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Parker Solar Probe: Three Years of Discoveries at Solar Cycle Minimum

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NASA's Parker Solar Probe (PSP), launched on 18 August 2018, is venturing closer to the Sun than any other spacecraft, exploring one of the most mysterious and unexplored regions of the heliosphere, i.e., the solar corona. PSP completed twelve of the scheduled 24 orbits. The spacecraft flew by Venus for the fifth time on October 16, 2021, to achieve a closest approach of 13.28 solar radii (from the Sun's center) on 21 November 2021. It will use the planet for two more gravity assists to reach its ultimate perihelion of 9.86 solar radii in December 2024. The primary science objective of the mission is to determine the structure and dynamics of the Sun's coronal magnetic field, understand how the solar corona and wind are heated and accelerated, and determine what processes accelerate energetic particles. PSP is, however, an exploration mission that is flying through the last unvisited region of space within our solar system, and the potential for discovery is enormous. The new phenomena revealed by the science data are forever changing our view of the solar corona and the solar wind. The science data show new and mysterious phenomena and plasma properties not seen before in the solar wind, e.g., the magnetic field switchbacks, the dust-free zone, solar energetic particles, and the Venus environment. A critical science goal of the Parker Solar Probe mission is to fly within the magnetically dominated corona, or below the Alfvén critical boundary where the solar wind plasma acquires most of its heat and acceleration. PSP crossed this critical boundary on 28 April 2021, for the first time. It has flown through the solar corona multiple times over the following orbits priding invaluable data linking the solar wind to processes at the base of the corona. I will provide an overview of the mission's scientific discoveries after three years of operation and how these discoveries are reshaping our view of the near-solar environment and the solar wind. Figure 1 illustrated the spacecraft flying through coronal structures. From left to right, coronal streamers are seen moving upward and downward in the upper and lower parts of the field-of-view, respectively.

Parker Solar Probe was designed, built, and is now operated by the Johns Hopkins Applied Physics Laboratory as part of NASA's Living with a Star (LWS) program (contract NNN06AA01C). Support from the LWS management and technical team has played a critical role in the success of the Parker Solar Probe mission.

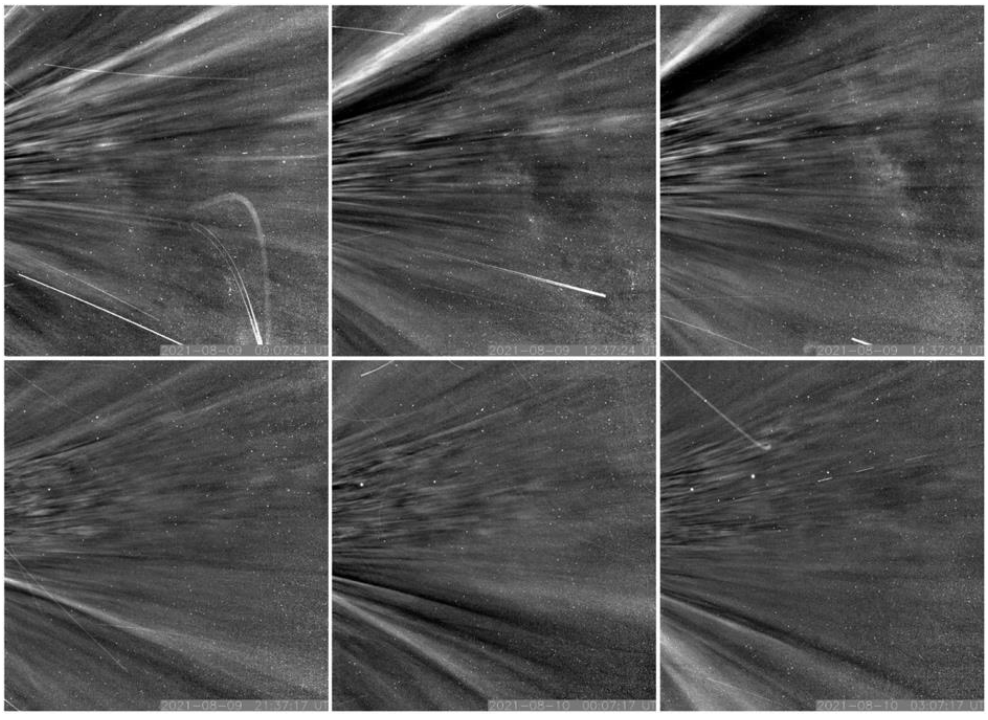

Figure 1. PSP/WISPR images around the ninth perihelion, where we see coronal structures moving upward in the upper part of the field of view and downward in the lower part. This motion is only apparent. At that time, PSP is gliding through these coronal structures that are the source regions of the solar wind. WISPR images also show a myriad of small structures that could not be seen from 1 AU. These features reflect the highly dynamic nature of the young solar wind.