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New 211 photographic meteor orbits in the IAU MDC

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Abstract. We introduce an upgrade of the photographic-meteor IAU MDC database to the current 2003 Version. Specifically, 211 orbits from 4 sources are added to the database. In contrast to the actual version, a large part of new data contain also determination errors of some parameters.

Key words: meteors – IAU MDC – photographic meteor database

1. Introduction

The databases of meteor orbits are the main source of our observational knowledge of meteor streams. During the last three quarters of century, a quite large number of meteor orbits have been determined. The largely dispersed data started to be collected and issued as the compactified databases by the Meteor Data Center of the International Astronomical Union (IAU MDC), which was established on the General Assembly of the union in 1982 (Lindblad, 1987). The IAU MDC database became reality especially thanks to the enormous work done by Prof. Bertil A. Lindblad, who not only collected the data and communicated with the original authors to remove some discrepancies, but also advertised the database and its wide-spread usage (e.g. Lindblad, 1995; 1999; 2001; Lindblad & Steel, 1993).

Of the observational techniques applied to meteors, the photographic ones are still the most precise. The last version of the photographic database was issued by the IAU MDC in 2003 (Lindblad et al., 2003). It contains a formally homogenized set of data on 4581 meteor orbits. Meanwhile a few hundred additional photographic orbits have been published. Or, some meteors published earlier have not been included in the catalogue yet. The IAU MDC is, therefore, preparing a release of new, upgraded version.

This report brings preliminary information about the increment of the newly collected database with respect to the 2003 version (Lindblad et al., 2003).

Table 1. The list of partial catalogues of the photographic meteor orbits newly included to the IAU MDC. In headings, the first character of *code* means the code of investigator/station and the successive digit is the serial number of the partial catalogue from this source. N is the number of orbits included in the partial catalogue.

code	N	investigator/station
B2	75	Betlem et al., Dutch Meteor Society
E3	98	Ceplecha, Spurný et al., European Network
R1	32	Trigo-Rodriguez et al., Spanish Meteor Network
T3	6	Ohtsuka et al., Tokyo Meteor Network

2. Content of new data

The actual upgrade consists of 211 orbits from 4 sources listed in Table 1. The orbits are referred to the equinox 2000.0. As B2 are labelled 75 orbits gained within an observational campaign of the Leonids in 1998 by the Dutch Meteor Society (Betlem et al., 1999).

The European Network (EN) managed by the Astronomical Institute of the Academy of Sciences of the Czech Republic in Ondřejov provided 98 orbits which are in the catalogue labelled as E3 (Ceplecha & Spurný, 1990; Borovička & Spurný, 1992; Spurný, 1994; 1995; 2003a; 2003b; 2004; 2010; Spurný & Borovička, 1997a; 1997b; 1998; Spurný & Ceplecha, 1992; Spurný et al., 1991; 2004).

The upgrade also contains 32 orbits determined from the observations conducted by the Spanish Meteor and Cometary Society (SOMYCE) (Trigo & Artéz, 1996; Trigo, 1997) and the Spanish Photographic Meteor Network (SPMN) (Trigo-Rodríguez & Castellano-Roig, 2000; Trigo-Rodríguez et al., 2000a; 2000b; 2004; 2005), which were published in the period 1996−2005. The collected partial catalogue of the Spanish data is labelled as R1.

Last, but not least, 6 orbits obtained by the Tokyo Meteor Network (Shiba et al., 1989; Shiba & Ohtsuka, 1992; Ohtsuka & Tomioka, 1993; Shimoda et al., 1994; 1995; Tomita et al., 1998) are included. This partial catalogue is labelled as T3 in the IAU MDC.

3. Comment on corrections

Before being included to the IAU MDC database, the consistency of the mutually depending quantities was checked. Specifically, the date of meteor detection has to agree with the solar longitude and longitude of the ascending node, orbital elements can be calculated from the geophysical parameters and vice versa, and additional orbital elements as well as geophysical parameters can be calculated from the appropriate basic set (e.g. the aphelion distance, semi-major axis and

reciprocal semi-major axis can be calculated from the perihelion distance and eccentricity).

The re-calculation of the orbital elements from the radiant coordinates and geocentric velocity in the time of detection was done in a standard way, whereby the actual position and velocity vector of the Earth were taken from the JPL ephemeris (DE406).

