COMPARISON OF THE PARAMETERS OF CORONAL MASS EJECTIONS AND TYPE II RADIO BURSTS IN CYCLES 23 AND 24

Irina A. Bilenko

Sternberg Astronomical Institute, Moscow M.V. Lomonosov State University

DH type II radio bursts (RBIIs) are believed to be generated by magnetohydrodynamic shock waves. Coronal mass ejections (CMEs) are considered to be the main phenomenon of solar activity, which are the sources of these shock waves. The results of the study of CMEs, RBIIs, and CMEs associated with RBIIs (RBII CMEs) from 1997 to 2017 are presented.

ALL CMEs and RBII CMEs

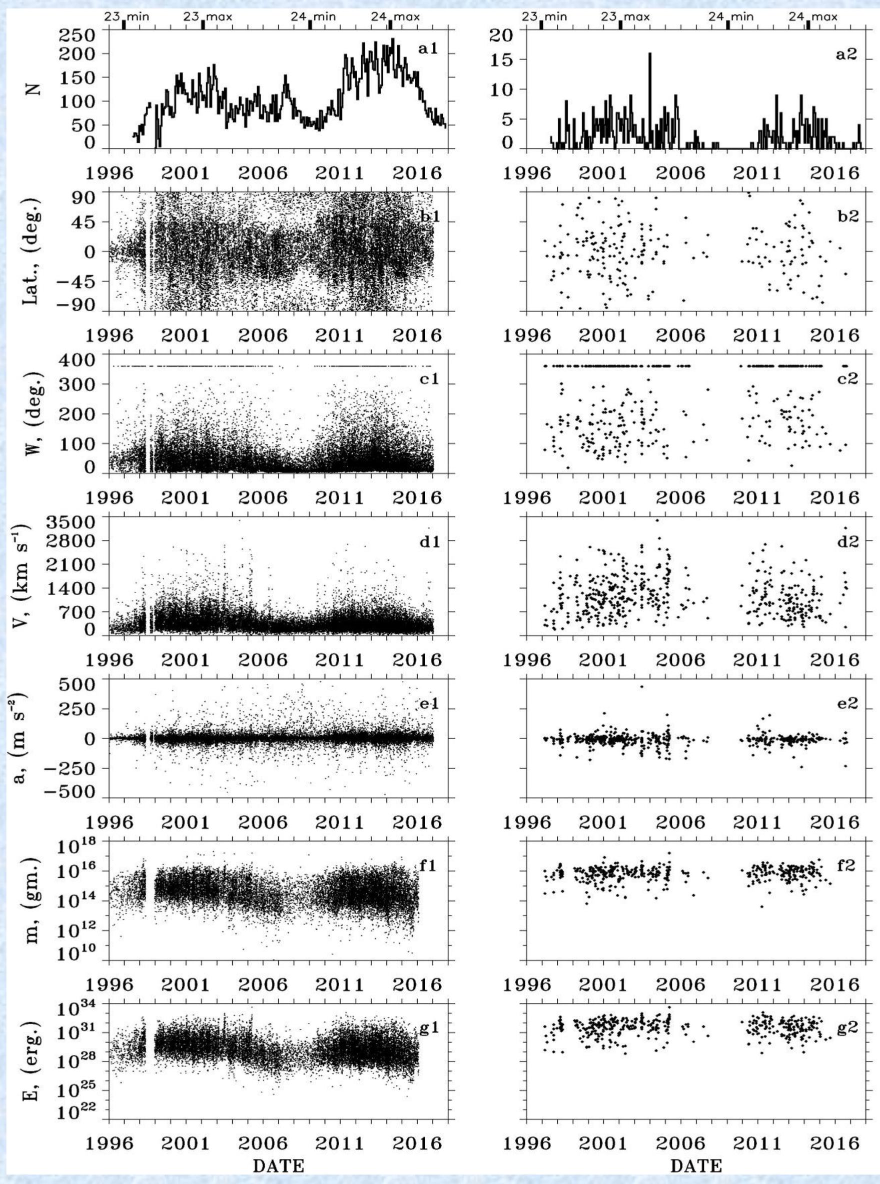
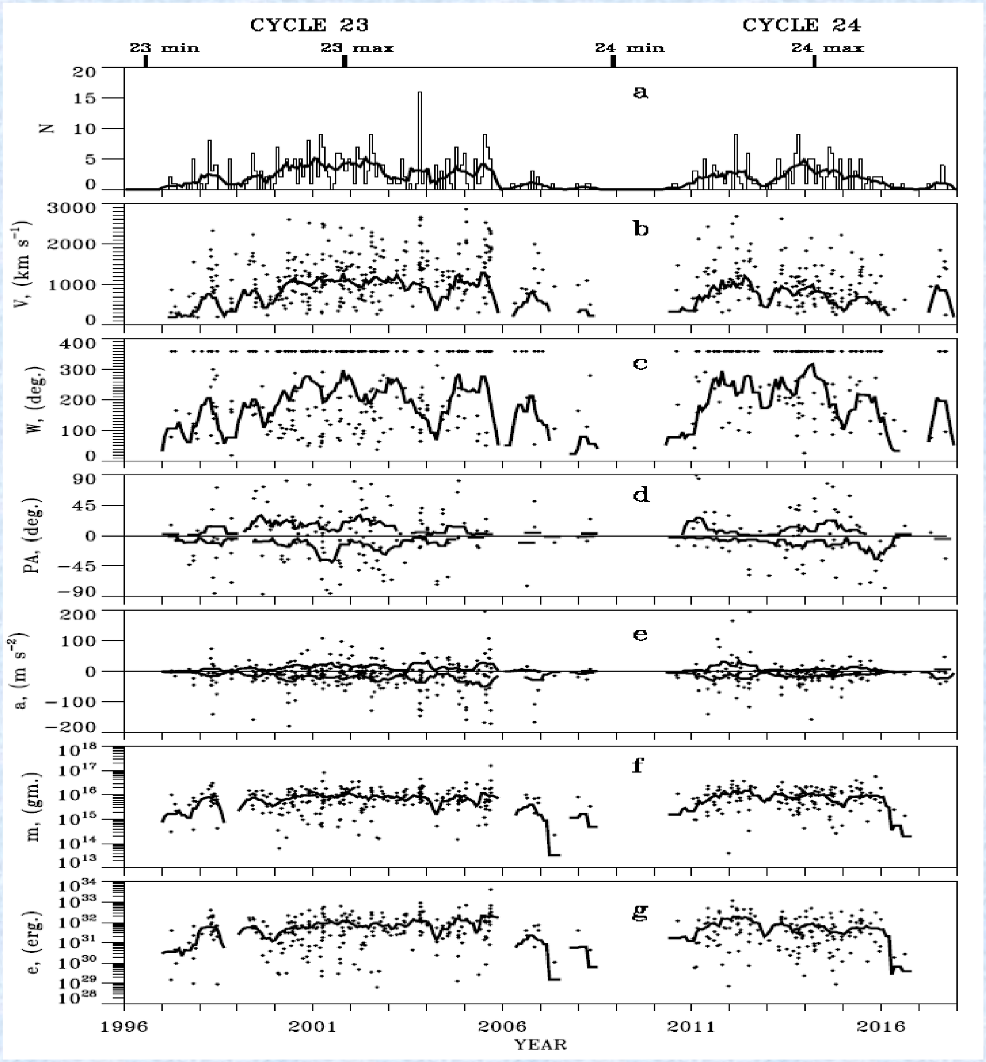
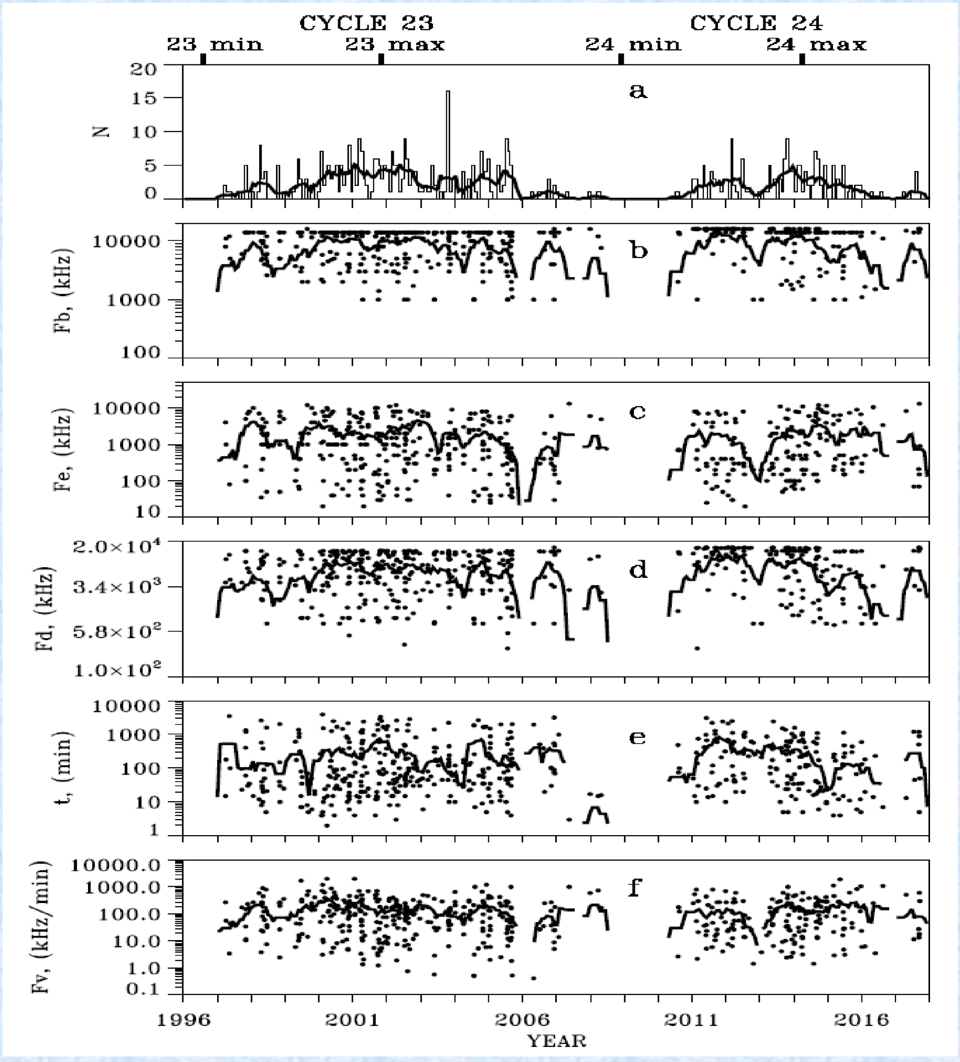


