3rd URSI AT-AP-RASC, Gran Canaria, 29 May – 3 June 2022

Interplanetary scintillation signatures of a continuing long term steady declining of solar cycle magnetic fields

Harsha Avinash Tanti*(1), Susanta Kumar Bisoi(2), and Abhirup Datta(1)
(1) Department of Astronomy, Astrophysics and Space Engineering, IIT Indore, Madhya Pradesh, India, 453552
(2) Department of Physics and Astronomy, National Institute of Technology Rourkela, Odisha, India, 769008

The long term variations of solar cycle magnetic fields made through studies of solar photospheric magnetic fields during solar cycles 21–24 show a steady decline in their values since mid-1990's. It is known that the solar photospheric magnetic fields extend out into the corona, and thereon, eventually, drag into the heliosphere by the ever-flowing solar wind plasma. Thus, it is expected that the signatures of the long term decline in solar photospheric fields shall be reflected in the solar wind fluctuations such as electron density fluctuations of the solar wind plasma and referred to as solar wind density turbulence, or otherwise, simply called as solar wind turbulence level. The causal relationship existing between the solar wind density fluctuations to that of the magnetic field variations make the study of the temporal changes of the solar wind turbulence level preferably important in the context of the recent declining of solar cycle magnetic fields observed during the solar cycle 24 [1]. The changes in solar wind turbulence level can be studied using an interplanetary scintillation (IPS) technique and has been used [2, 3] to report the IPS signatures of the steady declining magnetic fields during the solar cycles 22 and 23. Here, we made an attempt to study the IPS signatures of the observed declining during the solar cycle 24–25.

The electromagnetic waves emitted from distant extra-galactic radio sources are subjected to variations in their signal intensity when they are traversing through the solar wind plasma. The temporal variations observed in the intensity of the radio sources is commonly known as IPS [4]. The IPS observations obtained by the ground-based radio IPS telescope such as the ISEE, Nagoya, Japan at 327 MHz are used here to study the temporal changes in scintillation index ($S^2 = [(<I^2> - <I>^2)/<I^2>]$ where I is the signal intensity), a parameter which is actually a measure of the solar wind turbulence level. The variation of scintillation index, m, is dependant on the radio source size and the heliocentric distance between the line of sight (LoS) of the observer at the Earth and the Sun. In order to study the temporal variations of m for 10 radio sources selected based on the availability of enough number of observed data points for the respective sources, we first remove the angular source size dependency in a similar manner described in [3]. A Marian's model [5] is used to find the best fit of the source size and then by appropriately scaling the best fit of the respect sources to that of a point radio source 1148-001 having an angular size of 10 milliarcsecond, the angular dependencies was removed. Thereafter, the distance dependency was removed by normalizing the scintillation data of the point source at each heliocentric distance to that at the turn-over heliocentric distance [2]. Finally, the temporal variations of m for all 10 sources obtained between 1983–2020 has been found to show a continuing declining trend until 2020 that has begun almost three decades earlier. The continuously observed low values of solar wind turbulence level are apparently the effective signatures of the relatively weak solar cycle magnetic activity changes that has been happening recently on the Sun.

References

[1] Bisoi, S. K., Janardhan, P., and Ananthakrishnan, S., "Another mini solar maximum in the offing: A prediction for the amplitude of solar cycle 25", *Journal of Geophysical Research: Space Physics*, 2020, **125**, e2019JA027508, doi: 10.1029/2019JA027508.

[2] Janardhan, P., Bisoi, S. K., Ananthakrishnan, S., Tokumaru, M., and Fujiki, K., "The prelude to the deep minimum between solar cycles 23 and 24: Interplanetary scintillation signatures in the inner heliosphere", *Geophys. Res. Lett*, 2011, **38**, pp L20108, doi:10.1029/2011GL049227.

[3] Bisoi, S.K., Janardhan, P., Ingale, M., Subramanian, P., Ananthakrishnan, S. Tokumaru, M. and Fujik, K., "A study of density modulation index in the inner heliospheric solar wind during solar cycle 23.", *The Astrophysical Journal*, 2014, **795**, 1, pp 69, doi:10.1088/0004-637X/795/1/69.

[4] A. Hewish, P. F. Scott, and D. Wills, "Interplanetary scintillation of small diameter radio sources", *Nature*, **203**, 4951, pp 1214-1217, doi:10.1038/2031214a0.

[5] Marians, M., "Computed Scintillation Spectra for strong turbulance", *Radio Science*, 1975, **10**, 1, pp 115-119, doi:10.1029/RS010i001p00115.