YOHKOH SXT XPE Catalogue: A Description

X-ray Plasma Ejections (XPEs) are dynamical events seen in the solar corona in X-rays. They establish a wide range of macroscopic motions of a magnetized plasma with different morphology, kinematics and physical conditions, usually associated with solar flares.

The catalogue contains all XPEs, known for us, observed by the Soft X-ray Telescope (Tsuneta et al., 1991) during the whole time interval of *Yohkoh* operation, i.e. between 1991 October 1 and 2001 December 14. There are three main surveys of events that we used in our catalogue:

1. Kim et al. (2005) which contains 137 events observed between 1999 April and 2001 March.

2. Ohyama (2009) with 53 events that occurred between 1991 October and 1998 August. The survey was prepared for the aim of statistical research (Ohyama & Shibata, 2000), but it was not published.

3. Chmielewska (2010) which reports 116 events observed mainly within two time intervals: 1998 September – 1999 March and 2001 April – 2001 December that were not systematically searched before.

We incorporated also 65 XPEs reported in other scientific papers as well as in the electronic bulletin *YOHKOH SXT Science Nuggets* (http://www.lmsal.com/YPOP/Nuggets/). In summary, our catalogue contains 368 events.

We qualified events to the catalogue on the basis of the SXT observations exclusively. For this reason, we omitted some X-ray ejections from years 1991-2001 that are known according to observations made with other instruments alone, like the *Yohkoh* Hard X-ray Telescope, e.g. Hudson et al. (2001).

The general arrangement of the catalogue is a matrix of years and months of observations. In an entry, each XPE is identified by the chronological catalogue number, date, and time of occurrence. The letter (a) added to a start time means that the XPE begun actually earlier than show the available movies. The letter (b) added to an end time means that the XPE finished actually later than show the available movies. The letter (c) added to an end time means a time interval of available movies in which we cannot identify the XPE reported earlier by other authors. Further entries refer the XPE as well as the associated flare and CME.

"XPE" entry

This entry contains 8 columns labeled as follows: (1) event ID, (2) date, (3) time, (4) quality, (5) classification, (6) movies, (7) results of analysis, and (8) references. The first three columns are repeated from the higher entry.

In Col. (4) we evaluate a quality of available SXT observations by assignment one letter between (A) and (D). A letter (A) means the highest quality: the XPE is clearly seen and

only slightly disturbed by a flare saturation, observations have almost full spatial and time coverage, images are made at least by two different filters. In conclusion, events with this letter are a good source for any kind of qualitative analysis including a plasma diagnostics on the basis of the filter-ratio method (Hara et al., 1992). A letter (B) means also a generally good quality of observations, but a usage of only a one filter in some cases makes a plasma diagnostics unavailable. Nevertheless, XPEs marked with this letter always are good for a kinematical studies. A letter (C) means a poor quality for some of the following reasons: a brightness only slightly above the background, a short-time window, an unappropriate field of view, or a strong damage from a flare saturation. For events with this letter usually possible are only rather limited activities, e.g. a description with our 3-parameters classification. A letter (D) is designed for XPEs, mentioned by other authors, for which we cannot find out any presence of the event in movies that we made.

In Col. (5) we characterize general observational features of the XPE using a new classification scheme that we have developed in this catalogue. In our classification we define three criteria considering: (a) the morphology of the XPE, (b) its kinematics, and (c) multiplicity of the occurrence. Examining each criterion we distinguish two subclasses of events only: (a) 1 – collimated, 2 – loop-like; (b) 1 – confined, 2 – eruptive; (c) 1 – single, 2 – recurrent. In consequence, our classification can resolve 8 subclasses.

Our morphological criterion resolves only a direction of the moving soft X-ray plasma in comparison with the local magnetic field. Roughly speaking, in case of the subclass 1 the direction is parallel i.e. along the already existing lines, in case of the subclass 2 — perpendicular i.e. across the already existing lines (or strictly speaking – together with them). XPEs from the first morphological subclass usually take a form of a blob or a column of matter that propagates within a bundle of magnetic lines without any serious modification of their structure. Therefore, these events are more collimated (hence its name) and less energy-consuming. A direction of their motions depends on the configuration of guiding lines. XPEs from the second morphological subclass take a form of a rising loop or a system of loops. Sometimes the expansion is non-radial: the system is unequally anchored deeper in the atmosphere or meets another magnetic structure higher in the corona. Some events showed features of our both morphological subclasses, 1 and 2, in this case we classified them according to a more evident feature.

For the assignment into one of kinematical subclasses we have chosen a rate of the height increment above the chromosphere, $\dot{h}$. A negative value, $\dot{h} < 0$, means the subclass 1, the opposite case, $\dot{h} \geq 0$ means the subclass 2. XPEs from the first kinematical subclass can be connected with a plasma motion within closed magnetic structures as well as with some changes in a plasma situation or in the local magnetic field structure which do not evacuate any mass from the Sun. For XPEs from the second kinematical subclass, an increasing velocity in the radial direction in the field of view of the SXT allow us to anticipate a further expansion leading to irreversible changes (eruption) of the local magnetic field. In consequence, at least a part of the plasma escapes from the Sun. In some cases the classification was problematic because of a limited coverage of available observations, hence a question mark near some digits in this column.

According to our third criterion we separate disposable, unique XPEs that occurred once in time (subclass 1) from recurrent events for which following expanding structures can be

seen with time (subclass 2). The majority of XPEs described in the literature belongs to the subclass 1, however also samples of the subclass 2 were already presented. A partial time coverage of available observations increases probably the actual population of single XPEs, because a narrow observational window allows us to resolve only a single feature even for recurrent XPEs.

