The evolution of intermittency in the magnetosheath turbulence downstream of a quasi-parallel bow shock

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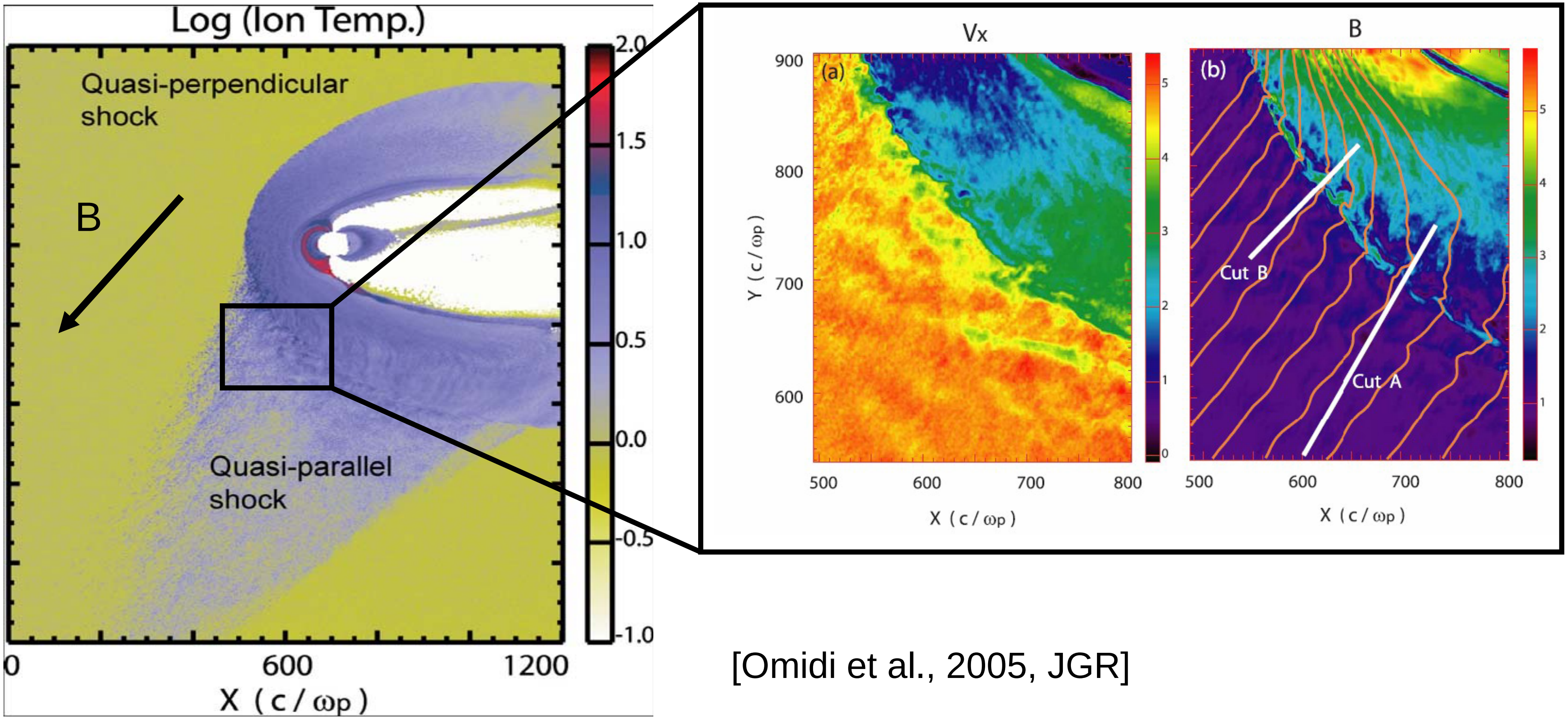
Turbulence behind a quasi-parallel shock



[Omidi et al., 2005, JGR]

Description of the scaling properties of turbulence 1

The standard approach - calculating the structure functions of a measured fluctuating parameter g(x):

$$S_q(l) = \frac{1}{L}\int_0^L \left| g(x+l) - g(x) \right|^q dx \sim l^{\zeta(q)}$$

- *Kolmogorov theory* (neutral fluids):

$$\zeta_q = q/3$$

- *Kraichnan-Iroshnikov theory* (MHD fluids):

$$\zeta_q = q/4$$

Description of the scaling properties of turbulence 2

An advanced approach - Wavelet Transform Modulus Maxima Method (WTMM):

