Acceleration of particles in different parts of erupting coronal mass ejections

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We examine particle energisation in CMEs generated via the breakout mechanism and explore both 2D and 3D MHD configurations. In the breakout scenario, reconnection at a breakout current sheet (CS) initiates the flux rope eruption by destabilizing the quasi-static force balance. Reconnection at the flare CS triggers the fast acceleration of the CME, which forms flare loops below and triggers particle acceleration in flares. We present test-particle studies that focus on two selected times during the impulsive and decay phases of the eruption and obtain particle energy gains and spatial distributions. We find that particles accelerated more efficiently in the flare CS than in the breakout CS even in the presence of large magnetic islands. The maximum particle energy gain is estimated from the energization terms based on the guiding-center approximation. Particles are first accelerated in the CSs (with or without magnetic islands) where Fermi-type acceleration dominates. Accelerated particles escape to the interplanetary space along open field lines rather than trapped in flux ropes, precipitate into the chromosphere along the flare loops, or become trapped in the flare loop top due to the magnetic mirror structure. Some trapped particles are re-accelerated, either via re-injection to the flare CS or through a local betatron-type acceleration associated with compression of the magnetic field. The energy gains of particles result in relatively hard energy spectra during the impulsive phase. During the gradual phase, the relaxation of the shear in magnetic field reduces the guiding magnetic field in the flare CS, which leads to a decrease in particle energization efficiency.