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Filament Connectivity and "Reconnection"

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Abstract. Stable long lived solar filaments during their lives can approach each other, merge, and form circular structures. Since filaments follow large scale polarity inversion lines of the photospheric magnetic field, their evolution reflects changes of the photospheric field distribution. On the other hand, filament interaction depends on their internal magnetic structure reviled in particular by filament chirality. Possibility of magnetic field line reconnection of neighbor filaments is discussed. Many examples of connectivity changes in a course of photospheric field evolution were found in our analysis of daily Hα filtergrams for the period of maximum activity of the solar cycle 23.

Keywords. Sun: chromosphere, Sun: filaments, Sun: prominences, Sun: magnetic fields

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The axial component of the filament magnetic field defines two classes of filaments, depending on the direction of the axial component: a filament is called dextral if this component is directed toward the right the filament is viewed from the side of the positive background polarity, and sinistral if the direction of the axial component is opposite to this (Martin *et al.* 1994). Analysis of the fine structure of filaments shows that the thin threads are rotated through a small angle clockwise to the axis in dextral and counterclockwise in sinistral filaments. This makes it possible to determine the class of a filament (the filament chirality) from its visual appearance, without information on the magnetic fields (Pevtsov *et al.* 2003).

When the ends of filaments with the same chirality approach each other, the "positive end" of one rope (a source of field lines) approaches the "negative end" of the other rope (a sink of field lines). The filament ends located on opposite sides of the neutral line have the same directions for both the axial and transverse fields. However, the vertical components can have antiparallel segments, where reconnection can occur. This results in the formation of loops overlapping the rope), which connect the regions of earlier rooting of each rope, so that the ropes themselves become "sewn" into a single object. The electric currents close at the photosphere at the filament ends before reconnection, and so form a single circuit from the right end of the right filament to the left end of the left filament after reconnection.

At a contact of filaments with opposite chiralities, their ends contact each other on one side of the polarity inversion line. Because the directions of the azimuthal components are the same and the directions of the axial components are opposite, a typical cusp is formed.

The approach of two antiparallel dipoles results in a quadrupolar magnetic configuration. At the initial time, the two neutral lines are initially separated by some polarity. These lines can sometimes contact (intersect) each other, but, strictly speaking, such a state is unstable, and the lines will diverge again in the case of arbitrary small changes in the fields. The connectivity of the neutral lines can change, and new lines will be separated by another polarity. If filaments of the same chirality exist at both polarity

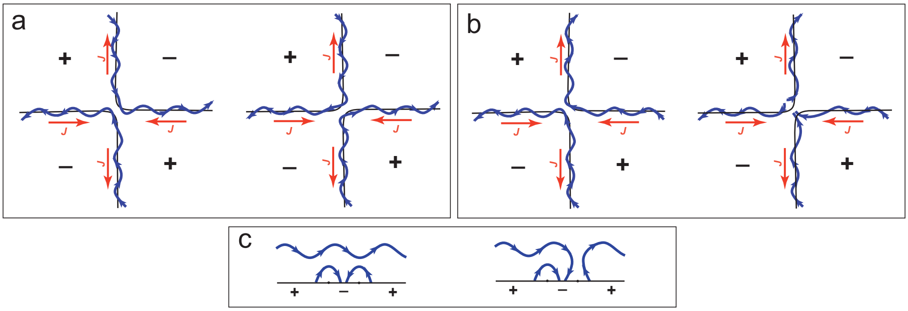

Figure 1. Schematics for (a) the reconnection of filaments with the same chirality; (b) the rupture of filaments with opposite chiralities during reconnection of neutral lines; (c) the rupture of a rope during reconnection with the photospheric field. Red arrows show the directions of electric currents J.

inversion lines, these filaments can "reconnect," exchanging their halves at the contact point (see Fig. 1(a)). The reconnection of filaments with the same chirality occurs at a null point of the field, where the dominant antiparallel axial components reconnect. The azimuthal components of the new halves are easily joined, since they have the same direction, and the currents reconnect. Of course, this idealized scenario is applicable only if the magnitudes of the currents and longitudinal fields in the approaching filaments are equal.

In the case of opposite chiralities, the axial components of the filament halves located at the reconnected neutral line are antiparallel and cannot be joined (see Fig. 1(b)). Therefore, they must reconnect with photospheric fields approaching the contact point; i.e., they must close at the photosphere. The ends of ruptured filaments should form cusps, as is typical for contacts of filaments with opposite chiralities. Figure 1(c) presents a schematic illustrating the reconnection between one field line of a magnetic rope and a loop of photospheric field, as viewed in the vertical plane passing through the diagonal of Fig. 1(b) (right), i.e., from the lower left to the upper right corner.

Examples of alterations of the filament connectivity occuring during the evolution of photospheric fields are presented in Kumar *et al.* (2010), Su *et al.* (2007), Filippov (2011). Theoretical and observational aspects of interaction of filaments, which show the same or opposite signs of magnetic helicities, are discussed in Schmieder *et al.* (2004), Aulanier & Schmieder (2008), Török *et al.* (2011).

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