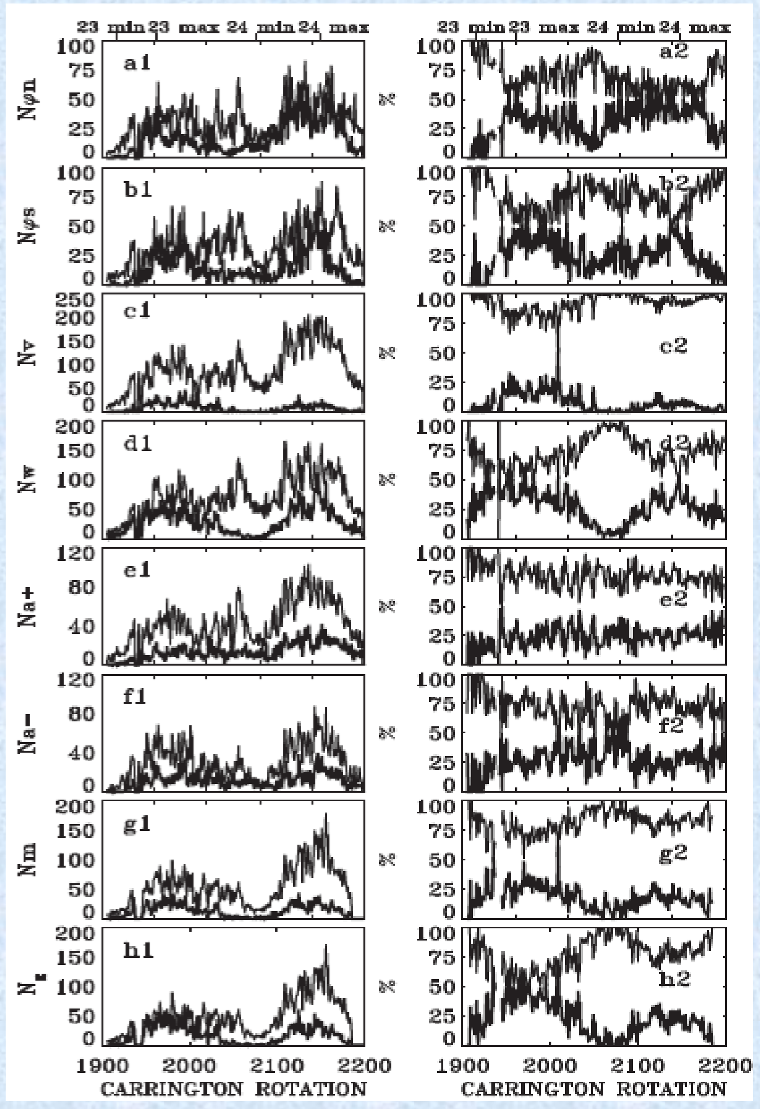
Figure 1 shows the parameters of all CMEs (left) and RBII CMEs (right) for 1997–2017. Each point corresponds to an individual event. Only a small percentage of CMEs were associated with RBIIs. The total number of CMEs was equal to 13924 in cycle 23 and it was equal to 15074 in cycle 24. However, the number of RBII CMEs was higher in cycle 23 (338) than in cycle 24 (180).

