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Two-component magnetic helicity for two-component turbulent fluctuations

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It is believed that the solar wind turbulence may consist of Alfvenic wave fluctuations. The identification of wave modes in the solar wind turbulence becomes an important issue. Some methods have been adopted to diagnose the possible wave characteristics, e.g., transport ratio of E to B in Bale et al. (2005), dispersion relation derived from k-filtering result by Sahraoui et al. (2010). Previous study results tend to attribute the solar turbulence to be mainly cascaded via (quasi-)perpendicular waves like kinetic Alfven wave or whistler wave, while the (quasi-)parallel Alfven cyclotron wave that may be crucial for perpendicular heating ions is often neglected.

This study presents the wave characteristics of the solar wind turbulence from the perspective of magnetic helicity. The reduced fluctuating magnetic helicity (sigma_m) is investigated as a function of the angle between solar wind velocity and local mean magnetic field (theta_VB). We find that, in the solar wind outward magnetic sector sigma_m is clearly negative in theta_VB<30 and 1<p<4s (p is time period) and positive in 40<theta_VB<140 and 0.4<p<4s. The sign of sigma_m changes when look at the inward magnetic sector. These features of sigma_m in many cases indicates the ubiquitous existence of left-handed polarized Alfven cyclotron waves in the solar wind turbulence in addition to the right-handed polarized kinetic Alfven waves or whistler waves.

To interpret these observational results in theory, we make a numerical calculation of the theta_VB distribution of sigma_m with a method similar to Howes et al. (2010), by assuming that sigma_m is contributed from the helicity of waves with two-component turbulent spectra (slab and 2D). The consistence between observational and modeling results indicates the possibility of hybrid wave modes (Alfven cyclotron waves and kinetic Alfven waves/whistler waves) in the solar wind turbulence.