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How the fast solar wind develops on the way from the Sun to Earth?

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The characteristics of solar wind through observations and modelling have been, during last few decades, addressed in the numerous analyses. However, the accuracy of the solar wind modelling is still strongly lagging behind the accuracy of the CME modelling (e.g. Hinterreiter et al. 2019, Maharana et al. 2022 and references therein).

The novel and recently available Parker Solar Probe (PSP, Fox et al. 2016) observations allow us to study the solar wind characteristics in the low solar corona, at few tens of solar radii, and not only at 1 au as before the time of PSP. The first several perihelion encounters of the PSP revealed the highly variable structure of both, fast and slow solar wind. An example of the solar wind plasma characteristics observed by the PSP is shown in Fig. 1. The top panel presents simultaneously the time series of the solar wind plasma density and velocity. The second panel shows the time series of the interplanetary magnetic field, while the third and fourth panel present the time series of the phi angle and the radial distance of the PSP spacecraft from the Sun, respectively.

In this study we compare the characteristics of the solar wind originating from the coronal holes of different sizes, with the characteristics of the same solar wind flows observed at Earth. As the accent is put on the solar wind characteristics originating from the small coronal holes, we have first employed a magnetic connectivity tool (developed by ESA's MADAWG group) to associate the solar wind observed by the PSP with their source regions on the Sun. After that we looked for the corresponding fast solar wind in the in situ observations at 1 AU. The example of the in situ signatures of a solar wind originating from a small coronal hole is presented in Fig. 1. During the marked time interval the solar wind velocity and density are anti-correlated, as generally observed in a case of solar wind originating from the coronal holes.
In this presentation we discuss how the characteristics of the solar wind observed by the PSP (originating from the small and large coronal holes) compare with the solar wind characteristics observed at 1 au. The observed solar wind flows, at close to the Sun distances and at 1 au, are also modelled by recently developed 3D MHD model EUHFORIA (Pomoell & Poedts, 2018).

References:
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[3] Fox et al., Space Science Review. 204, 7–48
[4] Pomoell, J & Poedts, S 2018, Journal of Space Weather Space Climate, 8, A35

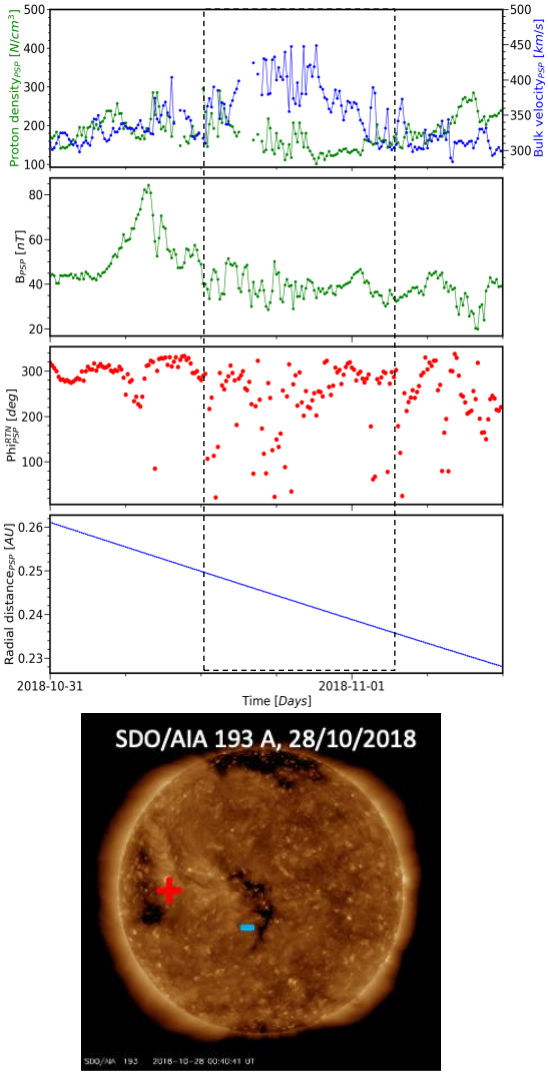

Figure 1 The top panel shows the solar wind characteristics as observed by the PSP. The source of the fast solar wind was small, narrow, elongated negative polarity coronal hole (bottom panel) observed at the centre of the solar disc few days earlier.