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The Structure, Properties and Origin of Switchbacks: Parker Solar Probe Observations

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Parker Solar Probe (PSP) mission aims to uncover the solar wind properties in the inner heliosphere. The PSP has completed its initial eight orbits by April 2021, and its deepest perihelion reached a radial distance of about 0.074 au. One of the most extraordinary observations in the near-Sun environment is the prevalent presence of switchbacks, which are defined as the rapid magnetic field reversals that last from seconds to hours. Current PSP observations pose many open questions in regards to the nature of switchbacks. In this work, we focus on three questions: 1) how stable are they propagate through the inner heliosphere? 2) what are their properties? 3) how are they generated? In order to answer these questions, we first identify more than one thousand switchbacks with PSP observations. Then, we analyze the small-scale current sheets distributions in switchbacks with partial variance of increments (PVI) method. We find that switchbacks have many more current sheets inside than outside, indicating that these micro current sheets together with the S-shape curvatures of switchbacks may play an important role to stabilize switchbacks. Additionally, we statistically investigate the plasma properties of switchbacks in different solar wind conditions. Our preliminary results suggest that the switchbacks seem to show different characteristics in different solar wind regimes, implying the switchbacks are much more complicated and dynamic structures than expected. Moreover, with the helium measurements, we investigate the variations of helium abundance ratios and alpha-proton drift speeds to trace the switchbacks back to their source regions. The results imply the magnetic reconnection works predominantly to form switchbacks, but the wave-turbulence mechanism may also contribute.