Domains of Magnetic Pressure Balance in Parker Solar Probe Observations of the Solar Wind

เขตแห่งสมดุลของความดันแม่เหล็กในการสังเกตลมสุริยะโดยยาน Parker Solar Probe

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This work was motivated by our previous work that proposed that an instability between solar wind streams in interplanetary space with different velocities can explain an observed transition in solar wind fluctuations, can strongly energize turbulence in the solar wind, and can explain "switchbacks" or temporary reversals in the interplanetary magnetic field (Ruffolo et al. 2020; see https://physics.sc.mahidol.ac.th/research/highlights/Ruffolo-2021-a/). That work commented on domains of nearly constant magnetic pressure in the solar wind. Actually the velocity **V** and magnetic field **B** of solar wind plasma undergo very strong turbulent fluctuations, but often these are so-called Alfvénic fluctuations that nearly conserve the magnetic field magnitude |**B**| and the magnetic pressure (which is proportional to $|\mathbf{B}|^2$).

Here we examined domains of approximate magnetic pressure balance in detail, using public data from NASA's Parker Solar Probe (PSP), mankind's first spacecraft to travel close to the Sun, for the first 5 orbits. We analyzed data from the FIELDS and SWEAP instrument suites. We developed a systematic definition of contiguous domains, as illustrated in Figure 1. We found that the mean domain duration generally has an inverse relationship with plasma β (ratio of plasma pressure to magnetic pressure) and is otherwise not dependent on distance from the Sun, and domains have an aspect ratio consistent with a spherical (isotropic) shape.

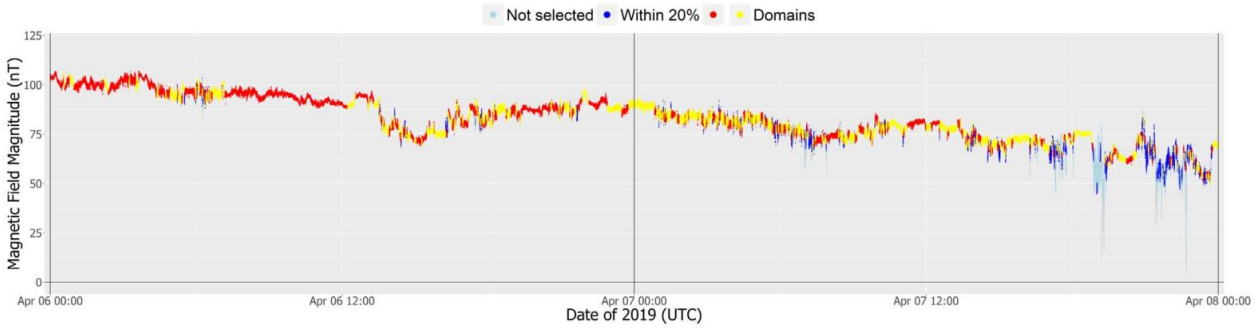

Figure 1: Magnetic field magnitude |**B**| and domains of approximate magnetic pressure balance identified from 1 s sampling of PSP/FIELDS measurements during 2019 April 6–7, a time period of 25–73 hr after the second PSP perihelion. Light blue points are at times that were not selected in the first stage of domain selection, dark blue is for time periods with |**B**| constant within 20% but rejected in the second stage of domain selection, and alternating red and yellow coloring indicates selected domains (|**B**| constant within 10% over all 600 s time periods within the domain). Domains are interrupted by particularly strong fluctuations in **B**, some but not all of which involve reversals in the sign of the radial component, i.e., switchbacks. The mean domain duration was much longer on April 6, in association with lower plasma β on that day.

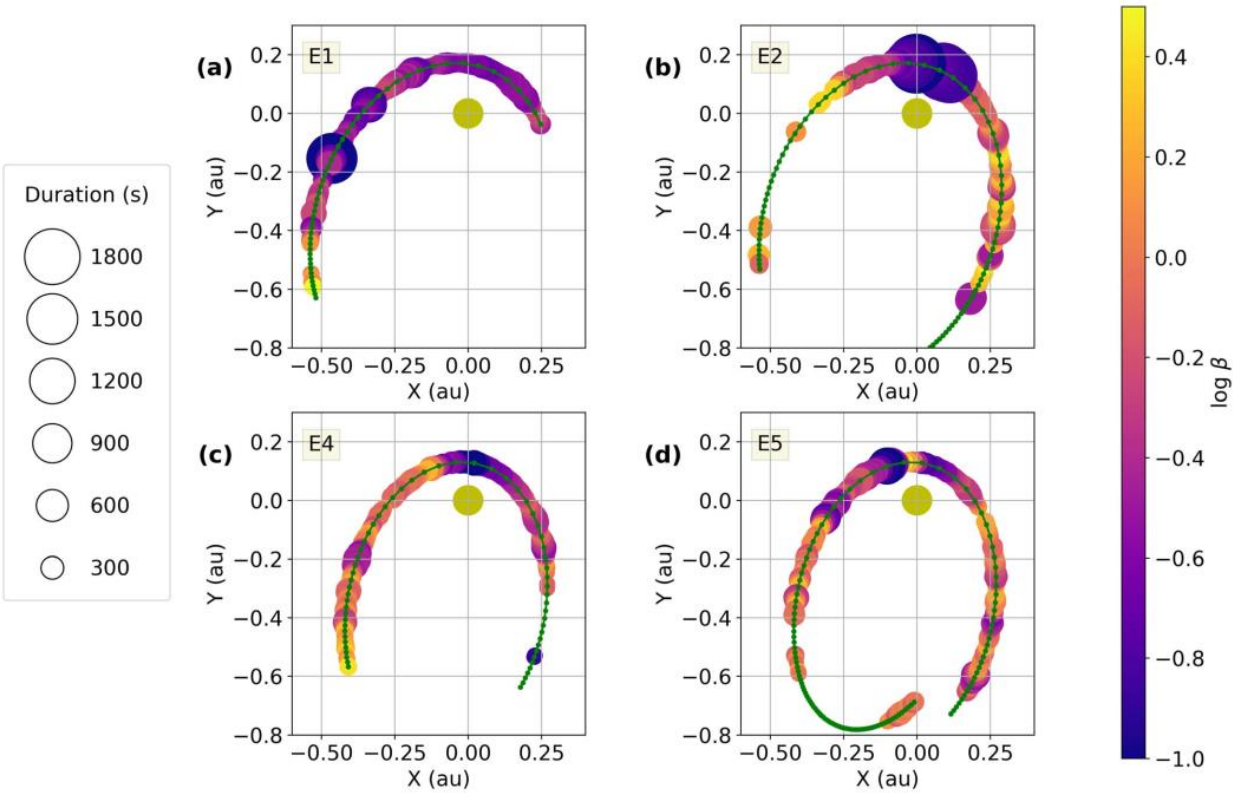

Figure 2: Mean duration of domains of approximate magnetic pressure balance (indicated by circle size) and plasma β (indicated by color scale) as a function of the location of PSP as it orbited counterclockwise around the Sun (yellow circle at x = 0, y = 0), for orbits E1, E2, E4, and E5. Small green markers represent the location of PSP at the start of each day. Data are shown for 1 day averages with 6 hr cadence. It is seen that the mean domain duration generally has an inverse relationship with β and is otherwise not dependent on distance from the Sun.