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Solar wind study using advanced technique of interplanetary scintillation measurements

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Radio waves from a compact radio source are scattered by electron density irregularities in the solar wind, and the scattered radio waves interfere with each other as they propagate to the Earth, producing diffraction patterns on an observer's plane. This phenomenon is called interplanetary scintillation (IPS). Since Hewish et al. developed the IPS technique in 1964, it has been used to study the three-dimensional solar wind structure and dynamics with advantages over in situ spacecraft measurements: It can observe three-dimensional solar wind in a short time, and the observations can be carried out consistently over a solar cycle. However, because of the IPS line-of-sight (LOS) integration effect, solar wind had to be studied with blurred images. In the late 1990s, new analysis methods of IPS observation, which can deconvolve the LOS integration effect using computer-assisted tomography (CAT) technique, were developed by collaborative works of groups at the STE Lab (Nagoya University) and CASS(UCSD). Four different CAT methods are developed. One is named the corotating tomographic method, which can be used to analyze temporarily stable solar wind structure. The second is the time-sequence tomographic method, which can be used for slowly varying solar wind structure. The third method is MHD-IPS tomography in which MHD simulation is incorporated with IPS observations using a tomographic method. The last one is time-dependent tomography, which can be applied to propagating CME measurements.

Corotating tomography can derive the detailed solar wind structure in the solar minimum phase from which we can study the latitudinal solar wind structure, origin of low-speed wind and coronal parameters which determine the solar wind acceleration mechanism. The time-sequence tomography and the time-dependent tomography can determine solar wind structure from short period observations and are now being tested for application to space weather forecasting. MHD-IPS tomography can provide solar wind parameters not only with velocity but also magnetic field, number density and temperature at any heliocentric distance. Thanks to IPS measurements, the solar wind can be observed consistently over a solar cycle and the solar cycle dependence of the solar wind structure is studied.

The IPS measurements have enough spatial resolution and accuracy to collaborate with spacecraft observations and theoretical studies of the solar wind. However the IPS at a single frequency cannot observe the solar wind in the full distance range from the Sun to the earth, and the IPS at a single site cannot monitor the solar wind 24 hours a day. Therefore, international collaboration among IPS facilities operated at different frequencies and different longitudinal sites is planned in the IHY.