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Catalogue and bibliography of the UV Cet-type flare stars and related objects in the solar vicinity

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Abstract. This new catalogue of flare stars includes 463 objects. It contains astrometric, spectral and photometric data as well as information on the infrared, radio and X-ray properties and general stellar parameters. From the total reference list of about 3400 articles, partial lists selected by objects, authors, key words and by any pairs of these criteria can be obtained[1].

Key words: stars: flare — catalogue

1. Intoduction

The Xth IAU General Assembly has defined the UV Cet-type variables as follows: "Dwarf stars of spectral classes dM3e-dM6e characterized by rare and very short flares with amplitudes from 1 mag to 6 mag. Maximum brightness (usually sharp) is attained in a few, or several tens of seconds after the commencement of the flare, total duration of the flare being equal to about ten to fifty minutes". This pure photometrical definition is kept in all editions of the General Catalogue of Variable Stars.

We propose a more general astrophysical definition: the UV Cet-type variables are stars on the lower part of the main sequence which show phenomena inherent to the solar activity. The most manifestations of the solar activity are detected on such stars: sporadic flares, dark spots, variable emissions from chromospheres and coronae, radio, X-ray and UV bursts. Numerous and well studied manifestations of solar-type activity provide a key to understanding the related stellar variability, while the observations of numerous UV Cet–type stars of different masses and ages, single objects and components of binary systems, provide an opportunity to approach to the solar activity from an evolutionary point of view and to examine its dependence on fundamental stellar parameters.

The UV Cet–type stars are known in the solar vicinity and in the nearest stellar clusters. The number of these objects in such clusters is many hundreds, but information about individual stars is very limited, and they are used mainly for stellar statistical investigations (Haro & Chavira 1965; Ambartsumian & Mirzoyan 1977; Mirzoyan et al. 1990; Caillault 1994). The number of known UV Cet–type stars in the solar vicinity is less by about an order of magnitude, but these objects are accessible, as a rule, for detailed astrophysical studies and give us a physical picture of their activity.

In recent years, a lot of new UV Cet–type stars in the solar vicinity have been discovered by traditional photometry and spectroscopy and by new kinds of researches in the UV and X–ray ranges. In particular, recently Hawley et al. (1996) gave a list of 321 dMe stars with rather strong H-alpha emissions and 3/4 of them should be regarded as new UV Cet-type stars in accordance with our definition. As a result, the existing catalogues of the UV Cet–type stars (Pettersen 1976; Shakhovskaya 1978; Pettersen 1991) turned out to be significantly non-complete. It stimulated us to carry out this work.

2. Catalogue description

We prepared the computer-readable version of the Database on the UV Cet-type stars and used it to make the Catalogue and Bibliography.

The Catalogue is presented in three tables.

Table 1 gives the list of UV Cet–type stars in the solar vicinity with their coordinates, proper motions, names and

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[1] Tables 1, 2 and 3 are only available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

catalogued designations, the last ones are taken mainly from SIMBAD.

Coordinates for 1950.0 were adopted from Gliese (1969), Gliese & Jahreiss (1979, 1991), Kholopov (1985, 1987), Samus (1990), Kholopov et al. (1985, 1987, 1989), Kazarovets & Samus (1990) or from one of the first publications on stellar activity.

Coordinates for 2000.0 were taken from two sources. Data for more than half stars considered were prepared by Dr. N.N. Samus and E.N. Pastukhova as a part of their work to form a modern astrometric basis for the General Catalogue of Variable Stars. They used the HIPPARCOS catalog (ESA 1997), the PPM catalog (Roeser & Bastian 1991, 1993); the Space Telescope Guide Star catalog (Lasker et al. 1990); the US Naval Observatory A1.0 catalog (Monet 1996); accurate coordinates from publications and original measurements from Digitized Sky Survey images with GSC stars as reference. Most flare stars have large proper motions. In many cases, such proper motions are not well known. Moreover, in several cases, the epochs of published positions are approximate to a couple of years. For this reason we present coordinates at 2000.0 to $0^s.1$ in right ascension and to $1''$ in declination. In the cases of known proper motions, the coordinates were reduced to equinox and epoch 2000.0; such coordinates are accompanied by the values of the annual proper motions in right ascension and in declination. If proper motions are not available, the coordinates are accompanied, whenever possible, with their epoch values (the equinox being still 2000.0). Data for rest stars labelled by asterisks were determined by Hawley et al. (1996) from the Space Telescope Digitized Sky Survey. Proper motions for these stars are from Gliese & Jahreiss (1991). For about dozen systems the astrometric data for A and B (or C) components are accessible only from independent sources; their disagreements show the realistic accuracy of the distance and proper motion determinations.

