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Magnetic switchbacks in the young solar wind: generation and evolution

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A major discovery of Parker Solar Probe (PSP) was the presence of large numbers of localized increases in the radial solar wind speed and associated sharp deflections of the magnetic field - switchbacks (SB). A possible generation mechanism of SBs is through magnetic reconnection between open and closed magnetic flux near the solar surface, termed interchange reconnection that leads to the ejection of flux ropes (FR) into the solar wind. Observations suggest that SBs undergo merging, consistent with a FR picture of these structures. The role of FR merging in controlling the structure of SBs in the solar wind is explored through direct observations, analytic analysis, and numerical simulations. Analytic analysis reveals key features of the structure of FRs and their scaling with heliocentric distance R that are consistent with observations and demonstrate the critical role of merging in controlling the structure of SBs. FR merging is shown to energetically favor reductions in the strength of the wrapping magnetic field and the elongation of SBs. A further consequence is the resulting dominance of the axial magnetic field within SBs that leads to the observed characteristic sharp rotation of the magnetic field into the axial direction at the SB boundary. Finally, the radial scaling of the SB area in the FR model suggests that the observational probability of SB identification should be insensitive to R, which is consistent with the most recent statistical analysis of SB observations from PSP.

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