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A Possible Mechanism of Flux Cancellation via U-loop Emergence on the Sun

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We use a 3-dimensional MHD simulation to investigate a dynamic process producing flux cancellation on the solar surface. Our calculations are fully self-consistent in that any prescribed dynamic process is not applied on the surface, which is self-consistently generated via the emergence of a twisted flux tube. Most of the flux that emerges below the surface is in the form of $¥Omega$-loops (concave down geometry), so that dense photospheric plasma can drain down along the legs of the loop as it rises into the corona. We find, however, that some U-loops (concave up geometry) can also emerge. A U-loop geometry implies that a field line has a dip below the surface and a local peak somewhere above the surface on either side of the dip. Although the emergence of U-loops can produce flux cancellation on the surface, loops with such a geometry are not expected to emerge easily, due to the trapping of dense plasma in the dipped portion of the loops. Our results indicate that if one of the peaks is sufficiently low, of the order of the photospheric gravitational scale height above the surface, plasma can drain out of the dipped portion by a siphon-like mechanism, allowing the U-part of loops to emerge and resulting in the cancellation of magnetic flux on the surface. But if both peaks of a U-loop are high compared to the photospheric scale height, dense plasma simply settles in the dip of the loop, preventing the U-part from emerging, rather producing reconnection which is another possible mechanism of flux cancellation. We also discuss the implications of our results for observations.

Keywords: Coronal mass ejections, Prominence eruption, Flux emergence