MHDシミュレーション研究におけるコロナ磁場との相互作用によるCMEの回転

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MHD simulation study of the rotation of CME due to the interaction with the coronal magnetic field

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Coronal mass ejections (CMEs) are one of main drivers of various disturbances in space weather. In particular, the timing of arrival, the strength, and the amount of southward magnetic flux brought by CMEs are important factors for space weather disturbances. These factors are determined as a result of launching and propagating of CMEs. In particular, the structure and dynamics of CMEs are likely to be influenced by the coronal magnetic field during the formation phase through the solar corona. Therefore, the understanding of the interaction of CME with the solar coronal magnetic field is necessary for improving the space weather forecast.

We performed a three dimension magnetohydrodynamic simulation of the interaction between CMEs and its ambient coronal magnetic field. In the initial conditions, an ejecting flux rope is embedded under two different ambient fields: hydrostatic atmosphere and a steady state of bimodal solar wind. In both cases, inner boundary magnetic field is set to be identical dipole magnetic field. Hence, magnetic field is potential dipole in the hydrostatic case while some fraction of polar field is open in the steady wind case.

The numerical results show that the ascent speed of flux rope in the steady wind case is faster than that in the hydrostatic case because of the background solar wind. It is found that the flux rope rotates during evolution in both cases, while the total angle of the rotation is significantly different. In the steady wind case, the flux rope continues to rotate from its start to 3 solar radius and the total rotation angle is about 90 degree. On the other hand, in the hydrostatic case the flux rope continues to rotate from its start to 4 solar radius and the total rotation angle is about 180 degree. We found that the area where the flux rope rotation continues is determined by the strength of the ambient magnetic field. The total rotation angle is found to be proportional to the amount of magnetic flux of ambient field that interacts with the flux rope through its rotation.

As shown in the numerical results, because the interaction with ambient magnetic field affects the rotation of CMEs, a realistic modeling taking into account of dynamics in the corona will be necessary for the prediction of the southward magnetic field in space weather forecast.