Wavelet based partition function:

$$Z(q,a) = \sum_{l \in L(a)} \left(\sup_{a' \le a} \left| T_\psi [g]\left(b_l(a'), a'\right) \right| \right)^q$$

Wavelet transform: $T_\psi [g](b,a) = \frac{1}{a} \int g(x) \psi \left(\frac{x-b}{a} \right) dt$

Scaling law of the partition function:

$$Z(q,a) \sim a^{\tau(q)}$$

Models of turbulence

1. P-model (Meneveau and Sreenivasan, 1987, 1991):

$$\tau(q) = -\log_2\left[P_1^{\zeta_q} + (1-P_1)^{\zeta_q}\right]$$

$P_1 = 0.5$ - no intermittency
$P_1=1$ - fully intermittent turbulence

2. Extended intermittency models (Tu et al., 1996, Marsch and Tu, 1997):

***-** scaling functions for the **Kolmogorov-like** cascade:*

$$\tau(q) = \left(-\frac{5}{2}+\frac{3}{2}\alpha\right)\frac{q}{3} - \log_2\left[P_1^{q/3} + (1-P_1)^{q/3}\right]$$

***-** scaling functions for the **Kraichnan-like** cascade:*

$$\tau(q) = (-3+2\alpha)\frac{q}{4} - \log_2\left[P_1^{q/4} + (1-P_1)^{q/4}\right]$$

