*Multi-Wavelength Investigations of Solar Activity*
*Proceedings IAU Symposium No. 223, 2004*
*A.V. Stepanov, E.E. Benevolenskaya & A.G. Kosovichev, eds.*

DOI: 10.1017/S1743921305009993

# Observations of CME-related phenomena in a wide spectral range

**V.V. Grechnev[1], V.G. Zandanov[1], A.M. Uralov[1], V.P. Maksimov[1], V.N. Borovik[2], G.B. Gelfreikh[2], I.Y. Grigorieva[2], V.G. Medar[2], and A.N. Korzhavin[3]**

[1]Institute of Solar-Terrestrial Physics, Irkutsk, Russia, email: grechnev@iszf.irk.ru
[2]GAO RAS, St. Petersburg, Russia
[3]SAO RAS, St. Petersburg, Russia

Coronal mass ejections (CMEs) are accompanied by several other active phenomena. However, neither their interrelation, nor CMEs' trigger mechanisms have not yet been adequately understood.

We study pre-eruptive, eruptive, and posteruptive phenomena associated with a CME of November 23, 2000 (Grechnev *et al.* (2004)). Almost all possible CME-related phenomena were observed during this event. We investigate this event by means of joint analysis of data obtained in EUV (SOHO/EIT), soft X-rays (Yohkoh/SXT and GOES), microwaves at 17 GHz (NoRH) and 5.7 GHz (SSRT), multifrequency radio data from RATAN-600, H$\alpha$ filtergrams (Yunnan Observatory), SOHO/MDI magnetograms as well as SOHO/LASCO images of the corona.

Two active regions were observed on November 23, 2000 in the southwest quadrant of the solar disk. They are 9231 whose magnetic configuration was complex, and 9238, which had almost decayed.

The eruptive event starts with disappearance of the filament in H$\alpha$ between 05:12 UT and 05:47, and brightening coronal loops visible in SOHO/EIT 195 Å image of 05:36. A 1F/C5.4 flare occurs in AR 9238 during 05:36–06:15 with a maximum at 05:48. Flare ribbons are visible in H$\alpha$, and flare coronal loops are conspicuous in extreme UV and soft X-ray emissions. The flare is followed by a series of subflares in AR 9231 and weak brightenings in AR 9238. Also, a powerful type III burst was recorded at Culgoora and Hiraiso observatories during 05:36–05:40. A weak burst (11 sfu) was observed in microwaves with the NoRH at 17 GHz and the SSRT at 5.7 GHz from 05:35 on with a maximum at 05:55.

From 06:06 on, SOHO/LASCO observed a CME propagating with a speed of 500–600 km s$^{-1}$ within position angles of about 215°, which corresponds to the position of the event site within the southwest quadrant of the solar disk. The CME launch time estimated using the extrapolated time-height plot inferred from the LASCO data is in accord with the onset time of the eruptive event in the chromosphere and the lower corona. The speed and mass of the CME are moderate, while the importance of the flare is low (C5.4). This indicates that the bulk of the stored energy which has released in the reformation of the magnetic configuration has been spent to the acceleration of the CME, and its minor part has released in the flare.

A posteruptive arcade at the site of the eruption was observed in various emissions for a long time. Its emission was recorded with the RATAN-600 in the range of 1.7–30 cm at many frequencies with characteristics corresponding to optically thin bremsstrahlung. This has made possible to estimate from microwave polarization data the line-of-sight magnetic field component of $\sim 200$ G in the corona at a height of about 10 000 km (Gelfreikh 1994).

## Results and conclusions

• The eruptive event occurred in an activity complex consisting of active regions 9231 and 9238 and included almost all eruptive and posteruptive phenomena, which allowed us to follow a chain of those events.

• The whole story of the events was as follows: emergence of a new magnetic flux resulted in a flare in AR 9231 which triggered activation and eruption of the filament followed by the CME and the flare in AR 9238 in which the posteruptive arcade was observed.

• The flux emergence that eventually caused the eruption in AR 9238 occurred far from the eruption site, in AR 9231. So, the prime cause of an eruption may take place at a remote site (but in a region magnetically connected with the region of the eruption).

• The structure of predominantly thermal microwave flaring sources correspond to the structures observed in H$\alpha$, soft X-ray, and EUV ranges in contrast to impulsive nonthermal flares, where bright microwave flaring sources are compact.

• The polarized radio emission observed in the event visualizes regions of different magnetic field strength and direction. Motion of a polarized radio source allows studying the magnetic field distribution in an arcade. The magnetic field strength has appeared to be $\sim 200\,\mathrm{G}$ at about $10\,000\,\mathrm{km}$ in the corona. We confirm this estimate with a detailed analysis of the emission mechanism.

• A special methodical issue is the importance of the microwave emission mechanism identification from observations in a wide spectral range. Improper interpretation of the polarization measurements can result in a well overestimated magnetic field strength in the corona. We have addressed a technique to estimate contribution of nonthermal emissions to the polarization observed. Polarization measurements for estimates of the magnetic fields from free-free emission should be performed at the highest frequency available.

## Acknowledgements

We are grateful to M.A. Livshits and G.V. Rudenko for fruitful discussions, and to V.I. Garaimov for the assistance in processing RATAN-600 data. We thank the instrumental teams of the Nobeyama Radioheliograph, SSRT, and RATAN-600 radio telescopes; Yohkoh, SOHO, and GOES satellites for the open-data policies which made available for us data used in this study. SOHO is a project of international cooperation between ESA and NASA. Yohkoh is a project of international cooperation between ISAS and NASA. We also used H$\alpha$ images from Yunnan Observatory available in the Big Bear ftp archive. This work was supported by the Russian Foundation of Basic Research under grants 02-02-16548, 03-02-16591, 03-02-17528, 03-02-17357, the Ministry of Industry and Science under grants 477.2003.2, 16 KI, OFN 18; and the Presidium of RAS under grant 7/2004.

## References

Gelfreikh, G. B. 1994, in IAU Coll. 144, Solar Coronal Structures, eds. Rusin V., Heinzel P., Vial J.-C., (Slovakia: VEDA), 21.

Grechnev, V. V.; Zandanov, V. G.; Uralov, A. M.; Maksimov, V. P.; Rudenko, G. V.; Borovik, V. N.; Gelfreikh, G. B.; Grigorieva, I. Y.; Medar, V. G.; & Korzhavin, A. N. 2004 *Solar Phys.*, submitted.