

Simulation study on internal velocity field variation of eruptive prominence

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Solar prominences, cool dense plasma clouds in the hot tenuous corona, sometimes erupt and evolve into coronal mass ejections. Prominence eruptions have attracted interest in the researches of space weather as well as solar physics. It is known that the interior of prominences is turbulent. Recent observational statistical studies reported that standard deviation of the Doppler velocity in the eruptive prominences started to increase several hours before eruptions even when the mean velocity was nearly zero. This finding is useful to predict prominence eruptions; however, the physical relationship between the magnetically-driven eruptive mechanisms (i.e., magnetohydrodynamic instabilities) and the internal velocity field variation of prominence has not been revealed.

In this study, we performed three-dimensional magnetohydrodynamic simulation including gravity, radiative cooling, and thermal conduction to reproduce eruption of turbulent prominence. In our simulation, a bipolar magnetic field is randomly introduced along the polarity inversion line of the sheared coronal arcade field. A magnetic flux rope is created by reconnection between the bipole and the coronal arcade field. Cool dense prominence is formed in the flux rope by radiative condensation. The prominence erupts after the flux rope exceeds the critical height of torus instability. Before the eruption, the height of flux rope axis monotonically increases; however, the velocity field inside the prominence has complicated distribution containing both upflows and downflows. We confirmed that the increase in standard deviation of the vertical velocity is quantitatively consistent with the observational results. To investigate the relationship with the magnetic field, we compared the histogram of the velocity components perpendicular and parallel to the magnetic field. As a result, we found that the upflows and downflows stem from perpendicular and parallel velocity, respectively. This result indicates that upflows and downflows are driven by Lorentz force and gravity along magnetic field, respectively. We also found that the increase in standard deviation of perpendicular velocity is larger than that of parallel velocity, suggesting that the increase in standard deviation of vertical velocity is caused mainly by increase in Lorentz force.

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