Three Dimensional Motion of Plasmas Associated with Coronal Mass Ejections Observed with NOrikura Green-line Imaging System (NOGIS)

Suzuki, I[(1)]., Sakurai, T[(1), (2)]., and Ichimoto, K[(2)].
(1) *The Graduate University for Advanced Studies (Sokendai)*
(2) *National Astronomical Observatory*
isuzuki@solar.mtk.nao.ac.jp

Abstract

NOrikura Green-line Imaging System (NOGIS), with its unique capability of Doppler imaging, was used to study a CME and its source region observed on 1999 May 7. In this event, the source region consisted of two loop systems, a small loop system and a neighboring larger loop system. The small loop moved toward the larger loop in the plane of the sky and apparently destabilized it, resulting in the CME with red-shift motion. The observations from NOGIS indicate that the two loop systems were involved in this CME, and the direction of mass ejection was determined by the magnetic field configurations around the source region and the location of the initial energy release in the magnetic field structure.

Instrument

NOrikura Green-line Imaging System (NOGIS)

NOGIS at the Norikura Solar Observatory in NAOJ consists of 10 cm coronagraph and a tunable birefringent filter. It can observe the coronal green-line emission (Fe XIV 5303 Å) ,which is also one of the lines in LASCO C1 instrument, and its Doppler shift simultaneously (right image). NOGIS has two kinds of imaging mode, FFI mode and PFI mode, and its field-of-view is 1.03 – 1.33 R_{sun} in FFI mode.

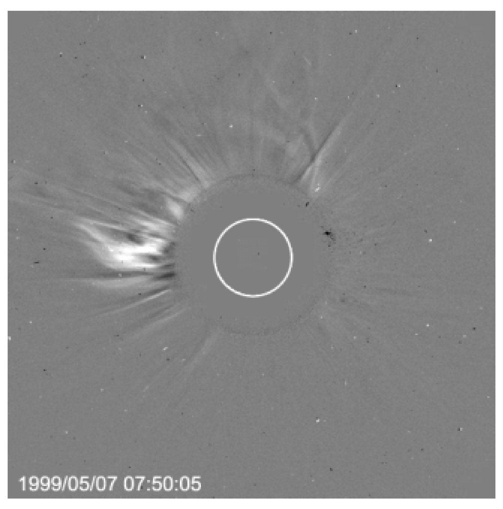
A coronal Doppler image (FFI) observed with NOGIS. Dark (bright) regions show blue (red) shifts.

Characteristics of NOGIS

Image modes : Full Frame Image (FFI) mode and Partial Frame Image (PFI) mode
Wavelengths : 5303 Å (Fe XIV line center)
5303 + 0.45 Å, 5303 – 0.45 Å (Red and Blue Doppler shifts)
5303 ± 2 Å (Double peak, for the subtraction of the sky contribution)
Spatial Resolution : 2.56 arcsec/pixel
Time Resolutions : 10 min. (FFI) and 1 min. (PFI)

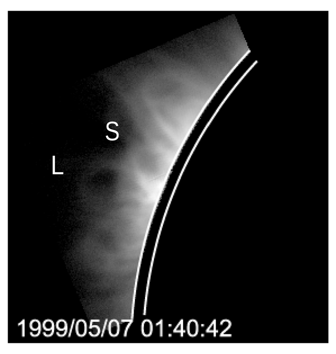
1999 May 7 Event

1. Observation with LASCO

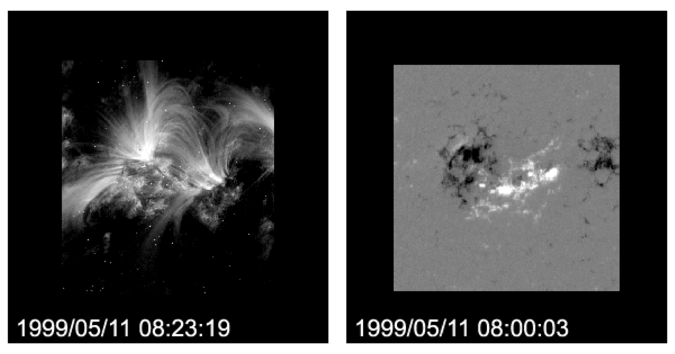


A CME observed in LASCO C2. It was ejected radially and eastward with a constant velocity (538 km/s) and a constant angular width.

