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/S1743921304006453

Large-scale activity observed on the solar disk in association with CMEs

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Abstract. We summarize the results of our studies of CME-associated EUV dimmings and coronal waves by 'derotated' fixed-difference SOHO/EIT heliograms at 195 Å with 12-min intervals and at 171, 195, 284, 304 Å with intervals of 6 or 12 hours.

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1. Subject and method of the analysis

Coronal mass ejections (CMEs) are accompanied, in particular, by such large-scale phenomena as dimmings (transient coronal holes, i.e., regions of temporary depressions of soft X-ray and extreme UV emissions) and coronal waves (propagating emitting fronts) (e.g., Thompson *et al.*, 1998; Zarro *et al.*, 1999; Hudson & Cliver, 2001). In several papers, we have studied CME-associated dimmings and coronal waves from fixed-difference 'derotated' SOHO/EIT (Delaboudinière *et al.*, 1995) heliograms, i.e., images in which the solar rotation is preliminary compensated, and the same base pre-event frame being subtracted from all heliograms. Such a technique allowed us to form and analyse 195 Å heliograms with 12-min intervals as well as images observed in different-temperature lines of 171, 195, 284, and 304 Å with 6-hour intervals. Usually, running-difference images are used, which emphasize changes of the brightness, location, and structure of emitting features between two subsequent heliograms but inevitably result in some artifacts. By contrast, derotated fixed-difference images show a realistic picture of dimmings, brightenings, and coronal waves with respect to the same base heliogram. These statements were illustrated particularly for the famous Bastille Day 2000 event (Chertok & Grechnev, 2004a).

2. Results

The analysis of of halo CME events has revealed, in particular, that when the global solar magnetosphere is complex (typical for the solar cycle maximum), dimmings are often anisotropic, spreading along narrow extended channel-like structures (Chertok & Grechnev, 2003a). These structures can embrace almost entire visible solar disk. Herewith, coronal waves are also observed as anisotropic disturbances propagating within a restricted angular sector.

We have found a large-scale homology of dimmings and coronal waves in repetitive CME events originating recurrently from the same eruptive center or active complex. Such a homology took place particularly in the 24–26 November 2000 series of six major flares and halo CMEs (Chertok *et al.*, 2004a), as well as during an extremely high eruptive activity in October–November 2003 (Chertok and Grechnev, 2004b).

The analysis of dimmings using the four EIT different-temperature lines showed that in many events the main dimmings coincide entirely or partially in all EIT bands. At the same time, dimmings exist which appear different, mainly, in the transition-region line

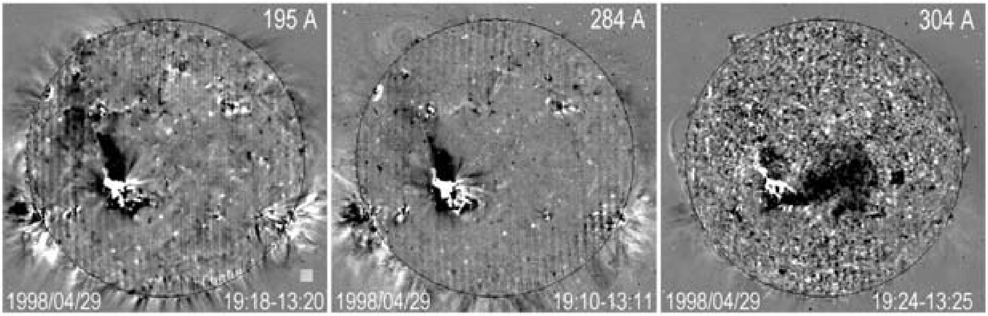

Figure 1. SOHO/EIT derotated fixed-difference images of the 29 April 1998 event with 6-h intervals illustrating CME-associated dimmings (dark areas) in the coronal lines 195, 284 Å and transition-region line 304 Å.

of 304 Å and in the highest-temperature coronal line of 284 Å. Moreover, there are events in which large transition-region dimmings are not visible in the coronal lines (Fig. 1) (Chertok & Grechnev, 2003b).

These results suggest that not only partial opening of the magnetic structures resulting in the depletion of stuff density and the decrease of the emission is important for development of the global CME-initiated dimmings. Besides, temperature variations can work in the formation of some dimming structures. This also means that these processes involve not only large-scale structures of the solar corona, but also cooler plasma of the transition region.

The outlined technique of 'derotated' fixed-difference images has also been applied to the analysis of the data of EUV telescope SPIRIT aboard the CORONAS-F spacecraft (Chertok *et al.*, 2004b; Kuzin *et al.*, 2004; Slemzin *et al.*, 2004).

Various difference images and corresponding movies for many CME events are presented at the web site http://helios.izmiran.troitsk.ru/lars/Chertok/.

Acknowledgements

We are grateful to the SOHO/EIT team members for data used in this research. SOHO is a mission of international cooperation between ESA and NASA. This work was supported by the Russian Foundation of Basic Research (grants 03-02-16049, 03-02-16591) and the Ministry of Education and Science (grants 447.2003.2, 1445.2003.2).

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