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Triggering Mechanism and Predictability of Solar Flares and Coronal Mass Ejections

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Solar flares and coronal mass ejections, the most catastrophic eruptions in our solar system, have been known to affect terrestrial environments and infrastructure. However, because the types of magnetic structures capable of triggering these eruptions are still unclear, our capacity to predict the occurrence of solar eruptions is substantially hindered. In this study, we solved this problem by systematically surveying the nonlinear dynamics caused by a wide variety of magnetic structures in terms of three-dimensional magnetohydrodynamic simulations. As a result, we determined that two different types of small magnetic structures, which are called the opposite polarity (OP) type and the reversed shear (RS) type, favor the onset of solar eruptions. These types of magnetic structures include magnetic fluxes reversed to the potential component and the nonpotential component of major field on the polarity inversion line, respectively. The simulations indicate that these small magnetic structures are able to trigger the eruptions if they include magnetic flux exceeding a threshold, which is determined by the strength and distribution of magnetic shear. The data of several major flares observed by Hinode and SDO strongly supported this conclusion (Kusano et al. 2012, Bamba et al. 2012 in prep., Toriumi et al. 2012 in prep.). The results suggest that the onset of solar eruptions is predictable, if we are able to measure the large-scale magnetic shear and to detect the two types of small magnetic structures.