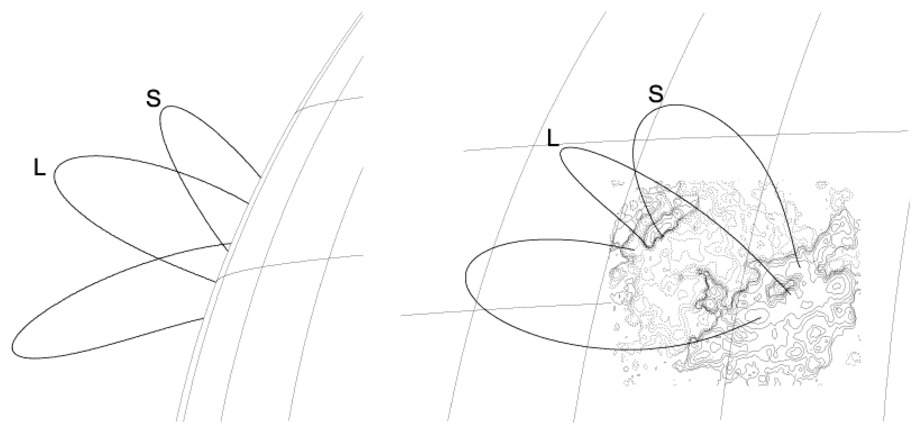
2. Magnetic Field Structure in the CME Source Region



(Top) Source region before the CME observed with NOGIS. It consisted of two loop systems, a small loop (S) and a large loop (L).

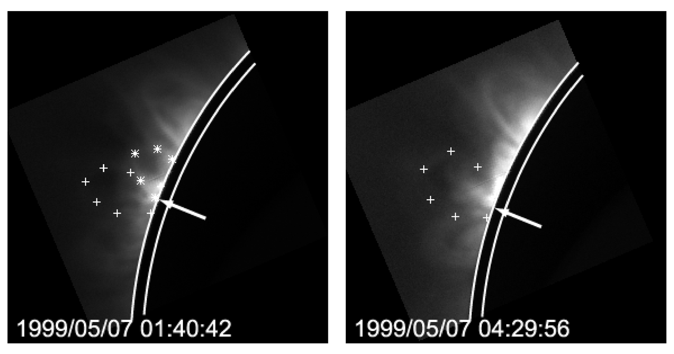


(Bottom) The source region after the CME observed with TRACE and its photospheric magnetic fields in MDI. Assuming that the magnetic field distributions were not significantly changed due to the CME occurrence, it can infer that the pre-CME source region consisted of the loop systems connecting the two polarities.

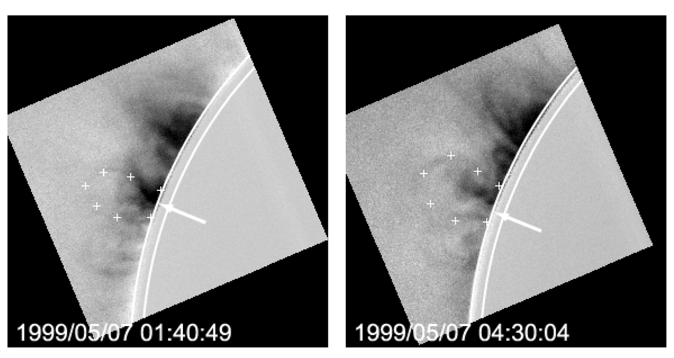


Current-free field lines calculated from the photospheric magnetic fields on the limb (left, May 7) and on the disk (right, May 11). These field lines correspond to the observation of NOGIS and TRACE.

