Thursday 29th June 2023
SERPENTINE meeting at IRAP, abstracts

- **Jan Gieseler** : « Open-Source Analysis Platform for Solar Energetic Particles provided by SERPENTINE »

  Abstract: Combining remote sensing observations with in-situ measurements is key to fully comprehend solar eruptive processes. The recently expanded heliospheric spacecraft fleet gives unique opportunities to investigate these processes from multiple viewpoints. But combining all these distinct observations from various instruments onboard different spacecraft is a bothersome task. To achieve maximal impact for exploitation of this data by the wider scientific community, the EU Horizon 2020 project SERPENTINE aims at providing a versatile set of tools. They are provided as open-source Python Jupyter Notebooks and are aimed at non well-versed programming scientists. Next to extensive examples on how to use the multi-spacecraft spatial configuration and solar magnetic connection plotter Solar-MACH, an analysis platform for studying the energetic particle component of the in-situ observations of solar energetic particle (SEP) events has been developed. This analysis platform consists of plotting tools (e.g, energetic particle time series or dynamic spectra) as well as analysis software that allow to automatically derive SEP onsets or estimate the path length and injection time of these particles using a time-shift analysis approach. In this presentation, we will give an overview on the already available set of tools and instructions on how to use them, which is also possible completely in the cloud on SERPENTINE's own JupyterHub server.

- **Rami Vainio:** "HPD tool: The effect of shock wave properties on the release timings of solar energetic particles"

  Link: https://hpdm-tool.streamlit.app/

  Abstract: We constructed a simple 2D geometrical model to describe the propagation and longitudinal extension of a disturbance. We used this model to examine the longitudinal extension of the wave front from the eruption site as a function of time, to calculate the connection times as a function of the longitudinal separation angle, and to determine the shock parameters at any connection point. We examined how the kinematic and geometric properties of the disturbance could affect the timings of the SEP releases at different heliolongitudes.
  We show that the extension of a wave close to the solar surface may not always indicate when a magnetic connection is established for the first time. The first connection times depend on both the kinematics and geometry of the propagating wave. A shock-related SEP release process can produce a large event-to-event variation in the relationship between the connection and release times and the separation angle to the eruption site. The evolution of the shock geometry and shock strength at the field lines connected to an observer are important parameters for the observed characteristic of the release times.

- **Domenico Trotta** : " SerPyShock tool"

  https://www.frontiersin.org/articles/10.3389/fspas.2022.1005672/full

- **Daniel Price:** "MAFIAT: Magnetic field analysis tools"

  Abstract: The magnetic twist is one of the key defining parameters of solar flux ropes (FRs). The routine computation of the winding of magnetic field lines, referred to as the twist, has the

potential to lead to significant advancement in the field of solar physics and solar—terrestrial research, e.g., by enabling more accurate investigations of FR morphology, stability, and temporal evolution. However, this has been hampered by the axial-dependence of the solution and the availability of simpler, albeit approximate, methods. Here we introduce the Magnetic Field Analysis Tools (MAFIAT) python library and Jupyter notebooks for the computation and exploitation of this quantity. The required axis location is specified manually by the user, either with their own preferred method, or using the twist number calculated from the parallel current by Magnetic Field Analysis Tools. The notebooks allow users to create a variety of novel visualisations of FRs and their twist distributions for scientific study. Magnetic Field Analysis Tools is written in Python and is released under the BSD 3-Clause Licence. Code available at: https://github.com/pricedj/mafiat.

- **Christian Palmroos**: "METHOD FOR SEP EVENT ONSET TIME UNCERTAINTY EVALUATION APPLYING POISSON-CUSUM COUPLED WITH BOOTSTRAPPING"

  Abstract: Onset times of Solar Energetic Particle (SEP) events are key information in relating the remote-sensing observations of a solar eruption to the in-situ measurements of the same phenomenon. Without precise knowledge of the onset time of an event, one can't identify the acceleration processes or the source region that set the high-energy stream of particles in motion. A limitation of several available methods to determine onset times is the lack of reasonable uncertainties for the quantity. The method presented here is a hybrid that employs Poisson-CUSUM (CUmulative SUM) and statistical bootstrapping.

  The CUSUM methods are statistical quality control schemes that give an early warning if the process or variable under inspection diverges too far from the normal state. Poisson-CUSUM refers to the specific CUSUM method that assumes the monitored variable to be Poisson-distributed.

  Our method chooses random samples from the pre-event background of SEP intensity-time profiles and uses them to create distributions of mean and standard deviation, which are the two critical parameters that CUSUM needs to identify the onset time. The two distributions of parameters thus yield a distribution of possible onset times, allowing one to statistically assess attributes of the distribution, such as mode, median and the standard deviation of the possible onset times. By further resampling the original data to coarser resolution and repeating the statistical bootstrapping analysis, we are able to see if and how the confidence intervals derived from these distributions change with varying time resolution, and especially if they seem to converge to a specific time interval. This underlying time interval is interpreted as a fundamental uncertainty to the onset of the event.

  The uncertainty of the onset times in varying energies is directly connected to the uncertainty of Velocity Dispersion Analysis (VDA) results, which is a further motivator behind the development of this method.

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- **Bernd Heber: "**HeliosVM: a easy to use tool for simulation the Helios E6 experiment

  Abstract: The HELIOS E6 instrument has been developed at the Institute for Pure and Applied Nuclear Physics in Kiel from 1967 to 1974 in order to measure Solar Energetic Particles, Galactic Cosmic Rays and particles that are accelerated locally by shock waves. Two identical instruments were in operation from December 1974 to March 1985 on HELIOS-1, and from January 1976 to March 1980 on HELIOS-2, covering the inner solar system between 0.29 and 1 AU, and have returned a wealth of data. However, in order to provide a

physical meaningful data set GEANT 4 simulation have been utilized successfully. In this contribution we present a jupyther notebook that is utilised to compute the responses of the E6.

- **Raul Gomez-Herrero:** « SERPENTINE online catalogues »

Abstract : The SERPENTINE project aims to take a major step in the understanding of gradual Solar Energetic Particle (SEP) events showing wide angular spread in the heliosphere. The detailed analysis of historical datasets and multipoint observations from the most recent missions exploring the inner heliosphere (Solar Orbiter, Parker Solar Probe and BepiColombo), combined with physical models, provides comprehensive information about the characteristics of CME-driven shocks in the corona and the interplanetary medium and their physical connections with with widespread SEP events. The results of these analyses are compiled into various event catalogues that will be publicly distributed, serving as basis for further scientific analysis by the wider scientific community. We present a summary of the event catalogues that will be provided to the community by the SERPENTINE project data center website.