Three-Dimensional Magnetohydrodynamic Simulation of Initiation Process of Coronal Mass Ejections

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Coronal mass ejections (CMEs) are one the most spectacular explosive phenomena, in which large amount of mass and magnetic flux are ejected to the inter planetary space, as a result of a disruption of coronal magnetic field. They are one of the most important phenomena for space weather science because they are closely related to solar energetic particles and geomagnetic storms.

Coronal magnetic field are formed by the emergence from the solar interior of the current containing magnetic field which are generated and amplified by dynamo effect. Generally, such a field forms a force-free sheared arcade. Due to the evolution of tearing mode instability or small scale magnetic reconnection in the current of the arcade, an isolate flux rope is formed. Such a flux rope is observed as an Ha prominence, if it contains cold dense plasma. Because a Ha prominence may exist for a long time, it is thought that a flux rope should be in mechanical equilibrium. When the ejection of the flux rope is a CME.

In this study, we performed three-dimensional magnetohydrodynamic (MHD) simulations in spherical geometry to reveal the whole process of a CME; the formation of a flux rope, triggering and launching of the CME, particularly based on the flux cancellation model, in which a CME is caused by flow on the photosphere. We performed the simulation with wide parameter ranges in order to clarify the condition for a flux rope to be ejected as a CME, we will report the detail of the numerical results in this paper.