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Next generation interplanetary scintillation observation system for space weather

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The solar wind, which is a high-speed plasma flow from the Sun, forms the heliosphere that contains all planetary systems including the Earth. The solar wind sometimes generates great disturbances to the environment around the Earth. This disturbance can cause enormous damage to social infrastructure such as communication failures and artificial satellite failures. The real-time observation of the solar wind and its forecasting have become more and more important for space weather. Interplanetary scintillation (IPS) is a radio scattering phenomenon caused by the turbulences in the solar wind. The IPS observation using ground-based radio telescopes has been an important technique to investigate the global structure of the solar wind in the heliosphere. The IPS observation has also been used for space weather research and operations.

Institute for Space–Earth Environmental Research (ISEE), Nagoya University have observed IPS to derive the solar wind velocity and density irregularities for several decades using large radio telescopes at 327 MHz. The derived solar wind characteristics are included in the three-dimensional (3D) global magnetohydrodynamic (MHD) simulation of the heliosphere to forecast the arrival of the solar wind and coronal mass ejections (CMEs). The accuracy of the CME forecast by IPS based MHD simulations better than that of MHD simulations without IPS data. This suggests that the IPS data can improve the accuracy of the space weather forecasts. On the other hand, the recent space weather requires more accurate prediction of the solar wind that requires more IPS observations. Now, a new project to develop the next generation IPS observation system is in progress. We consider a new ground-based radio observation system at 327 MHz by constructing a 2D flat phased-array antenna system consisting of multiple dipole antennas, and installing digital beam forming devices. The multidirectional simultaneous IPS observation using this system enables the solar wind observation 10 times as much as the conventional radio instruments have been done. This project will greatly contribute to understanding the solar wind and improving the accuracy of space weather forecasts. We have developed a prototype of the digital phased array instrument. This instrument has 8 analog-digital converters (ADCs), field-programmable gate array (FPGA), and 10-Gbit Ethernet output. This system enables us to measure 8 beams simultaneously by processing 8 types of different beamforming in parallel. A small scall array system is under construction as a phase-I project.