

Solar Origin of a Sequence of SEP-Producing CMEs via the "Lid Removal" Mechanism

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Both coronal mass ejections (CMEs) and solar energetic particle (SEP) events are of concern for space weather. Here we report on the solar source of a pair of CMEs that produced a strong SEP event. The CMEs resulted from back-to-back ejective eruptions from a single active region on 2012 January 23. We examine the onset of these eruptions using magnetograms and EUV images from the HMI and AIA instruments on the Solar Dynamics Observatory (SDO) spacecraft, and EUV images from the STEREO spacecraft. Cheng et al. (2013) showed that the first eruption's ("Eruption 1") flux rope was apparent only in "hotter" AIA channels, and that it removed overlying field that allowed the second eruption ("Eruption 2") to begin via ideal MHD instability; here we say Eruption 2 began via a "lid removal" mechanism. We show that during Eruption-1's onset, its flux rope underwent "tether weakening" (TW) reconnection with the field of an adjacent active region. Standard flare loops from Eruption 1 developed over Eruption-2's flux rope and enclosed filament, but these overarching new loops were unable to confine that flux rope/filament. Eruption-1's flare loops, from both TW reconnection and standard-flare-model internal reconnection, were much cooler than Eruption-2's flare loops (GOES thermal temperatures of ~9 MK compared to ~14 MK). This eruption sequence produced a strong solar energetic particle (SEP) event (10 MeV protons, $>10^3$ pfu for 43 hrs), apparently starting when Eruption-2's CME blasted through Eruption-1's CME at 5---10 R_s. This occurred because the two CMEs originated in close proximity and in close time sequence: Eruption-1's fast rise started soon after the TW reconnection; the lid removal by Eruption-1's ejection triggered the slow onset of Eruption 2; and Eruption-2's CME, which started ~1 hr later, was three times faster than Eruption-1's CME.

Keywords: Coronal Mass Ejection (CME) Onset, Solar Energetic Particles (SEPs), Solar Filament Eruptions, Solar Flares