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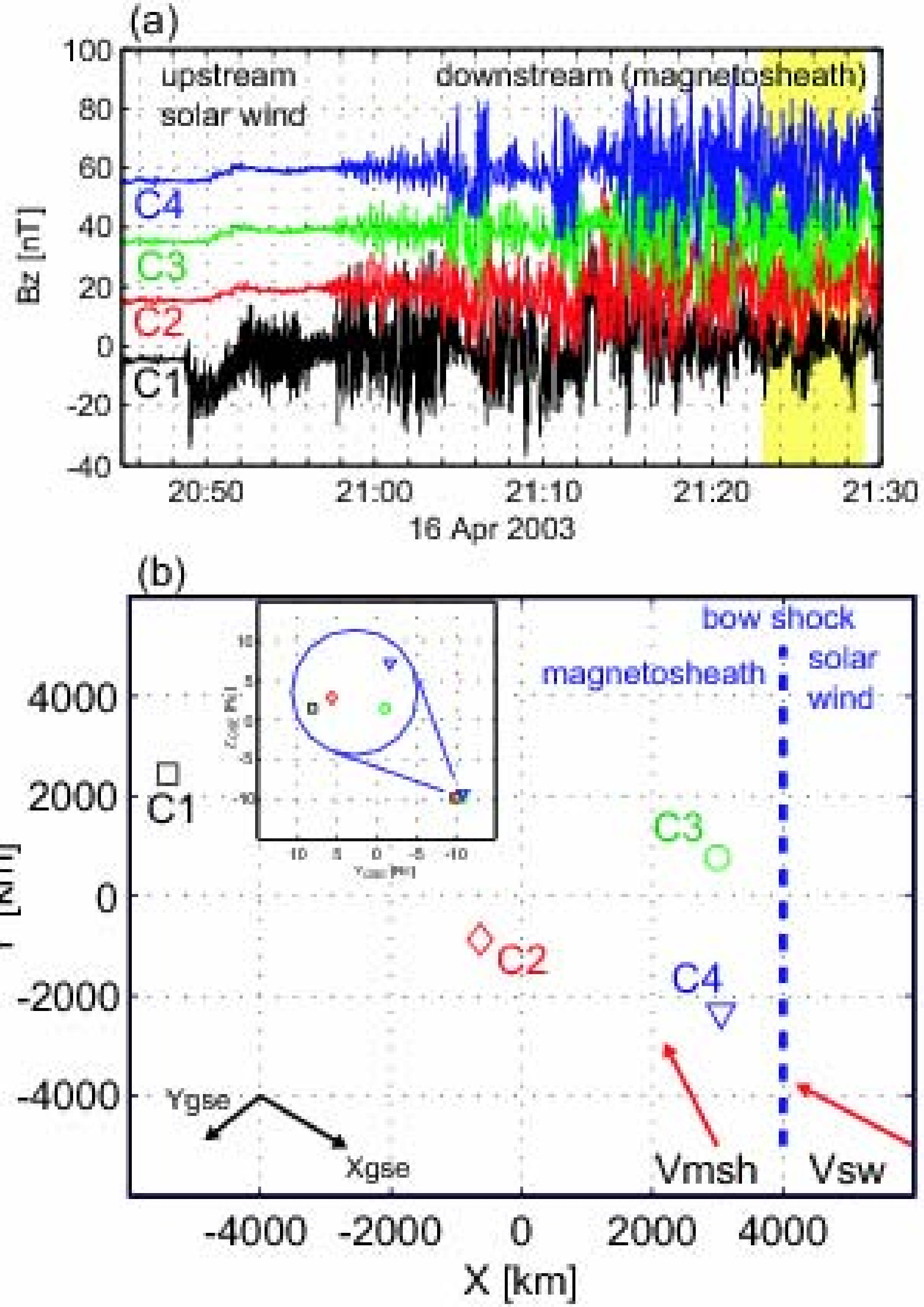
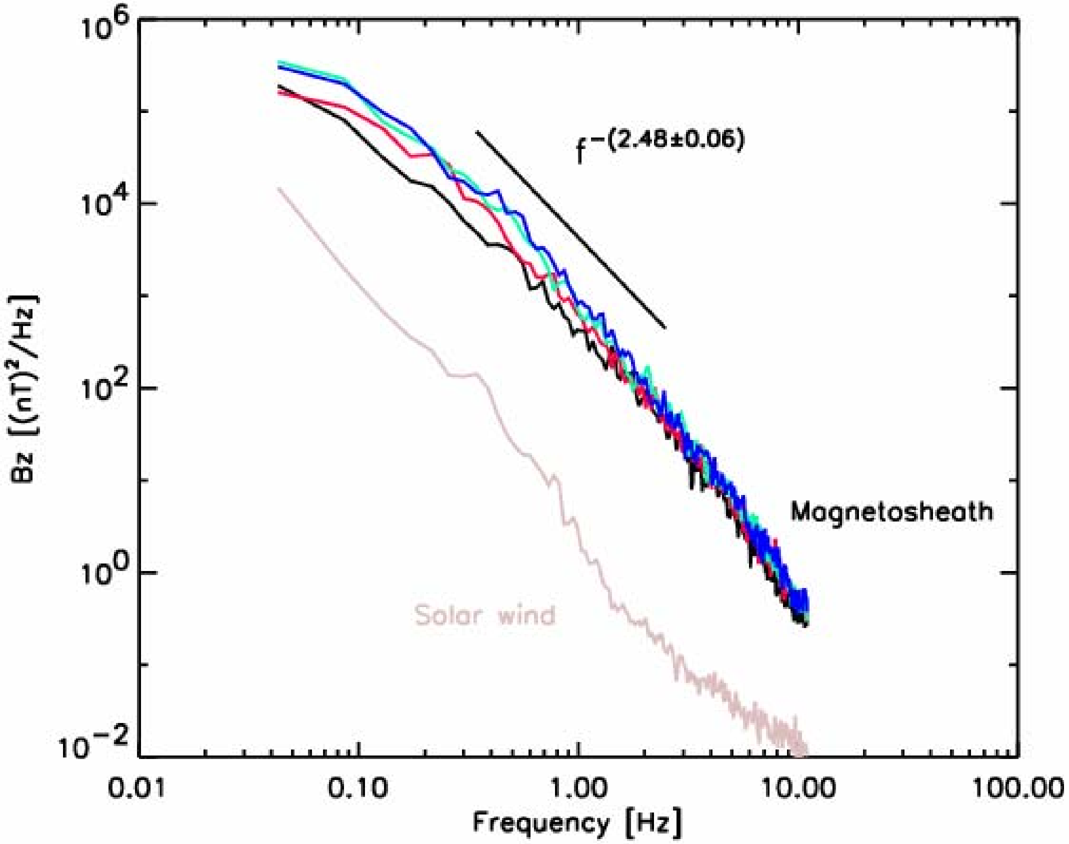


