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Localized magnetic field structures and their boundaries in the near-Sun solar wind from Parker Solar Probe measurements

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One of the most striking discoveries made by Parker Solar Probe during its first three encounters with the Sun is the presence of a multitude of relatively small-scale structures that stand out as sudden deflections of the magnetic. They were named “switchbacks” since some of them show up the full reversal of the radial component of the magnetic field and return to “regular” solar wind conditions. We carried out an analysis of three typical switchback structures having slightly different characteristics: I. Alfv´enic structures, where the variations of the magnetic field components take place conserving the magnitude of the magnetic field constant; II. Compressional, where the magnetic field magnitude varies together with changes of the components of the magnetic field; III. Structures manifesting full reversal of the magnetic field, they may be presumably similar to Alfv´enic, but they are some extremal class of “switchback structures”. We analyzed the properties of the magnetic field of these structures and the characteristics of their boundaries. Our observations and analysis lead to the conclusion that the structures represent localized magnetic field tubes moving with respect to surrounding plasma. The very important characteristic of these tubes consists of the existence of a relatively narrow boundary layer on the surface of the tube that accommodates flowing currents. These currents supposedly closed on the surface of the structure, and typically they have comparable azimuthal and the tube axes aligned components. These currents are supported by the presence of the effective electric field ensured by quite strong gradients of the density, and ion plasma pressure. The ion beta is typically larger than one inside the structure, and less than one outside. Another important feature is an electromagnetic wave accommodated on the surface of the structure. Its role consists in assistance to particles in carrying currents, to electrons parallel to magnetic field, and perpendicular to field to ions.

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