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James Clerk Maxwell Prize for Plasma Physics Talk: Who needs turbulence? A tour of turbulence effects and outstanding questions in space plasmas

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Investigators of hydrodynamics are well-accustomed to the leading order and even dominant effects of turbulence. However even 50 years after the discovery of solar wind turbulence, there seems to be a persistent reluctance to recognize the potential for widespread turbulence effects in space and astrophysical plasmas. Therefore the question posed in the title above remains relevant [1]. Turbulence is a deeper subject than wave modes and spectral slopes. Present evidence in observations and from simulations establishes a rich current context, and an array of unresolved issues, regarding turbulence in magnetofluids, and weakly collisional plasmas, such as those observed in space and astrophysics. Here we review the status of turbulence physics derived from observations, mainly from coronal, interplanetary and magnetospheric in situ and remote sensing data. We will also review some of what is learned so far from simulations and theory. Subjects will include: the relevance of MHD, the nature of the plasma cascade, self-organization, local relaxation processes, intermittency and coherent structures, effects on reconnection, and channels for energy conversion. Work on these subjects, an effort very much still in-progress, will lead to deeper understanding of the heating of the solar corona, the acceleration of the solar wind, energy transfer into the geospace system, the propagation of energetic particles throughout the cosmos. In this regard there is great potential in long-awaited multispacecraft turbulence missions such as HelioSwarm [2]. Partial support for this work is acknowledged from the Magnetospheric Multiscale Misson, the ISOIS instrument team on the Parker Solar Probe Mission, and NASA Living with a Star and Hemispheric Guest Investigator Programs. [1] Matthaeus, W.H. & Velli, M. Space Sci Rev (2011) 160: 145. https://doi.org/10.1007/s11214-011-9793-9 [2] Matthaeus, W., et al. arXiv:1903.06890 [physics.space-ph]