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Radio spikes to diagnose the solar corona

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Solar spikes are short-duration, narrowband, and strongly polarized radio emissions. Observed from decameter to decimeter frequencies, they are often detected during solar eruptive events. However, what conditioned their occurrence is still debated since they do not appear at each solar flare. Many studies have been performed in the decameter range based on single-day observation or several days in a row, thus mainly following the same active region. Our approach analyzes several sequences of spike emissions occurring during unrelated days in 2022 and 2023. The goal is to distinguish between intrinsic and time-dependent spike characteristics. Then, some coronal plasma conditions enabling their occurrence are deduced.

NenuFAR is a recent ground-based facility dedicated to decameter radio observations. It is opened to the international community since December 2022. Owing to its high spectral and temporal resolution in spectral observations (down to 0.1kHz and 0.30ms, respectively – but not simultaneously) and the polarimetric measurements in four Stokes parameters, it provides clues to study the electron propagation at the base of the corona (observations between 10 to 85 MHz). The beam size of the instrument in the "Time-frequency" mode does not allow the identification of the emission site (0.5° to 4° beam size). However, imaging is systematically performed simultaneously with the spectral mode, enabling the location of the emissions.

A thousand spikes were selected during different days in 2022 and 2023. A statistic will be presented on the time duration, frequency extension, intensity above background, polarization, and time-frequency drift. Two generation scenarios are usually discussed: the first relies on the breakup of the electron beam providing the free energy to destabilize the plasma, and the second depends on the damping of the Langmuir waves through electron-ion collisions. Comparison between the spike time duration and beam velocity on one side and temperature on the other enables us to check these two scenarios. Since the observations were performed on unrelated active regions, we will discuss the dependence of several parameters, like temperature, velocity beam, and turbulence factor, on the type of eruptive events. Figure 1 displays two examples of results. A specific event corresponding to an intense Type II event is also detailed.

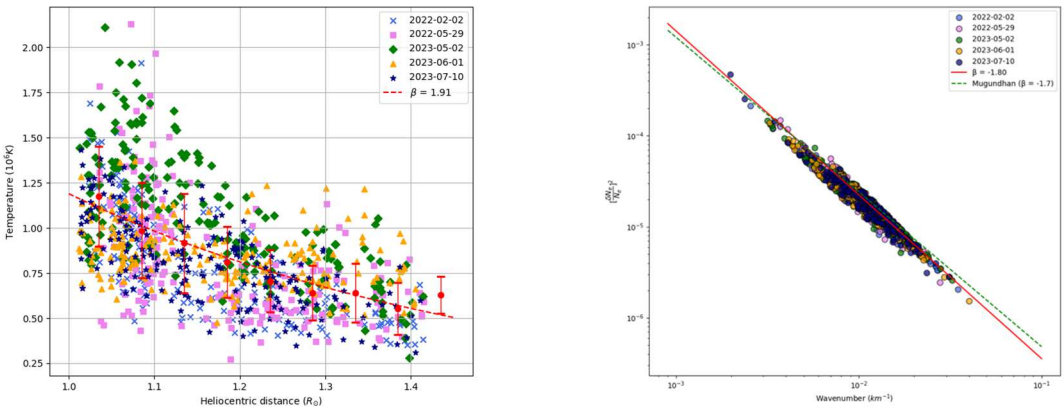

Figure 1: Temperature (left) vs. heliocentric distance and density fluctuation vs. wavenumber (right) for the studied days. In this last figure, our fitting is compared to the results of Mugundhan et al. (2017).