The identification of stars with ROSAT and EUVE sources is achieved by cross-referencing with the list of ROSAT sources by Shara et al. (1993), the 1st EUVE catalogue by Malina et al. (1994) and the 2nd EUVE catalogue by Bowyer et al. (1996).

We include AM Her with unseen flare components (USCs) detected only during its powerful optical flare, and β Boo, whose flare component was detected only during a radio burst.

According to the current stellar evolution concept, the T Tau-type variables are predecessors of the UV Cet stars, at least, of the more massive of them. The RS CVn variables are the post-main sequence stage of spectroscopic binary systems with components of small and moderate masses. However, in both cases the transitions to and from the UV Cet-type variables are not sharp. Therefore, there is a possible confusion in classification, and some objects regarded as UV Cet stars may belong also to the T Tau or RS CVn variables.

Table 2 contains data from optical and infrared observations. One of the designations reported in Table 1 and indications on a component if a star is a member of a binary system (independently on that such indication exists or is absent in the designation used) are given in Cols. 1 and 2 respectively. Distances (Col. 3) are from trigonometric parallaxes from the HIPPARCOS catalog (ESA 1997) and from Gliese & Jahreiss (1991) or from spectral parallaxes from Hawley et al. (1996) (marked by asterisks) and from several different parallax sources (marked by #). Spectral classes (Col. 4) are from different older sources and, after "/", from homogeneous classification by Hawley et al. (1996). Equivalent widths of the H-alpha emission line approximated to 0.1 Å for 321 stars from Hawley et al. (1996) and, marked by asterisks, from spectral data of Stauffer & Hartmann (1986) and from photometric measurements by Herbst & Miller (1989) are given in Col. 5. UBV photometric data are listed in Cols. 6–9. Initially, the latter data were adopted from the same sources as the 1950.0 coordinates. Some stars have multicolour photometric data (Cols. 6–15), adopted from Pettersen (1976) or from Doyle & Butler (1990). Then, photometric data were taken from SIMBAD. We follow photometric systems in accordance to Bessel (1990) and Leggett (1992). Photometric observations of close binaries give the total brightnesses of the systems and such data are marked by "J". Several of them were resolved by HIPPARCOS. Thus, the photometric data in Table 2 are not strictly homogeneous, and should be used as approximate values only.

The IRAS fluxes in Jy $= 10^{-26}$ watt m^{-2} Hz^{-1} $= 10^{-23}$ erg cm^{-2} s^{-1} Hz^{-1} (Cols. 16–19), are given accordingly to Tsikoudi (1988, 1990), Mullan et al. (1989) and Mathioudakis & Doyle (1993). Numbers within [ ] are upper limits given as 3 times of the noise level at the positions of sources.

The bolometric luminosities (Col. 20) are from Bookbinder (1985), Tsikoudi (1988), Pallavicini et al. (1990), Doyle & Butler (1990) and Katsova & Tsikoudi (1993). The stellar masses (Col. 21) and stellar radii (Col. 22) in solar units are taken from Rodonò (1986), Doyle & Butler (1990), Panagi & Mathioudakis (1993), Zakhozhaj (1994) and several particular publications. The last column (23) of the Table 2 contains indications of photometrical evidence for stellar spottedness, the existence for such data (from Alekseev & Gershberg 1996) is indicated by "S".

Table 3 contains non–optical data on the stars in their quiet state.

The EINSTEIN data, presented as the Imaging Proportional Counter (IPC) fluxes (0.15 − 4 keV) from the Slew Survey where 1 count s^{-1} $= 3\,10^{-11}$ erg cm^{-2} s^{-1} (Col. 24), are taken from Elvis et al. (1992). The values of the X–ray luminosities (Col. 25) in erg s^{-1} are from

Bookbinder (1985), Agrawal et al. (1986), and Katsova & Tsikoudi (1993).

The EXOSAT data, obtained with the Low Energy (LE) Detector (0.05−2 keV) in erg s^{-1} (Col. 26), are given according to Schmitt & Rosso (1988) and Pallavicini et al. (1990).