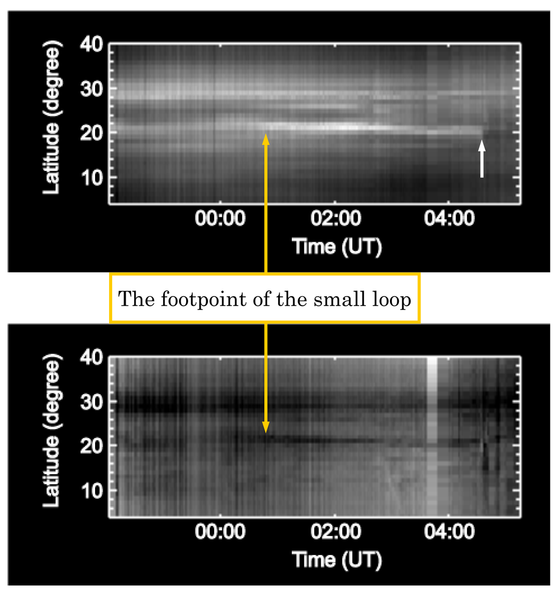
3. Activity of the Loop Systems before the CME



NOGIS intensity PFIs (top) and Doppler PFIs (bottom). Prior to the CME, the southern footpoint of the small loop (*) moved toward the southern footpoint of the large loop (+). Arrows show the location of the footpoint of the small loop.

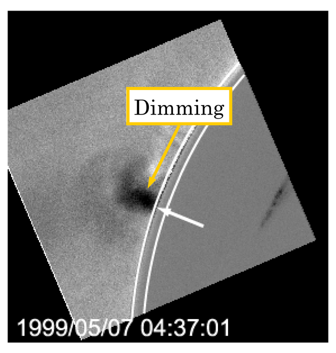


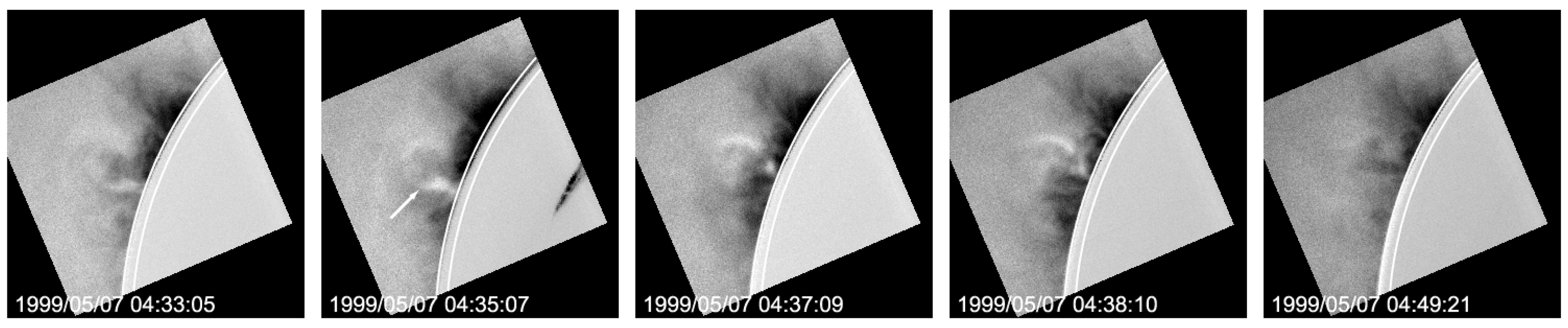
Since downward plasma motion along the small loop was seen, the blue shift of the small loop (dark region in the bottom images) might be explained due to almost downflow. The large loop was almost static.



NOGIS latitude-time maps at 1.08 R_{sun} : intensity (top) and Doppler shift (bottom). It is confirmed that the footpoint of the small loop with blue shift moved toward the large loop (to the lower latitude). The speed in the plane of the sky was 0.2 km/s. The white arrow shows the time of the CME onset.

4. Mass Ejection Observed with NOGIS



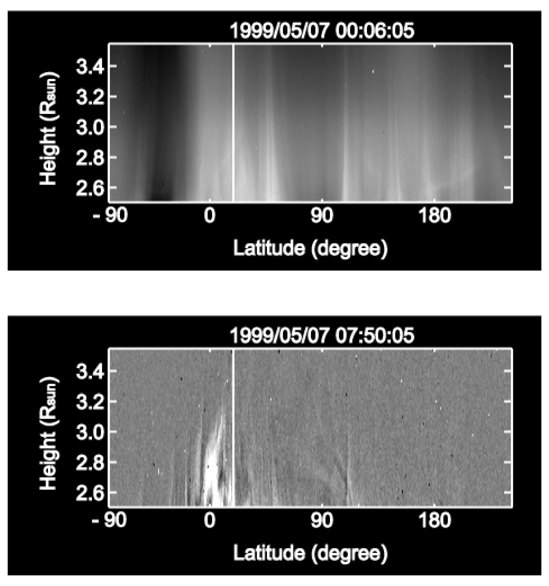


The footpoint of the small loop touched and destabilized the large loop, resulting in the mass ejection.

