On the validation of the rotation procedure from HEE to MFA reference frame in presence of Alfvén waves in the interplanetary medium

Giuseppina Carnevale\textsuperscript{1,2}, Mauro Regi\textsuperscript{2}, Patrizia Francia\textsuperscript{1}, and Stefania Lepidi\textsuperscript{2}

\textsuperscript{1}University of L'Aquila, Physical and Chemical Sciences, L'Aquila, Italy (carnegiuse@gmail.com)
\textsuperscript{2}Istituto Nazionale di Geofisica e Vulcanologia, L'Aquila, Italy

Alfvén waves play an important role in the stability, heating, and transport of magnetized plasmas. They are found to be ubiquitous in the solar wind, mainly propagating outward from the Sun, especially in high-speed streams emanating from coronal holes. When high-speed streams impinge on the Earth's magnetosphere, the impact of Alfvénic fluctuations can cause magnetic reconnection between the intermittent southward IMF and the Geomagnetic field, leading to energy injection from solar wind into the Earth's magnetosphere. In this work, we tested a rotation procedure from the Heliocentric Earth Ecliptic (HEE) to the Mean-Field Aligned (MFA) reference frame, identified by means of the Empirical Mode Decomposition (EMD), of both solar wind velocity and interplanetary magnetic field at 1 AU. Our aim is to check the reliability of the method and its limitations in identifying Alfvénic fluctuations through the spectral analysis of time series in the MFA reference frame. With this procedure, we studied the fluctuations in the main-field-aligned direction and those in the orthogonal plane to the main field. To highlight the peculiarities of each case of study and be able to better identify Alfvén waves when applying this procedure to real data, we reproduced the magnetic and velocity fields of a typical corotating high-speed stream. We tested the procedure in several cases, by adding the presence of Alfvén waves and noise. We performed the spectral analysis of the MFA component of both magnetic and velocity fields to define the power related to the two main directions: the one aligned to the ambient magnetic field and the one orthogonal to it. The efficiency of the procedure and the result's reliability are supported by Monte Carlo tests. The method is as well applied to a real case represented by a selected corotating solar wind stream. The results are also compared with those obtained by using the Elsässer variables to analyze the Alfvénicity of fluctuations via the cross-helicity, which is related to the degree of correlation between the solar wind velocity and the magnetic field fluctuations.