Especially important is Col. (6) in which all available movies that illustrate an evolution of the XPE are collected. The movies consist of images obtained by the SXT and are written in the MPEG format. The images made by using particular filters and spatial resolutions are collected in separate movies. A label informs about contents of the movie, e.g., AlMg/HN marks images obtained with the AlMg filter of half-normal resolution. We used standard annotations of filters and spatial resolutions applied in the *Yohkoh* software (Morrison, 1994): the filter Al.1 – the wavelength range 2.5-36 Å , AlMg – 2.4-32 Å , Mg3 – 2.4-23 Å , Al12 – 2.4-13 Å , Be119 – 2.3-10 Å ; the full-normal resolution, FN, — 2.45 arcsec, half-normal resolution, HN, – 4.9 arcsec, quarter-normal resolution, QN, – 9.8 arcsec. A particular resolution means a specific field of view: 2.6 × 2.6 arcmin, 5.2 × 5.2 arcmin, 10.4 × 10.4 arcmin, for the FN, HN, and QN resolution, respectively. Sometimes we divided images made with the same filter and the same spatial resolution onto separate movies that consist of images made with the same time exposition. In this case, their labels contain additionally successive roman digits.

The movies consist from images that we previously processed using a standard *Yohkoh* routine SXT_PREP, which allowed us to reduce an influence of typical instrumental biases. In the images the heliospheric coordinates are overwritten by using the SolarSoft routine PLOT_MAP. For better identification of a faint features slightly above the background, we represented a signal distribution with non-linear colour tables Nos. 16 ("Haze"), 33 ("Blue-red"), or 3 ("Red temperature") available in the Interactive Data Language (IDL). Images that form movies in the catalogue are sometimes non-uniformly spaced in time, therefore it is strongly advised to watch a time print that is present in each image.

The XPEs for which a more detailed analysis have been already performed show in Col. (7) an entry with a concise report about results. Inside the report, obtained values of investigated parameters like velocity, acceleration, temperature, emission measure, electron density, pressure, and secondaries, as well as references, are given. For 12 events a more complete set of results is presented in form of plots and tables illustrating the whole evolution (Ronowicz, 2007).

Finally, in Col. (8) references to all reports (also in the electronic form) in the chronological order are given.

"SXR flare" entry

This entry contains a basic info about the flare that was associated with the given XPE. The first three columns are repeated from the higher entry. Each record describes following attributes: date, time of start, maximum, and end defined on the basis of the *Geostationary Operational Environmental Satellites (GOES)* 1–8 Å light curve, *GOES* class, location in heliographic coordinates, NOAA active region number. These tags are empty if no flare was associated with the XPE. By clicking on the *GOES* class, one can view the *GOES* light

curves in two wavelength ranges: 1–8 (upper) and 0.5–4 Å (lower). Time span of plots is always two hours and includes the occurrence of the XPE, which is marked by vertical lines. The hatched area on the plot represents *Yohkoh* nights.

Records presented in this entry are generally adopted from the Solar-Geophysical Data (SGD), however some clarifications and supplements were necessary. For example, the lacking locations were completed on the basis of SXT images as a place of bright loop-top kernels. The values obtained in this way are given in parenthesis. Coordinates of events that occurred behind the solar limb are taken mainly from Tomczak (2009).

"HXR" entry

This entry presents some attributes of hard X-rays emitted by the flare that was associated with the given XPE. The first three columns are repeated from the higher entry. The observations are derived by the *Yohkoh* Hard X-ray Telescope, HXT (Kosugi et al., 1991). The HXT measured the hard X-ray flux in four energy bands: 14-23 (L), 23-33 (M1), 33-53 (M2), and 53-93 keV (H). Each record contains peak time and peak count rate (together with the background) inferred for the energy band M1. If these tags are empty, it means that no sinal above the background occurred. By clicking on the catalogue number, one can view the HXT light curves in all energy bands. These plots include the occurrence of the XPE, which is marked by vertical lines. If designed, we enclose also a number of the *Yohkoh* Flare Catalogue (HXT/SXT/SXS/HXS), http://gedas22.stelab.nagoya-u.ac.jp/HXT/catalogue/. This catalogue is available also as the online material to Sato et al. (2006).

"CME" entry

This entry contains some attributes of the Coronal Mass Ejection (CME) that was associated with the given XPE. The first three columns are repeated from the higher entry. The observations are derived by the Large Angle and Spectrometric Coronagraph, LASCO, (Brueckner et al., 1995) onboard the *Solar and Heliospheric Observatory (SOHO)*. From the *SOHO* LASCO CME Catalog (Gopalswamy et al., 2009), http://cdaw.gsfc.nasa.gov/CME_list/, values of the following parameters are given: date and time of first appearance in the C2 coronagraph field of view, central position angle, angular width, speed from linear fit to the $h(t)$ measurements, acceleration inferred from the quadratic fit. The first appearance time is the link to the beginning of the list of events in the *SOHO* LASCO CME Catalog for a given year and month. By clicking on the entry "Related links" one can view a javascipt movie of the CMEs within the C2 field of view for a given day. Movies reside at the the homepage of the *SOHO* LASCO CME Catalog. The "CME" entry is empty when during a given XPE the LASCO did not derive any observations.

"References" entry

In this entry references to all reports (also in the electronic form) in the chronological order are given.

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