URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Radio Occultation Observations of the Solar Corona with Akatsuki Spacecraft

T. Imamura*(1), S. Chiba(1), H. Ando(2), M. Tokumaru(3), D. Shiota(4), Y. Murata(5), H. Takeuchi(5), T. Toda(5)
(1) University of Tokyo, Japan, e-mail: t_imamura@edu.k.u-tokyo.ac.jp; chiba-shota78@g.ecc.u-tokyo.ac.jp
(2) Kyoto Sangyo University, Japan; e-mail: hando@cc.kyoto-su.ac.jp
(3) Institute for Space-Earth Environmental Research, Nagoya University, Japan; e-mail: tokumaru@isee.nagoya-u.ac.jp
(4) National Institute of Information and Communications Technology, Japan; e-mail: shiotad@nict.go.jp
(5) Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Japan; murata@vsop.isas.jaxa.jp; takeuchi.hiroshi@jaxa.jp; toda.tomoaki@jaxa.jp

The solar wind, a supersonic plasma flow blowing in the solar system, originates from the solar corona. The mechanisms for heating the solar corona and accelerating the solar wind are major problems of space physics; theories suggest the energy deposition by magnetohydrodynamic waves are important. In order for the high-speed plasma flow to be created, heating of the corona from the coronal base to distances of 10–20 solar radii is required. The physical processes in this distance region is difficult to observe with optical methods because of the low density of the plasma and is difficult to observe with in-situ methods because of the proximity to the Sun. Radio occultation is one of the powerful methods that can explore this region. Spacecraft radio occultation, in which spacecraft are used as radio sources and ground antennas receive radio signals, is especially useful for retrieving various physical parameters in regions from far distances to the close proximity to the Sun, although observation opportunities are limited as compared to interplanetary scintillation (IPS) measurements that use natural radio sources.

We have conducted radio occultation observations of the solar corona repeatedly using JAXA’s Venus orbiter Akatsuki during its superior conjunction periods. After the launch of the spacecraft in 2010, coronal sounding campaigns were conducted in June–July 2011, May–June 2016, December 2017–January 2018, August 2019, and March-April 2021. Radio waves in X-band (8.4 GHz) stabilized by an onboard ultra-stable oscillator were transmitted from the spacecraft and received at the Usuda Deep Space Center (UDSC) in Japan. In each campaign, signals were recorded in open-loop mode for several hours every 2–3 days, and regions from the vicinity of the Sun to heliocentric distances of ~10 solar radii were covered. From the recorded data, we can derive the flow velocity, the density fluctuation spectrum, the characteristics of compressive waves, and the axial ratio and the inner scale of turbulence. Right and left circular polarizations were recorded, allowing also the derivation of Faraday rotation that provides information on Alfven waves. From the radial distributions of these physical quantities and the comparison between different solar activity phases, we can investigate the mechanism for solar wind generation and the variation in the solar activity cycle. The results from the campaign in 2011 have already been reported [1, 2, 3]. An overview of the whole observation campaigns and the comparison between the epochs will be given in the presentation.

References

[1] T. Imamura, M. Tokumaru, H. Isobe, D. Shiota, H. Ando, M. Miyamoto, T. Toda, B. Häusler, M. Pätzold, A. Nabatov, A. Asai, K. Yaji, M. Yamada, M. Nakamura, “Outflow structure of the quiet Sun corona probed by spacecraft radio scintillations in strong scattering,” *Astrophys. J.*, **788**, 117(10pp), June 2014, doi:10.1088/0004-637X/788/2/117.

[2] M. Miyamoto, T. Imamura, M. Tokumaru, H. Ando, H. Isobe, A. Asai, D. Shiota, T. Toda, B. Häusler, M. Pätzold, A. Nabatov, M. Nakamura, “Radial distribution of compressive waves in the solar corona revealed by Akatsuki radio occultation observations,” *Astrophys. J.*, **797**, 51(7pp), December 2014, doi:10.1088/0004-637X/797/1/51.

[3] H. Ando, D. Shiota, T. Imamura, M. Tokumaru, A. Asai, H. Isobe, M. Pazold, B. Hausler, and M. Nakamura, “Internal structure of a coronal mass ejection revealed by Akatsuki radio occultation observations,” *J. Geophys. Res.,* **120**, 5318–5328, July 2015, doi:0.1002/2015JA021076.