Nature of Elsässer Variables in the slow solar wind turbulence

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Elsässer Variables \(z^\pm\) are widely considered as outward and inward propagating Alfvén waves in the solar wind turbulence study. It is believed that they can interact nonlinearly with each other to generate energy cascade. However, \(z^-\) variations sometimes show a feature of convective structures or a combination of white noise and pseudo-structures. Here we present the amplitude of \(z^\pm\) in \(\sigma_c\) (normalized cross helicity) - \(\sigma_r\) (normalized residual energy) plane in order to get some information on the nature of \(z^\pm\). Measurements from the WIND spacecraft in the slow solar wind during 2007-2009 are used for analysis. In each interval with length of 20 min, we calculate \(\sigma_c\), \(\sigma_r\), and consider the variance of \(z^\pm\) as the amplitude of them for the given interval. We find that in the \(\sigma_c\)-\(\sigma_r\) plane, the level contours of the average \(z^-\) amplitude present a feature of nearly horizontal stratification, which means that the amplitude of \(z^-\) is independent of the value of \(\sigma_c\), and is just related to \(\sigma_r\). The horizontal-stratification feature suggests that \(z^-\) could be convective structures. While the level contours of the average amplitude of \(z^+\) are approximately concentric semicircles, and the circle with larger radius corresponds to larger \(z^+\) amplitude. It indicates that \(z^+\) represents Alfvén waves. The nature of \(z^\pm\) in the slow wind here will help us to understand more about the cascade process in the solar wind turbulence.