(Top) A running difference image of NOGIS intensity PFI during the ejection. The arrow shows the location of the footpoint of the small loop just before the ejection. Dimming event (the depleted region) was occurred where the southern footpoints of the two loops touched.

(Bottom) A sequence of the mass ejection in NOGIS Doppler PFIs. The mass ejection with red shift (white structure indicated by the arrow) was observed. It shows that the mass was ejected away from the observer (the velocity along the line-of-sight was a few km/s). The loop systems disappeared after the ejection.

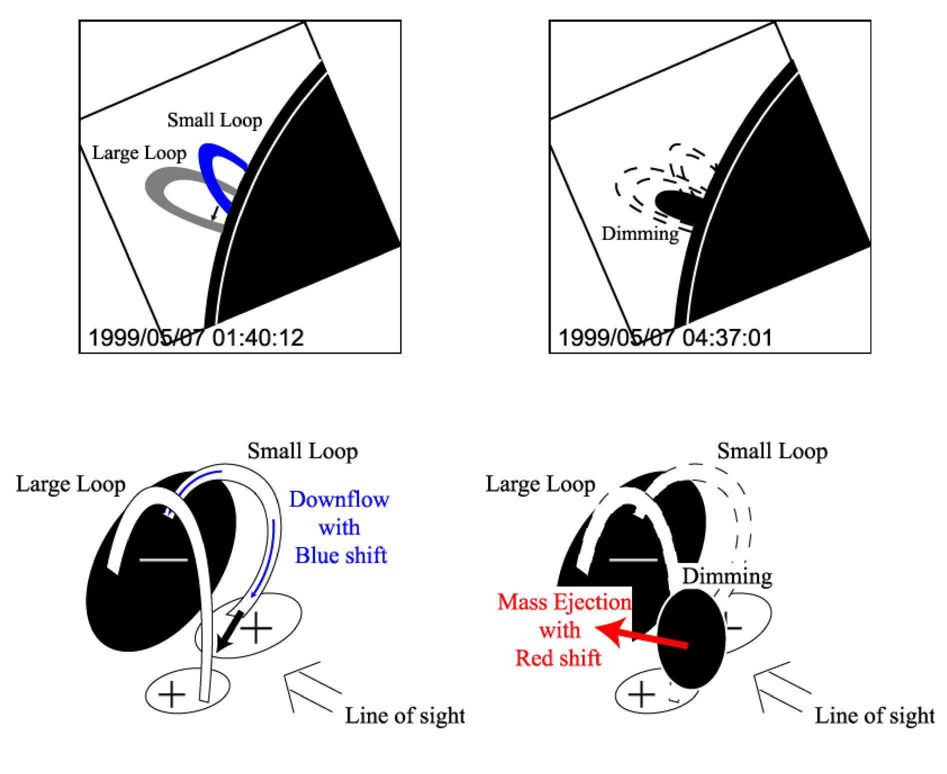
5. Positional Relationship between the Source Region and the CME



LASCO C2 height-latitude maps : raw image before the CME (top) and running difference during the CME (bottom). The vertical lines show the latitude of the dimming region observed with NOGIS.

The dimming region was not centered at the CME but was located on the northern edge of the CME. It suggests that in the plane of the sky the mass was initially ejected south-eastward (to the lower latitude in the images) from the source region rather than radially.

6. Summary and Overview



Summarizing the results,

1. The source region of this CME was consisted of the two loop systems, a small loop and a large loop.
2. Prior to the CME, the small loop moved toward the large loop.
3. The small loop touched and destabilized the large loop, resulting in the CME occurrence.
4. The dimming event was seen where the southern footpoints of the two loops touched.
5. The mass was initially ejected away from the observer (in the line-of-sight), and south-eastward (in the plane of the sky) rather than radially.

(Left) An overview of the event. These observations indicate that the direction of mass ejection was determined by the magnetic field configurations around the source region and the location of the initial energy release in the magnetic field structure.