Study of solar wind issues using interplanetary scintillation

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Interplanetary scintillation (IPS) observation has been greatly improved by development of the deconvolution method which uses computer assisted tomographic analysis (CAT) technique (Kojima et al., 1998). The CAT analysis method can retrieve intrinsic solar wind speed with high spatial resolution. Along with several advantages over in situ measurements, the IPS CAT has been used to study the important issues on the solar wind such as solar activity dependence of 3D solar wind structure, the origin of the slow solar wind, the acceleration mechanism of the fast solar wind.

1. 3D solar wind structure

Ulysses observed the bimodal velocity structure in the minimum phase and small but noticeable gradual increase in velocity towards higher latitudes (Woch et al., 1997). Velocity asymmetry was also observed in the high-latitude fast wind between the northern and southern hemispheres (Goldstein et al., 1996). Although Ulysses took about ten months to observe these solar wind features at all the latitudes from the south to north poles, the IPS CAT can observe these features within a few months. Using this advantage, the solar activity dependence of the 3D solar wind structure has been studied.

2. Origin of low-speed solar wind

Compact low-speed streams which appeared in the solar minimum phase near the solar equator were studied (Kojima et al., 1999). The slowest speed region is not located right above the closed loops (helmet structure), but is shifted away from them and connected to the open field regions (coronal hole) in the vicinity of the closed loops. Therefore, this compact stream is magnetically unipolar and consequently a neutral line does not traverse through it. This solved the long-standing question why the lowest speed locus tends to deviate from a neutral line. The IPS CAT also found another kind of a slow wind source in the polar region at the solar maximum when a polar coronal hole became small and was going to disappear in 1990 (CR 1829) and 1999 (CR 1955) (Ohmi et al., 2001, 2003).

3. Solar wind acceleration mechanism

Coronal holes play important role in determining the solar wind structure. In order to model the solar wind acceleration it is important to find the universal relation between the global properties of the solar wind and corona. However most coronal holes are at high latitudes where spacecraft cannot access, with the exception of the Ulysses. Therefore the IPS CAT, which can derive an unbiased solar wind velocity map over all latitudinal ranges, is a useful important tool to find the relation between the wind velocity and the coronal magnetic condition. The IPS CAT together with coronal magnetic field data did find a physical parameter combination B/f of a flux expansion rate f and photospheric magnetic field intensity B has a high correlation with the solar wind velocities from various kinds of coronal holes (Hirano et al., 2003; Kojima et al., 2004, 2006, 2007).

Elucidation of the acceleration profile is another important issue to give observational constrains to the acceleration models. The IPS is a unique device which can observe the solar wind from the near sun region to 1AU with collaborative IPS observations at different radio frequencies (Kojima et al., 2004).