Large-scale electron solar wind parameters of the inner heliosphere with Parker Solar Probe/FIELDS

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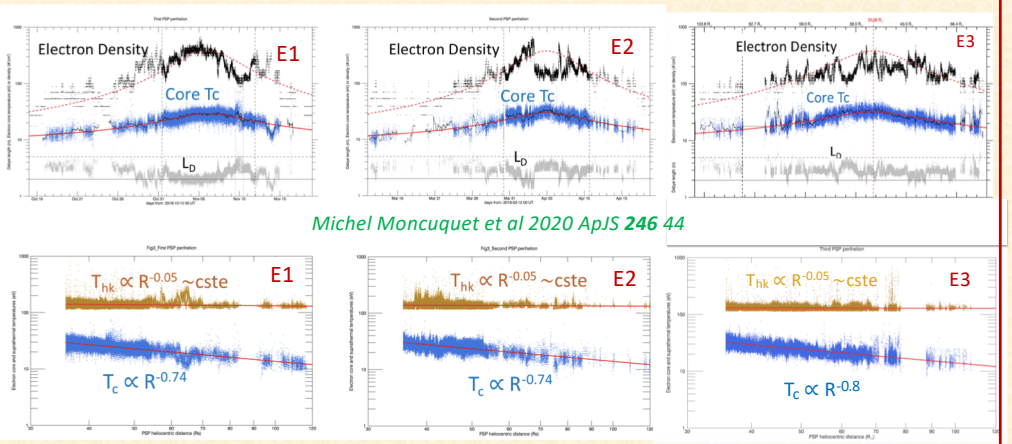
Datasets : FIELDS/RFS/PSP using QTN diagnostics – Perihelion @ 36 Rs
Analysis of 3 encounters:
E1: 15 oct – 17 nov 2018 ;
E2: 12 mar – 17 april 2019 ;
E3: 15 aug – 12 sept 2019

METHOD: QUASI-THERMAL NOISE (QTN)

- ✓ **QTN** measures in situ electrostatic fluctuations of the plasma, due to the particle thermal motion, at the terminals of a passive electric antenna, using a sensitive radio receiver. *Meyer-Vernet, N., K. Issautier, and M. Moncuquet (2017), doi:10.1002/2017JA024449*
- ✓ **QTN yields electron parameters** : electron density from the plasma frequency, electron core temperature from the thermal plateau (below the peak) and halo temperature from the height of the peak

ELECTRON PARAMETERS VARIATIONS WITH RADIAL DISTANCE



*Michel Moncuquet et al 2020 ApJS **246** 44*

Fig 1: Variations of the electron density, core temperature and halo temperature from the three first encounters of PSP [Moncuquet et al., 2020]. Same kind of variations for Tc. Halo temperature almost constant with distance. Density variations around R^{-2} (red dotted line).

ENERGY FLUX IN THE HELIOSPHERE

$$W_P = n * m_p * V_p * \left[\frac{V_p^2}{2} + \frac{5K_B(T_e+T_p)}{2m_p} + \frac{GM}{R_\odot}\right]$$

W_p= kinetic energy + enthalpy energy + energy to leave the Sun's gravitational potential

DISCUSSION

- ✓ Averaged energy flux independent of latitude and solar wind speed within 10%, based on 20-years of data (Helios, Ulysses, Wind). It varies weakly over the solar cycle.
- ✓ Its value is 79 $W.m^{-2}$ at 1 Rs. A large spread of stellar winds have the same energy flux.

*Le Chat, G., Issautier, K. & Meyer-Vernet, N. Sol Phys **279**, 197–205 (2012).*

- ✓ Encounter 1 & 2 have different types of wind structures. The deduced energy flux value obtained on a short time interval (a few days) is 90 and 60 W. m^{-2} at 1 Rs, respectively.
- ✓ Results in agreement to long-term intervals.
- ✓ Energy flux varies with the radial distance

STATISTICAL STUDY

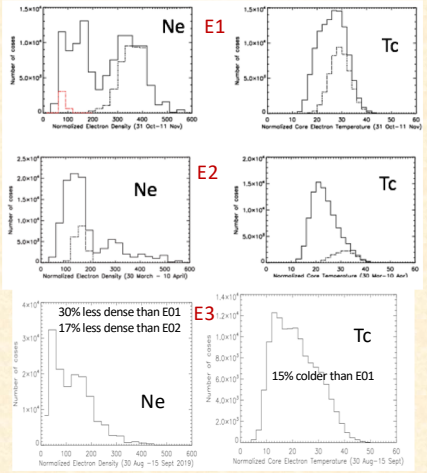


Fig 2: Histograms of the electron density and core temperature scaled to 36 Rs, obtained for the three first encounters. For E1 (top panels), we superimpose a dilute wind period (9-10 nov) as a red dotted-dash line and a period of dense wind (grey distribution) around the 1rst perihelion (3-6 nov). For E2 (middle panels), we overplot as a dotted-dash grey line the histogram of density and temperature measured around perihelion 2 (3-6 April 2019). For E3, the histogram of the electron density is much more dilute, with a mean value 30% less dense than E1 and 17% less dense than E2. The histogram of core temperature is 15% colder than E1.

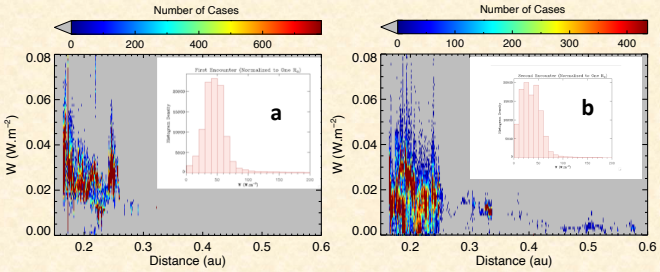


Fig 3: solar wind energy flux as a function of the radial distance, measured by PSP during its first encounter (a) and second one (b). The corresponding histogram of the energy flux scaled to 1 Rs gives the mean value in agreement with Le Chat et al. (2012)

PERSPECTIVE

- ✓ Following orbits of PSP will enable to improve the statistics on the energy flux value.
- ✓ Comparison of the energy flux using proton and alpha particle densities
- ✓ Since Encounter 4, QTN is much more reliable to have accurate electron parameters (because of $L > L_D$)