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Multispacecraft observation of turbulence evolution in the inner heliosphere

Luca Sorriso-Valvo[1,2]
[1] Swedish Institute of Space Physics, Uppsala, Sweden,
[2] ISTP/CNR – Institute for Plasma Science and Technology, Bari, Italy
e-mail (speaker): lucasorriso@gmail.com

The solar wind is characterized by turbulence, whose role in the global dynamics of the heliosphere and in the plasma heating and particle energization processes is complex and crucial [1,2]. Its radial evolution and the resulting non-adiabatic plasma heating are among the open questions. The exceptional deployment of spacecraft in the inner heliosphere offers a unique possibility to perform multi-point observations of solar wind turbulence.

Rarely occurring in the past, orbital configurations allow the measurement of the same plasma parcel at different distances from the Sun during radial alignment events, or of plasma from the same stable solar source. These represent the best possible way to properly determine the radial evolution of turbulence, undisturbed by solar variability and by interactions with the large-scale solar wind structure.

Ideally, selection of events relies on the analysis of orbital information jointly with the solar wind speed, corroborated by data-driven model reconstruction of the connectivity to the solar coronal source regions, cross-correlation evaluation, and visual inspection [3].

Another useful configuration occurs when two or more spacecraft measure, at different distance from the Sun, solar wind streams coming from the same source region, but at different times. If the source is reasonably stable, the turbulence can be considered as stationary and a comparison can be made.

A few events of both kinds have already occurred, providing preliminary results that are presented here. For the first type, these include an old radial alignment of Ace and Ulysses [4], and more recent ones of Solar Orbiter and Parker Solar Probe [3], and one of Parker Solar Probe and Bepi Colombo [5].

For the second type, in preparation for the numerous upcoming events a study was performed using Helios 2 recurrent fast and slow streams emitted by the same solar sources [6]. A more recent recurrent stream was also measured by Solar Orbiter and Parker Solar Probe [7].

For these events, the evaluation of the spectral properties, intermittency, and of the turbulent energy transfer rate through the linear scaling of the third-order moment showed that the turbulence decays during the expansion, both in fast and in slow solar wind.

Assuming a power-law decay, it was possible to measure the decay exponents for each case, which are crucial ingredients of solar wind modeling.

A long list of upcoming and past events exist, which will soon provide a thorough and statistically robust mapping of the radial evolution of turbulence.

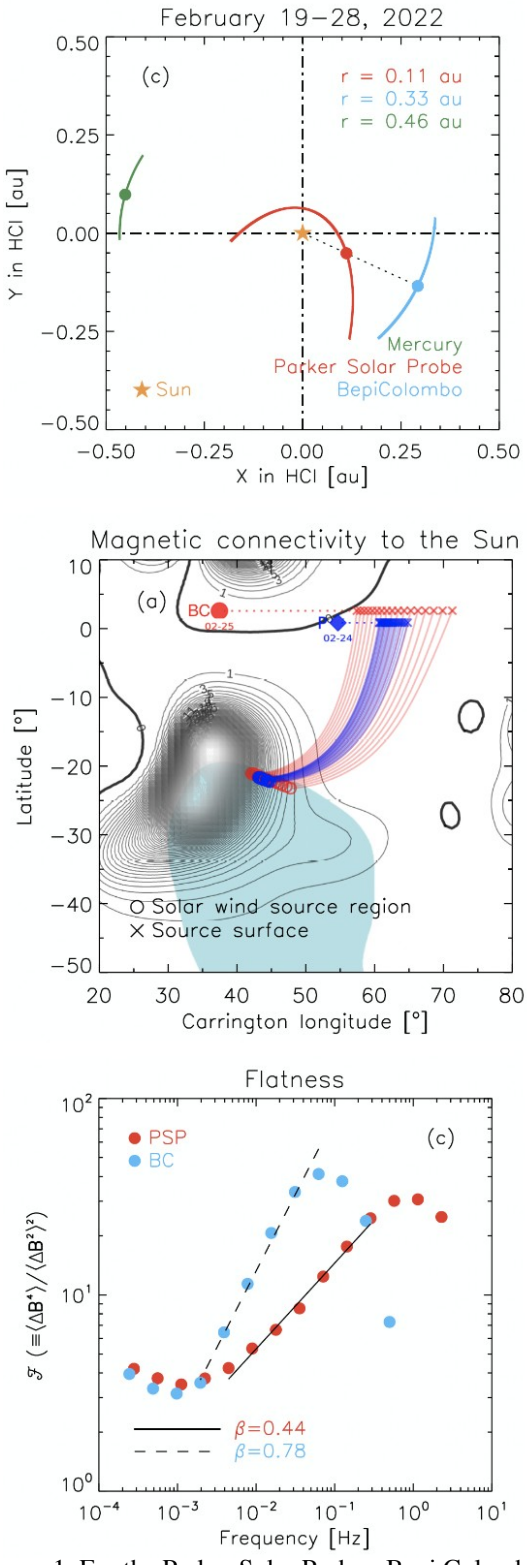

Figure 1. For the Parker Solar Probe - Bepi Colombo alignment event: orbital parameters (top), solar connectivity plots (center) and radial evolution of the flatness (bottom). Figure from Ref. 5.

References
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[7] Sorriso-Valvo et al., in preparation.