The ROSAT data are obtained for the All–Sky Survey from the both Wide–Field Camera (WFC) and the Position–Sensitive Proportional Counter (PSPC). The WFC used two filters: S1a (90 − 185 eV) with the maximum around 124 eV, and S2a (62 − 111 eV) with the maximum around 90 eV. The WFC count rates in counts ks^{-1}, taken from Pound et al. (1993) and Wood et al. (1994), are presented in Col. 27. For a plasma temperature within the range of $2\ 10^5 < T < 6\ 10^6$ K and for column density $N_H = 10^{18}$ cm^{-2}, 1 count s^{-1} for S1a filter is $(3-5)\ 10^{-11}$ erg cm^{-2} s^{-1} and 1 count s^{-1} for S2a filter is $(2-5)\ 10^{-11}$ erg cm^{-2} s^{-1}. For $N_H = 10^{19}$ cm^{-2}, the corresponding fluxes are $(5-7)\ 10^{-11}$ erg cm^{-2} s^{-1} and $(4-15)\ 10^{-11}$ erg cm^{-2} s^{-1}, respectively. In general, in making quantitative use of the WFC data, conversion from WFC count rates into fluxes must be carried out for any input spectrum, using the effective area curves reproduced in Fig. 3 of Pounds et al. (1993). The S1a and/or S2a filter count rates marked by "F" were enhanced by flare events. The PSPC data from the ROSAT all-sky survey in the range 0.1 − 2.4 keV for apparent X-ray fluxes in erg cm^{-2} s^{-1} (Col. 28) are taken from Schmitt et al. (1995) and from Hünsch et al. (1998). The values of $\log L_X$ (Col. 29) in erg s^{-1} are from Fleming et al. (1993) and Hünsch et al. (1999). The latest X-ray luminosities are derived by Hünsch et al. (1999) using the stars' distances as given by HIPPARCOS.

The results of the Extreme-Ultraviolet Explorer (EUVE) mission for red dwarf stars are from Bowyer et al. (1996). Count rates of sources detected during the all-sky survey as well as by deep exposures with the scanner telescopes for four bands, 100 Å, 200 Å, 400 Å, and 600 Å are listed in Cols. 30 − 33 in counts ks^{-1}. To convert count rates into absolute band energy fluxes, it is necessary to use the absolute effective areas. The wavelength-integrated effective areas, $A_{\rm eff}(\lambda)d(\lambda)$ in cm^2. Å for four sky-survey filter bands of EUVE adopted from Table 5 of Bowyer et al. (1996), are the following: 100 Å − 753; 200 Å − 186; 400 Å − 33; 600 Å − 93. Detections for 11 stars obtained with the scanner telescope by deep exposures or by long exposures with the deep-survey instrument are marked by "#"; other values of the effective-area integrals should be used for them, namely: 100 Å − 1608; 200 Å − 992.

The existence of X–ray flare observations for a star is indicated by "X" in Col. 34.

Wavelengths of radio observations are presented in Col. 35.

The radio fluxes in mJy (Col. 36) and the radio luminosities ($\log L_r$, erg s^{-1} and $\log L_R$, erg s^{-1} Hz^{-1}) (Col. 37) are taken from Gibson (1985), Drake & Caillault (1991), Güdel (1992) and Güdel et al. (1993) and from Bookbinder (1985). The existence of radio data for flares is indicated in Col. 38 by "R".

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3. The bibliography

The Bibliography contains references to papers about each star listed in Table 1. Referred papers contain mainly original observational data, and comparative discussions with other objects under consideration have also been partly included. References are chronologically regulated and completed with key words. We have used the following list of key words:

Flares: photometry and colourimetry
Flares: optical spectra
Flares: UV emission
Flares: X–ray and high energy emission
Flares: energetics
Flares: statistics
Flares: theory
Radio emission
Polarization
Quiet state photometry
IR radiation
Photospheric spectra
Quiet chromosphere spectra
Quiescent UV emission
Quiescent X–ray emission
Outer atmospheres: theory
Starspots and long–term variability
Magnetic fields
Rotation, age
Fundamental & kinematic parameters
Catalogue
Review.

In some cases, binarity of stars hampers a single-valued selection of references for objects under consideration. Thus, for photometric observations of rather close binaries, that are carried out with short–focus telescopes as a rule, both components fall into the entrance diaphragm, and such observations give results for systems in total – such photometric data, as noted above, are marked by "J" in Table 2. However, spectral observations with longer focus telescopes provide information on the components separately. Therefore, to avoid gaps, we select references for an XXX A component both as papers on XXX A and XXX as well. This leads to some surplus list of references while selection for an XXX A only would lead to a non–complete list of references.

We aspired to include in the Bibliography all papers with information on stellar activity, but the last ones only with astrometric, fundamental photometry, stellar statistical as well as with eclipse data up, to the end of 1997. In this work we used our card catalogue on the UV Cet–type stars, Abstracts on Astronomy and Astrophysics, a set of monographs and Proceedings of meetings on related topics, Prof. W. Wentzel's microfiche catalogue on flare stars, as well as references listed below. Finally, a cross–check with the SIMBAD database was carried out.

The Bibliography is too large to be printed and it would not be convenient to use in such a version. However, extractions from the Bibliography by an author or by two authors, by a star (by any designition from Table 1), by a key word and by any pair combinations of these criteria can be obtained from
http://www.crao.crimea.ua/databases/UVCet/
or from the CrAO web site mirror at Stanford
http://quake.stanford.edu/crao or upon e-mail requests to the authors.

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