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Unresolved Magnetic Flux Removal Process in the Photosphere

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The mutual loss of magnetic flux due to the apparent collision of opposite-polarity magnetic elements is called “magnetic flux cancellation” as a descriptive term. This flux cancellation is essential to the process of replacement of old magnetic flux with newly emerging flux in the quiet Sun on a timescale of a few days, and also to the process of removal of sunspot magnetic flux from the photosphere. An Omega-loop submerging below the surface or a U-loop rising through the photosphere is the usual idea to explain the magnetic flux cancellation. Magnetic reconnection may be crucial for the formation of these loops, especially for the submerging Omega-loop. In fact, chromospheric and coronal activities are often observed at the cancellation sites. We investigate the evolution of 5 cancellation events of the opposite-polarity magnetic elements at granular scales by using accurate spectropolarimetric measurements with the Solar Optical Telescope aboard Hinode. We find that the horizontal magnetic field, which is expected in both submerging Omega-loop model and emerging U-loop model, does not appear between the canceling magnetic elements in 4 of the 5 events. The approaching magnetic elements in these events are more concentrated rather than gradually diffused, and they have nearly vertical fields even while they are in contact each other. We thus imply that the actual flux cancellation is highly time dependent event near the solar surface at scales less than a pixel of Hinode/SOT (about 200 km). At the polarity inversion line formed by the canceling magnetic elements, highly asymmetric Stokes-V profiles are observed. We confirm that such asymmetric profile can be made by the sum of the profiles at the opposite-polarity magnetic elements next to the polarity inversion line. This means that the approaching bipolar flux tubes still keep their nature within the pixel where they come in contact with each other, and thus supports the unresolved flux removal process within the pixel at the polarity inversion line.