Power Spectral Density



0.33 – 2.5 Hz

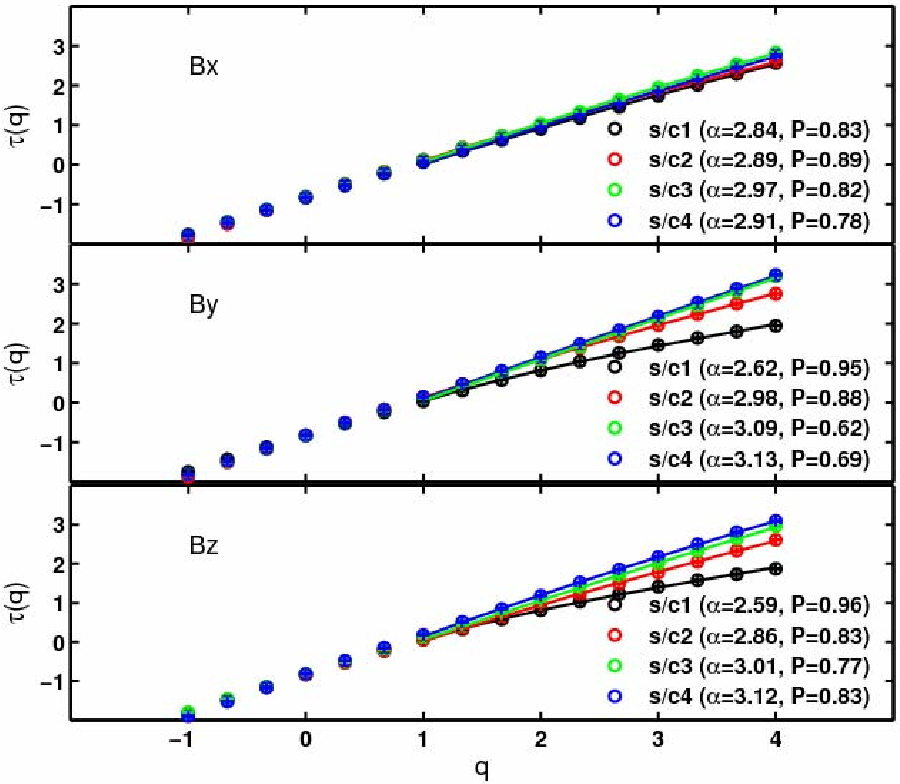
0.3 – 4 s

150 -1100 km

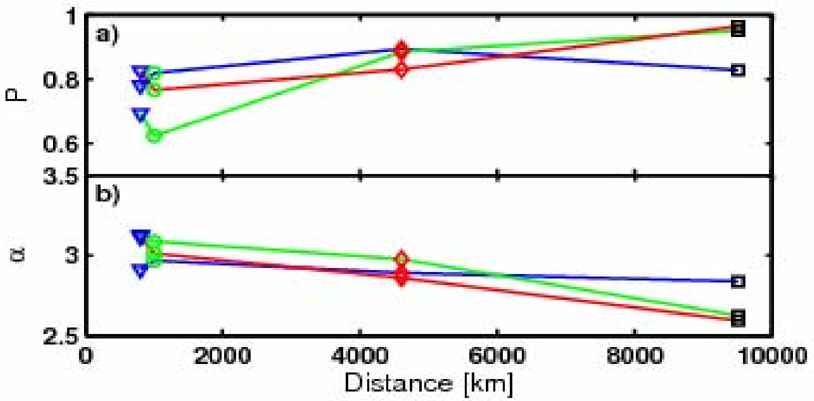
2 - 15 c/ω_{pi}

(V_{msh} ~ 375 km/s)

Scaling exponents (WTMM)



P and α vs distance



Summary 1:

We have analyzed the intermittency development of the magnetosheath plasma turbulence close to the bow shock using for the first time multi-point Cluster observations.

- the scaling exponents obtained analyzing the magnetic field fluctuations at spatial scales 2-15 c/ω_{pi} are very well described by the extended structure function model, meaning that magnetosheath turbulence is *not in a fully developed state* after the shock crossing.

Summary 2:

- there is clear *anisotropy* of the turbulence with respect to the shock normal. The intermittency of the magnetic field components in the shock plane shows fast development from lower to higher values, while the component along the bow shock normal shows no clear evolution.

- there is small intermittency and no anisotropy in the frequency range between 3-10 Hz (25 - 125 km).

Questions:

- Why a model for non-fully develop turbulence describes the turbulence behind the bow shock?

- Why the intermittency increases away from the bow shock? Is turbulence decaying?

- What causes the intermittency? Small-scale current sheets associated with reconnection?

- What is the origin of the fluctuations between 3-10 Hz? Why they have different scaling properties?

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