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Pattern of small-scale structures in the turbulent magnetosheath

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Various types of coherent structures are associated with non-Gaussian behaviour and intermittency of turbulent fluctuations. To gain a better understanding of the geometrical and dynamical characteristics of these spatial structures, we have quantitatively examined the velocity and magnetic field gradient using measurements from the Magnetospheric Multiscale mission. By analyzing the geometric invariants of the coarse-grained gradient tensor, the pattern of the small-scale structures is studied in the turbulent magnetosheath downstream of a quasi-parallel shock. Unlike the case of hydrodynamic turbulence, we find that: (1) The joint probability density function of the second and third invariants of the velocity gradient tensor jPDF(R_A, Q_A) does not exhibit a 'teardrop' shape. Instead, it is symmetric along the R_A=0 axes, meaning the structures are generally two-dimensional. (2) The second invariant of the rotation-rate tensor is correlated with the second invariant of both the original and the traceless strain-rate tensor, implying the existence of vortex sheet. Similarly, the magnetic field pattern also suggests the dominance of quasi-2D structures, while the correlation between the second invariant of the symmetric, and the skew-symmetric, parts of the magnetic field gradient tensor are stronger. Further analysis based on wavelet cross-coherence of velocity and magnetic field has revealed the Alfvénic nature of these small-scale structures. Comparisons between our results with numerical simulations and previous statistics are made.