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Low-frequency observations of pulsars sample the Heliosphere

C. Tiburzi*(1), G. M. Shaifullah(2), P. Zucca(1), L. Bondonneau(3), G. Capuano(4), J.-M. Griessmeier(3), S. Guglielmino(4), I. Jebaraj(5), J. Magdalenic(5), A. P. Pellizzoni(6), E. Samara(5), G. Theureau(3)
(1) ASTRON − Oude Hoogeveensedijk 4, 7991 PD Dwingeloo (NL)
(2) Università di Milano-Bicocca − Piazza della Scienza 3, I-20126, Milano (IT)
(3) LPC2E Université d'Orléans / CNRS, 45071 Orléans cedex 2 (FR)
(4) Osservatorio Astronomico di Catania −Via S. Sofia 78, 95123 Catania (IT)
(5) SIDC-ROB − Ringlaan 3, 1180 Brussels (BE)
(6) Osservatorio Astronomico di Cagliari − Via della Scienza 5, 09047 Selargius (IT)

Pulsars observed at low frequencies are ideal probes to study the propagation effects induced by magnetized plasma; i.e., dispersion, scintillation, scattering and Faraday rotation, that are all characterized by inverse dependencies on the observing frequency. Pulsar radiation crosses, and hence is affected by three unique, magnetized plasmas: the ionized interstellar medium (IISM), the Solar wind (SW) and the ionosphere.
The Soltrack project is a cutting-edge experiment that uses high-quality, long-term, high-cadence pulsar observations carried out with the high-frequency antenna arrays of the LOw Frequency ARray (HBA/LOFAR, operating at 150 MHz) and NenuFAR (operating at 50 MHz) to study the heliosphere and its phenomena in terms of their impact on both Pulsar Timing Array experiments and Space weather applications.

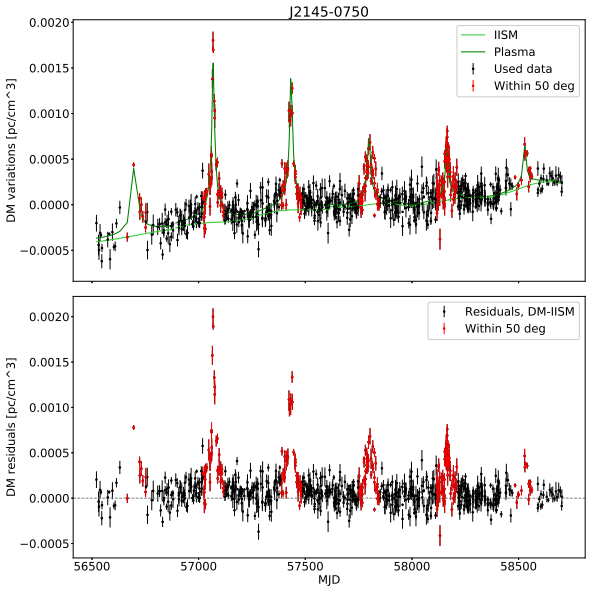

Figure 1. Time series of the "dispersion measure" (DM, i.e., the column density) parameter for the LOFAR dataset of pulsar J2145−0750. In black are the DM data points (red if the angular distance between the pulsar and the Sun was less than 50°). In light and dark green are, respectively, the plasma models of the IISM and the SW.

In particular, Soltrack has recently provided the first evidence of the Solar cycle's impact on pulsar data (see Figure 1), developed a new software to detect pulsar occultations by coronal mass ejections (CMEs), performed a wide ranging search for CMEs in the LOFAR pulsar dataset, identified the influence of Solar streamers on pulsar observations, discovered a first evidence of dispersion chromaticity due to the SW, and applied pulsar-derived measurements to the validation efforts of the EUHFORIA magneto-hydrodynamic software, that simulate the SW properties for Space weather purposes. Ongoing research encompasses the extraction of information about the heliospheric magnetic field. Figure 1 shows the SW dispersive effects along one of pulsars monitored with LOFAR, PSR J2145−0750. The upper panel shows the dispersive contributions from both the IISM and the SW, while the bottom panel displays the heliospheric part only.
In this talk, we will describe the fundamental concepts at the basis of the Soltrack experiments, and describe the results reached while paving the road for the application of pulsar data to heliospheric analyses.