VARIATIONS IN THE NUMBER AND PARAMETERS OF RBII CMEs AND RBIIs IN CYCLES 23 AND 24



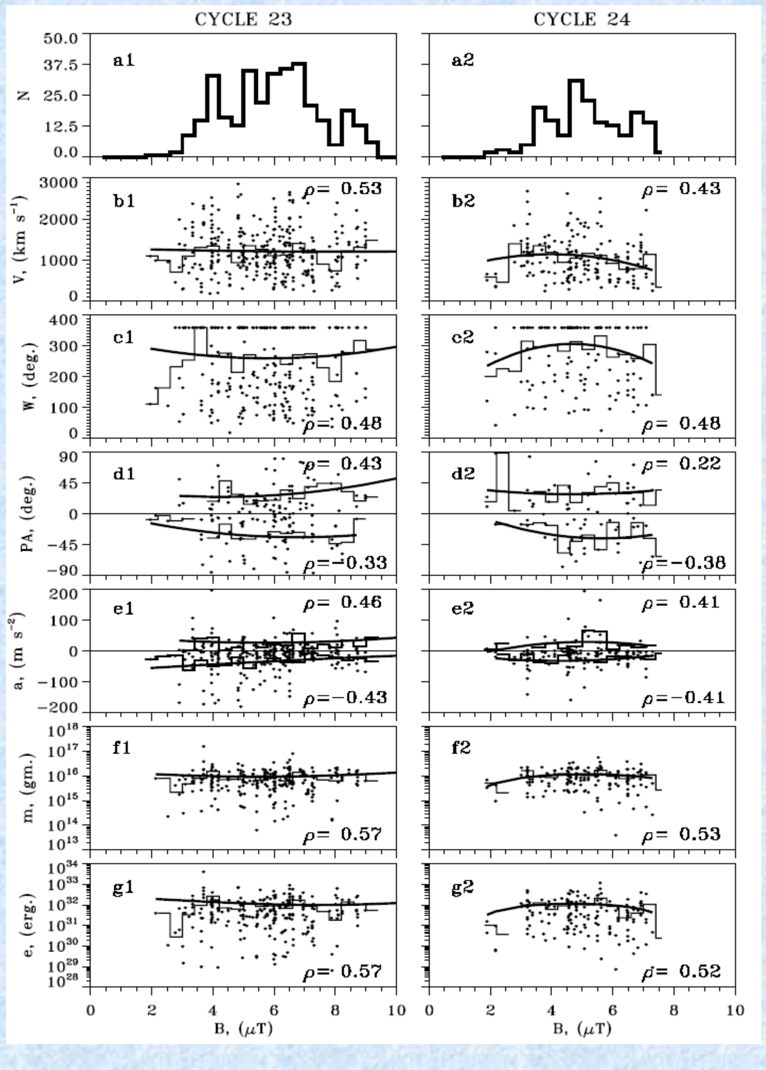


In Figure 2, the variations in the number and parameters of RBII CMEs in cycles 23 and 24 are shown: the number of RBII CMEs in each CR (N), the values of their velocity (V), angle in the sky plane (W) , latitude distribution (RA), acceleration (a), mass (m), and kinetic energy (e). Figure 3 shows variations in the number and parameters of RBIIs in cycles 23 and 24: starting frequency (Fb), ending frequency (Fe), the difference between the starting and ending frequencies (Fd), the duration (t), and the average rate of frequency change during the RBII observation time (Fv). Each point corresponds to a separate event. Thick solid lines are 7 CR averaged values. The significant differences between the RBII number in cycles 23 and 24 are seen. In cycle 23, the number of RBII is greater, but their maximum number in CR remains at the same level at different phases of the cycle, with the exception of the outburst of extreme events in October 2003. Unlike cycle 23, the number of RBII CMEs and their parameters follow solar activity cycle in cycle 24. The maximum number of RBIIs in CR was the same in both cycles (9 RBIIs in a CR). This corresponds to the dynamics of photospheric magnetic fields of strength above 100 G and powerful CMEs (Bilenko, 2020).



