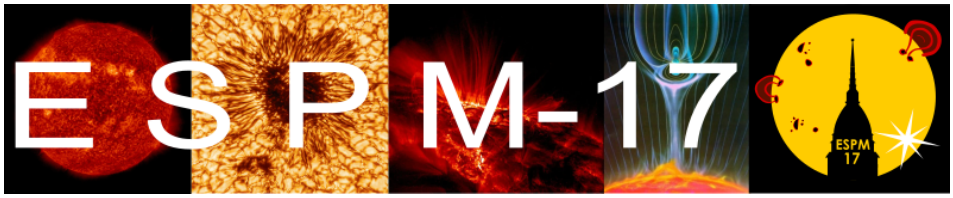

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Sunspot Scars: New Features of Solar Flux Rope Footpoints

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The properties of pre-eruptive structures of coronal mass ejections (CMEs) are important for forecasting solar eruptions, the former of which are usually quantified by measuring the properties of their footpoints in observations. However, the matter of how to identify the footpoints of pre-eruptive structures and how to do so with the use of ground-based instruments still remains elusive. In this work, we reveal for the first time an arc-shaped structure intruding in the sunspot umbra, which we call a "sunspot scar", through analysing a CME event on July 12, 2012 and two CME events from observationally inspired magnetohydrodynamic simulations performed by OHM and MPI-AMRVAC. The sunspot scar displays a more inclined magnetic field relative to that in the surrounding umbrae, and it is manifested as a light bridge in the white light passband. For both the pre-eruptive and CME flux ropes, the sunspot scars mark the edges of their footpoints, as the field lines anchored in the sunspot scar are spatially at the transition between the flux rope and the coronal loops and temporally in the process of the slipping reconnection which builds up the flux rope. Therefore, the sunspot scar provides a new method for the identification of pre-eruptive and CME flux rope footpoints. Furthermore, it opens up a new perspective for studying the evolution of solar eruptions with the extremely high-resolution photospheric observations from the current and next-generation giant ground-based telescopes.

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