PL-3 AAPPS-DPP2020
4th Asia-Pacific Conference on Plasma Physics, 26-31Oct, 2020, Remote e-conference

The nature of solar wind turbulence: challenge for future study

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Solar wind is a plasma moving with super-sonic velocity outwardly in the solar terrestrial space. Solar wind fluctuations have simultaneous both the turbulence nature and the wave nature[1]. How to describe the interactions inside the solar wind turbulence has been a long debate problem. Here we report new observations and their comparison with theoretical models. We find that the convective structures in the solar wind turbulence have important influence on the power spectral index obtained from the wavelet techniques proposed by Horbury et al. (2008)[2] or structure functions proposed by Chen et al. (2012)[3]. If one does not remove this influence, one gets anisotropic spectra which support critical balance theory (Goldreich and Sridhar, 1995)[4]. However, when we remove the structures and only select the intervals with stationary background field, the power spectra become isotropic[5,6,7,8]. We find that the normalized self-correlation level contours are nearly 3D isotropic[9,10,11]. We also find in the high-speed wind that the Elsässer variables $\delta z-$ is composed of noise[12,13], questioning the existence of non-linear interactions between $\delta z+$ and $\delta z-$[14]. We also find an evidence to support the cyclotron resonance damping at high-frequency break[15,16,17]. Both the previous fluid turbulence models and the MHD turbulence models are not supported by these observations. These results propose a new challenge: how to model the solar wind turbulence. One needs to make a breakthrough to develop a new turbulence model to describe our new observations in the solar wind fluctuations.

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