Formation of current sheets and plasmoids within corotating/stream interaction regions

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High speed streams originating from coronal holes are long-lived plasma structures that form corotating interaction regions (CIRs) or stream interface regions (SIRs) in the solar wind. The term CIR is used for streams existing for at least one solar rotation period, and the SIR stands for streams with a shorter lifetime. Since the plasma flows from coronal holes quasi-continuously, CIRs/SIRs simultaneously expand and rotate around the Sun, approximately following the Parker spiral shape up to the Earth’s orbit.

Coronal hole streams rotate not only around the Sun but also around their own axis of symmetry, resembling a screw. This effect may occur because of the following mechanisms: (1) the existence of a difference between the solar wind speed at different sides of the stream, (2) twisting of the magnetic field frozen into the plasma, and (3) a vortex-like motion of the edge of the mothering coronal hole at the Sun. The screw type of the rotation of a CIR/SIR can lead to centrifugal instability if CIR/SIR inner layers have a larger angular velocity than the outer. Furthermore, the rotational plasma movement and the stream distortion can twist magnetic field lines. The latter contributes to the pinch effect in accordance with a well-known criterion of Suydam instability (Newcomb, 1960, doi: 10.1016/0003-4916(60)90023-3). Owing to the presence of a cylindrical current sheet at the boundary of a coronal hole, conditions for tearing instability can also appear at the CIR/SIR boundary. Regardless of their geometry, large scale current sheets are subject to various instabilities generating plasmoids. Altogether, these effects can lead to the formation of a turbulent region within CIRs/SIRs, making them filled with current sheets and plasmoids.

We study a substructure of CIRs/SIRs, characteristics of their rotation in the solar wind, and give qualitative estimations of possible mechanisms which lead to splitting of the leading edge a coronal hole flow and consequent formation of current sheets within CIRs/SIRs.