 displays strong 3-wave interactions in the foreshock (middle left). After BS involved into the eigen magnetospheric oscillations by $P_{x\mathrm{plus}}$ impulses, the oscillations are and seem to be driven in MSH by the modulated plasma jets [3]. In the MHD model [4] horizontal maxima at ∼0.5 and 0.07 mHz are reasonably close to the observed cases (∼0.7–1 and 0.05 mHz, bottom middle).

Results. The digital-like impulses in $P_{x\mathrm{plus}}$ provoke the strongest 3-wave interactions, resulting in appearance of the modulated jets [3, 7]. The MHD model confirms the decisive role of the upstream propagating waves in the strong 3-wave interaction.

We demonstrate the following new results:

1. Strongly nonlinear waves (impulses in the sunward Poynting flux) are acting to reduce the dominant dynamic pressure of the solar wind at the geomagnetic boundaries via the strong nonlinear 3-wave interaction.

2. There are 4 zones of the nonlinear interactions:

– bow shock;

– pre-magnetopause deflection region [2];

– "Plasma Balls" (PB) [2]; with a turbulent barrier separating the flowing and stagnant plasmas [2];

– resonances are identified as triggered by the short wave impulses of sunward Poynting flux [1, 2, 8]. The sunward Poynting flux bursts trigger surface waves at BS, which modulate the jet production at the BS [1, 2]. The sunward . We analyze data on 27.03.2005 from CLUSTER-4 (C4), DOUBLE STAR TC1 (DS; DS was in low-latitude MSH for 17 hours);

– foreshock which starts to trigger the interactions.

3. The resonances from magnetopause can be transported back to bow shock namely by the spikes observed in $P_{x\mathrm{plus}}$.

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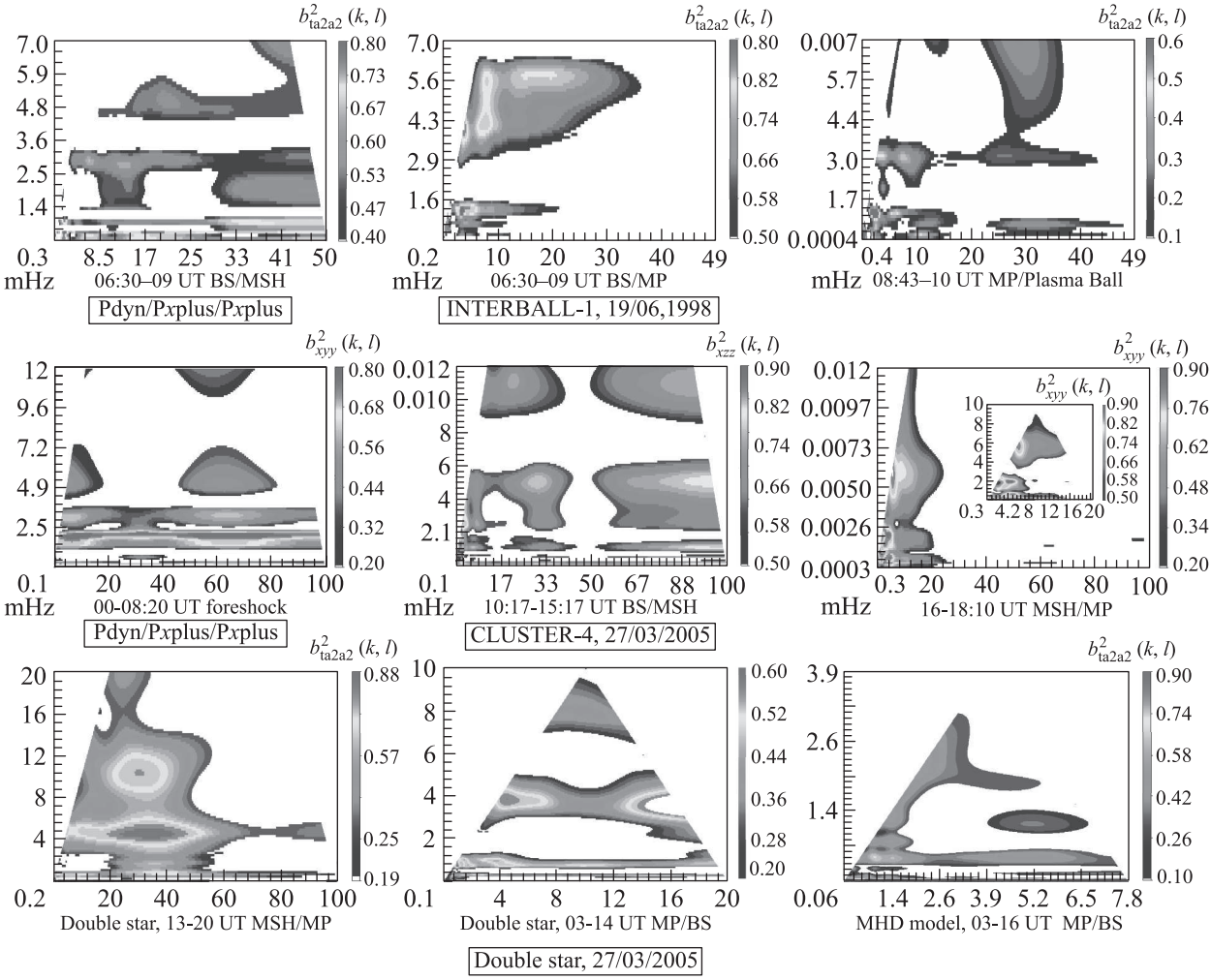

Fig. 1. (Color online) Wavelet bi-spectra ($F_{\rm vertical}+F_{\rm horizontal}=F_{\rm sum}$ (not shown); inputs: $P_{\rm dyn}/P_{x\rm plus}/P_{x\rm plus}$, see text). From top/left to right: I1 BS/MSH; I1 BS/MP; I1 MP-Plasma Ball (PB) [2]; middle: C4 foreshock; C4 BS/MSH; – C4 MSH/MP (+blow up); bottom: DS MSH/MP; DS MP/BS; MHD model

4. The MHD model [3] qualitatively reproduces the nonlinear physics of the solar wind interaction with geomagnetic field in the region from the bow shock to the magnetopause.

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