"Bursty" Reconnection during Solar Eruptions: MHD Simulations and Comparison with Observations

Magnetic reconnection plays a fundamental role in the eruption of Coronal Mass Ejections (CMEs). White light observations of "rays", which have be interpreted as being coincident with the current sheet at the reconnection site, indirectly provide evidence for its occurrence underneath the erupting ejecta. We have continued our detailed studies of the eruption of CMEs by using global MHD simulations to study the formation and evolution of "blobs" within the reconnection site. We compared their properties with SOHO/LASCO observations of similar structures flowing along current sheets associated with CMEs, and related their formation to standard theories of reconnection, and the tearing mode in particular.

To illustrate this, in Figure 1, we compare observations of such blobs with a generic MHD simulation of the eruption of a CME, which reproduces the basic features of this phenomenon. In the top panels, we summarize the aftermath of an eruption that occurred on November 18, 2003. The event has been described in detail by Ko et al. (2003) and Lin et al. (2005). The sequence contains a ray-like feature bridging the ejecta to the lower corona, together with a sequence of blobs that move along, or through the ray. The bottom panels summarize the evolution of the current sheet beneath the erupting flux rope in our MHD simulation. The grey-scale images show simulated polarized brightness and the contours are the magnetic flux function, equivalent to magnetic field lines in two dimensions. A movie is also available in the electronic version of this article. The panels, which are equally spaced in time show the repeated formation of a set of blobs that move away from the Sun. We emphasize that this simulation was not specifically intended to mimic the November 2003 event. In fact, similar simulations have been used to interpret a number of other events (Riley et al., 2002, Riley et al., 2003). Nevertheless, there is a good general agreement in the formation of a bright ray under the erupting flux rope and the formation and propagation of the blobs. Finally, note that the blobs coincide with o-type points in the magnetic field, with x-type points lying between them.

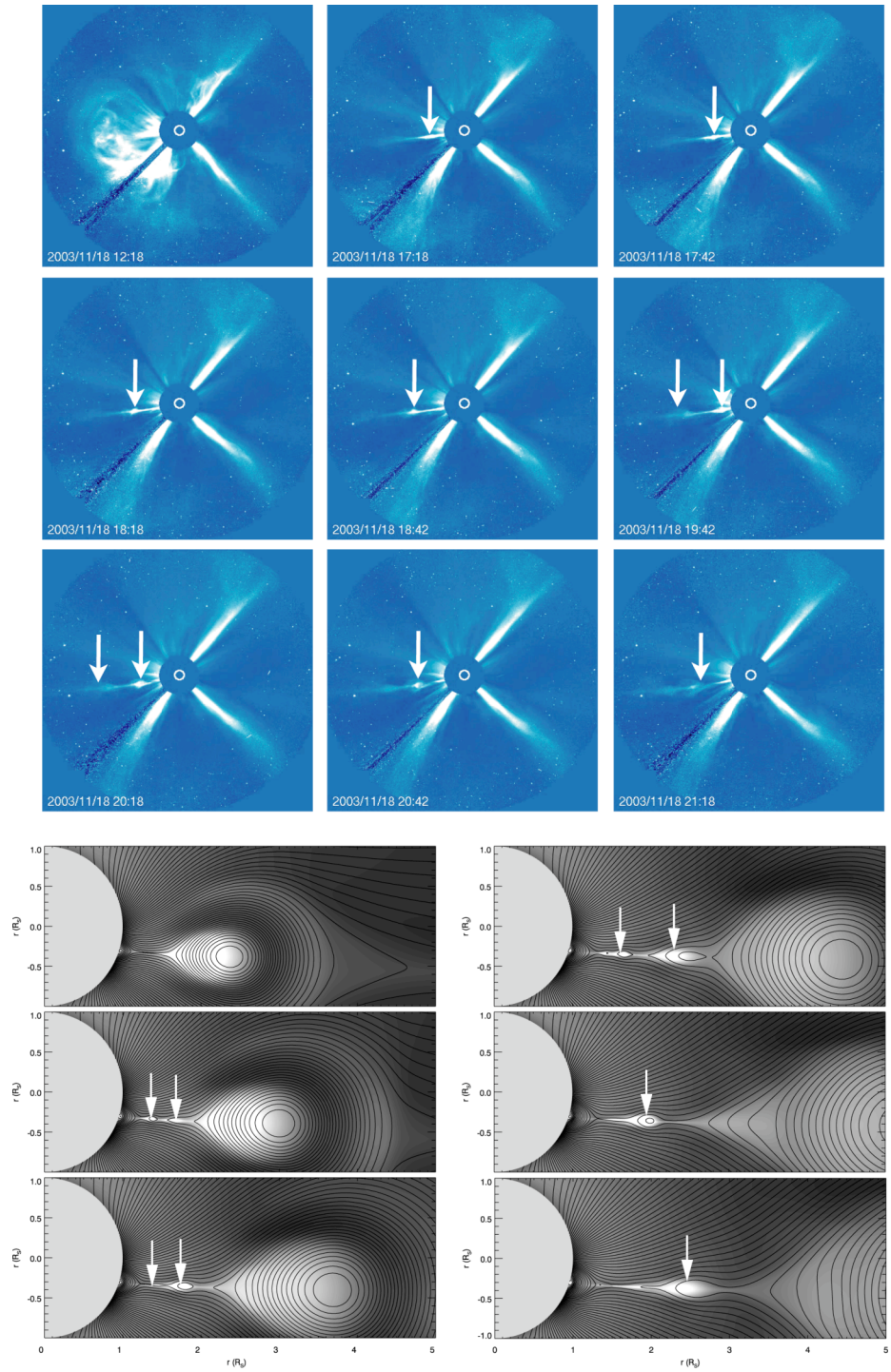

Figure 1. (Top) Sequence of LASCO/SoHO C3 images during November 18th, 2003 summarizing the post-eruption structure beneath the CME. The top-left panel shows the CME traversing the field of view, while the remaining panels show a bring ``ray" like feature bridging the ejecta to the lower corona, together with a sequence of “blobs” that move along the ray. Vertical white arrows indicate the positions of the blobs. Note that that the first two panels are separated by 5 hours, while the remaining panels are separated by 30 minutes. (Bottom) Sequence of frames from an axisymmetric simulation of a CME eruption based on flux cancellation. The contours show the magnetic flux function, which in two dimensions is a good fiduciary of magnetic field lines. The grey-scale image underneath is a simulated white light image. White arrows mark the position of the blobs in each frame.