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Nature of the solar wind turbulence

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The fluctuation energy in the solar wind turbulence can heat the plasma through cascading and dissipation processes. However, the energy cascading and dissipation mechanisms in the solar wind turbulence remain under debate. We have studied the solar wind turbulence through observations from the aspects of isotropic cascade, turbulence characteristics, dissipation, and development. Our new results include: 1) We find that the observed spectral anisotropy of solar wind power spectra in the inertial range results from the small-scale intermittency rather than the widely accepted critical balance cascading process(Wang et al., 2014, 2015, 2016; Wu et al., 2020b). 2) We find that the 2D and 3D level contours of magnetic field and velocity self-correlations are isotropic for short intervals from about 10hours to 1hour. This result is not consistent with the prediction by the critical balance cascade theory about more pronounced elongation at smaller scales than at larger scales (Wang et al., 2019; Wu et al., 2019ab). 3) We find a pure Alfvén wave at 1 AU for the first time and the noise nature of Elsässer variable z-, which suggests that the energy cascading produced by the nonlinear interactions between the outward-propagating and inward-propagating Alfvén waves may not exist in the highly Alfvénic solar wind (Wang et al., 2012, 2018c, 2020). 4) We identity the intermittent structures in the solar wind turbulence as being mostly rotational discontinuities (RDs, 86.5%). And the RD-associated intermittent structures are found to be not accompanied with local heating of the solar wind plasma (Wang et al., 2013). 5) We show the continuous variation of the spectral break frequency between the inertial range and dissipation range on full-range β in the solar wind turbulence. Our result favors the idea that the cyclotron resonance is an important mechanism for energy dissipation at the spectral break (Wang et al., 2018ab). 6) In both fast and slow wind, we find that the sweeping energy supply rate is consistent with the observed perpendicular heating rate, which supports the concept that the energy added from the energy-containing range is transferred by an energy cascade process to the dissipation range, and then dissipates to heat the solar wind (Wu et al., 2020a). These findings will promote the understanding of the cascading and heating processes about the solar wind turbulence.

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