ROTATION OF ERUPTING MAGNETIC FLUX ROPES IN CORONAL MASS EJECTIONS

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The magnetic field orientation of Earth-directed coronal mass ejections (CMEs) is one of the main factors in determining their geoeffectiviness. Field orientations rotated by up to 160 degrees with respect to the magnetic orientation of the CME source region on the Sun have been found on arrival of the CME at the Earth's magnetosphere. The possibility of such strong rotations presents a difficulty to the forecast of the geoeffectiveness of CMEs. Unfortunately it is not yet well understood what causes the rotation of CMEs about their rise direction. Several physical mechanisms have been suggested, but quantitative studies of the parametric dependence of the rotation are still lacking for all of these mechanisms. Here we present the first systematic study of CME rotation mechanisms, based on numerical MHD simulations of a flux rope CME model. We focus on the two mechanisms suggested to be most important in the low corona, namely the conversion of flux rope twist into writhe and the interaction of the flux rope current with the component of the ambient coronal magnetic field along the flux rope. By varying the initial flux rope twist and the shear angle of the ambient magnetic field, we find a continuous range of flux rope rotations between ~20 and ~140 degrees in the simulations. This underlines the need to improve our capabilities to estimate these quantities on the Sun reliably. Strong rotations of more than ~100 degrees require both high flux rope twist (i.e. the occurrence of the helical kink instability) and the presence of a significant shear of the ambient field with respect to the initial flux rope orientation.

Magnetic flux ropes, Coronal mass ejections, Space Weather

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