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Magnetic field variability detected by interplanetary scintillation over the long term

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The study of the long-term variations of the solar photospheric magnetic fields during solar cycle 21-24 shows a declining trend since the mid-1990s. In the solar photosphere, magnetic field lines extend into the corona, where the solar wind plasma eventually drags the magnetic fields into the heliosphere. As a result, long-term declines in solar photospheric magnetic fields expected to manifest themselves in solar wind fluctuations, such as fluctuations in electron density within the plasma in the solar wind, referred to as solar wind density turbulence, or just solar wind turbulence levels as a whole. This relationship between the solar wind density fluctuations and solar photospheric magnetic field variations makes the study of the temporal behaviour of the solar wind turbulence level important. As a result the signatures of the long term steady decline of the solar cycle magnetic fields can be probed by observing the changes in the solar wind turbulance levels [1]. The temporal behaviour of the solar wind turbulence level can be probed using interplanetary scintillation (IPS) technique [2]. Recent studies reports the steady decline of the solar magnetic fields during the solar cycles 22 and 23 by studying the IPS signatures [3]. In this work, analysis of declination of the solar magnetic field during solar cycle 24–25 using the IPS technique is attempted.

The solar-wind plasma causes the a variation in the intensity of the electromagnetic waves emitted from distant extra-galactic radio sources when it is traversing through it. The analysis of such intensity variation of intensity of the radio sources is known as IPS [4]. In order to analyse the temporal variations in scintillation index ($S^2 = [(< I^2 > - < I >^2)/ < I^2 >]$, here I - signal intensity), the IPS observations made by a ground-based radio IPS telescope, such as the ISEE in Nagoya, Japan, at 327 MHz, were utilized. The scintillation index is a parameter that is used in order to measure the solar wind turbulence level. The fluctuations of the scintillation index, m, is dependant on the heliocentric distance between the Sun to the radio source - observer line of sight (LoS) and the angular size of the radio source. Based on the availability of enough number of data points from the IPS observation, 10 radio sources were selected. Thereafter, to study temporal variation of m, we removed the angular source size dependency and the heliocentric distance between the Sun and LOS dependency in a similar manner described in [3]. The source size dependency is removed by using the Marian's model [5] to find the angular size of the source, then by appropriately scaling the best fit with respect to that of a point source 1148-001 having an angular size of 10 milliarcsecond. Afterwards using appropriate normalization, the scintillation data of the point source at each heliocentric distance is adjusted to the turn-over heliocentric distance in order to remove the distance dependenc [2]. Lastly, the temporal variations of m obtained over the period 1983–2020 show a decline that began almost 30 years ago and is continuing to decline. Recently, there have been relatively weak changes in solar cycle magnetic activity on the Sun. These low levels of turbulence are the effective signatures of these changes.

References

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