RADIAL EVOLUTION OF SOLAR WIND TURBULENCE ANISOTROPY BASED ON CT-IMAGING OF THE MULTI-DIMENSIONAL POWER SPECTRAL DENSITY

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We present observations of the power spectral anisotropy in the wavevector space of solar wind turbulence and study how it evolves in interplanetary space with increasing heliocentric distance. We use magnetic field measurements from the Helios 2 spacecraft within 1 AU. To derive the power spectral density (PSD) in the ($k_\parallel$, $k_\perp$) space based on single-satellite measurements is a challenging task that had not been accomplished previously. Here, we derive the spectrum PSD2D($k_\parallel$, $k_\perp$) from the spatial correlation function CF2D($r_\parallel$, $r_\perp$) by a transformation according to the projection-slice theorem. We find the so-constructed PSDs to be distributed in k space mainly along a ridge that is more inclined toward the $k_\perp$ axis than the $k_\parallel$ axis. Furthermore, this ridge of the distribution is found to gradually get closer to the $k_\perp$ axis as the outer scale length of the turbulence becomes larger with increasing radial distance. In the vicinity of the $k_\parallel$ axis, a minor spectral component appears that probably corresponds to quasi-parallel Alfvenic fluctuations. Their relative contribution to the total spectral density tends to decrease with radial distance. These findings suggest that solar wind turbulence undergoes an anisotropic cascade transporting most of its magnetic energy toward larger $k_\perp$ and that the anisotropy in the inertial range is radially developing further at scales that are relatively far from the ever increasing outer scale. For the ion-scale fluctuations, we speculate, from the radial evolution of the extended oblique major component, a transition tendency from dominance by oblique Alfve n/ion-cyclotron waves (<1 AU) to dominance by kinetic Alfven waves (>1 AU).