TEMPORAL EVOLUTION OF THE NUMBER OF DIFFERENT TYPES OF CMEs

In Figure 4 (left panels), thick lines indicate the number of CMEs with parameters greater than (thin lines - equal to or less than): PA=40 deg., V=700 km/s, W=60 deg., a=|20| m/s^2, m=200x10^{13} gr., e=10^{30}erg. In right panels, the fraction in percent of the total number of CMEs in each CR is shown. For different categories, the number of events had different behavior. The number of fast, wide, low-latitude CMEs with greater mass and energy, and low acceleration followed solar cycles, and their maximum parameter values were approximately at the same level in both cycles or even lower in cycle 24. The number of high latitude, slow, narrow CMEs, with lower mass and energy, and high acceleration, was higher in both cycles and the difference increased significantly in cycle 24.



DEPENDENCE OF RBII CMEs ON MAGNETIC FIELD IN CYCLES 23 AND 24

Figure 5 shows the dependencies of the number and parameters of RBII CMEs and RBIIs on the magnetic field strength calculated using formula (Bilenko, 2018) at a distance of 5 Rs in cycles 23 and 24. All dependencies are approximated by second order polynomials (thick lines). Thin lines show histograms of the dependencies. The Spearman correlation coefficients are shown in the right corners. Three periods can be distinguished. Significant differences are observed in the dependencies of the parameters and the number of RBII CMEs in cycles 23 and 24 that are more pronounced for the parameters V, W, a, and PA. Since the total magnetic field is lower in cycle 24, all dependencies are shifted towards lower values of B. However, the increase in the number of events in both cycles starts from B≈3 μT.

CONCLUSION

- The parameters of RBII CMEs in cycles 23 and 24 (1997–2017) and their dependence on the strength of the magnetic field in the region of RBII generation were investigated.
- The study showed that CMEs associated with RBIIs constitute a separate CME population. CMEs and RBII CMEs behave differently in cycles 23 and 24. The results indicate that while the total number of CMEs increased from 13924 in cycle 23 to 15074 in 24, the number of RBII CMEs decreased from 338 in cycle 23 to 180 in cycle 24. In cycle 24, not only the number of CMEs increased, but also their parameters and cycle variations changed.
- Since the magnetic field was lower in cycle 24, the dependencies of all parameters of RBII CMEs and RBIIs were shifted towards lower values of B. However, the growth in the number of events in both cycles began in the same way, approximately, with B≈3 μT.
- Cycle variations in the RBII CME number and parameters coincide with the dynamics of powerful CMEs.
-The presence of separate RBII CME groups, depending on the magnetic field strength, may indicate that there are different types of RBIIs and the different conditions are required for RBII generation.

DATA

RBII and RBII CME parameters were obtained from the catalog of Gopalswamy et al. (2019) with the addition of data on acceleration, mass, and energy from the CDAW catalog (Gopalswamy et al., 2009). Data on magnetic fields were taken from WSO.

REFERENCES

Bilenko, I.A., Solar Phys., V. 293, no. 7, id 106, 2018.
Bilenko, I.A., Astrophys. J., V. 889, 1, 12pp, 2020.
Gopalswamy, N., Yashiro, S., Michalek, G., et al., Earth Moon Planet. V. 104, P. 295–313, 2009.
Gopalswamy, N., Mäkelä, P., and Yashiro, S., Sun & Geosphere. V. 14, P. 111–140, 2019.

Acknowledgements

We used the SOHO/LASCO CDAW and RBII catalogs. This CME catalog is generated and maintained at the CDAW Data Center by NASA and the Catholic University of America in cooperation with the Naval Research Laboratory. SOHO is a project of international cooperation between ESA and NASA. The RBII catalog used in this study was obtained via the web site http://cdaw.gsfc.nasa.gov/CME_list/radio/waves_type2.html. The Wilcox Solar Observatory data used in this study was obtained via the web site http://wso.stanford.edu at 2018:03:11_01:13:34 PST courtesy of J.T. Hoeksema. Wilcox Solar Observatory is currently supported by NASA.