It is, perhaps, worthy to note that a lot of very small differences between the corresponding values calculated by the original authors and recalculated values occurred. Many of these differences lie slightly outside the interval delineated by the published errors. The differences could appear due to rounding of the input values, using a different method of calculation of the Earth's position and velocity, as well as, maybe, making some approximations by the authors in the processing. The original values published by the authors were retained in these cases.

4. On the new data format

The format of the IAU MDC data has evolved with a gradual improvement of computer technique. The original format from the beginning of the collection of photographic data was designed only for the Fortran-formated integer parameters of meteors. The subsets of geophysical and orbital data of a meteor were constrained to a single, 80-character line of the datafile. Individual values were not separated by spaces and decimal points were omitted. It was, therefore, necessary to establish a more comfortable format which appeared in the 2003 version of the database. All data on a meteor were concentrated to 4 lines, separated by a blank line, of a single datafile.

In the last period, a lot of parameters started to be published together with the determined errors. In addition, the new data occur with mutually different precision, therefore the 2003-version format, which assumes the fixed Fortran writing again, has also become obsolete, meanwhile, and we are forced to establish a new, flexible format, applied to the newly prepared version. Eventually, the data in the newly prepared version are attempted to be recorded in a universal way independent of any specific computer-language or web-interacting-database (like, e.g., My-SQL). So, the purpose of the new format of the data is defining the list of parameters intended to be considered by the IAU MDC (not only at the photographical data) rather than to define a computer-language-writing format. With the help of the list, the IAU MDC specifies its request for the particular data.

The list of the considered meteor-data parameters is given in Table 2 (for a more detailed description of individual parameters, see the electronically published documentation to the Version 2003, which is available on: `http://www.astro.sk/~ne/IAUMDC/Ph2003/`). At the moment, the list consists of 29 parameters. It is supposed that, if needed, it can be extended by another items.

Table 2. The list of parameters included in the new 2013 version of IAU MDC database. No.P. is the serial number of the parameter in the list and C.P. is the code of the parameter. The positional parameters are referred to the equinox 2000.0.

No.P.	C.P.	explanation
1	#IC:	IAU MDC identification code
2	ANo:	number/code assigned to the meteor by author
3	Yr :	year of the detection
4	Mn :	month of the detection
5	Day:	day and fraction of day of the detection (UT)
6	LS :	solar longitude corresponding to the date of the detection [deg]
7	mv :	magnitude of maximum photographic brightness of meteor
8	HB :	height of beginning of meteor trail [km]
9	HM :	height of maximum brightness [km]
10	HE :	height of end of meteor trail [km]
11	RA :	right ascension of geocentric radiant [deg]
12	DEC:	declination of geocentric radiant [deg]
13	Vi :	extra-atmospheric velocity [$\mathrm{km\,s^{-1}}$]
14	Vg :	geocentric velocity [$\mathrm{km\,s^{-1}}$]
15	Vh :	heliocentric velocity [$\mathrm{km\,s^{-1}}$]
16	cZ :	cosine of the angular distance of geocentric radiant from the zenith
17	Qm :	quality code
18	q :	perihelion distance [AU]
19	e :	numerical eccentricity of orbit
20	1/a:	reciprocal semi-major axis [$\mathrm{AU^{-1}}$]
21	a :	semi-major axis [AU]
22	Q :	aphelion distance [AU]
23	i :	inclination of orbit to the ecliptic [deg]
24	arg:	argument of perihelion [deg]
25	nod:	longitude of ascending node [deg]
26	pi :	longitude of perihelion [deg]
27	Sh :	shower number
28	Mas:	pre-atmospheric photometric mass [g]
29	lgM:	decadic logarithm of the mass

Basically, a unique 5-character identification code, consisting of a 3-digit serial number of the meteor in a given partial catalogue and a 2-character code of this partial catalogue, is assigned to every meteor included into the IAU MDC database. The original designation, under which the meteor was published by the author(s), is also listed.

Each parameter is given in two lines of the datafile. In the first line, the code of the parameter and two binary values are written. If the first value is "1" and the second value is "0", then only the value of the parameter without

the determination error is presented in the second line. If both values are "1", then the second line contains the value of the parameter together with the determination error. (The place for the parameter can be reserved with its code, binary values both equal to "0", and blank second line. Such a record is identical to the omission of the parameter.) The number of decimal digits of the value of any parameter and its determination error is arbitrary, usually depending on the precision of its determination.

The record about a given meteor begins with the meteor identification code and is terminated with the line containing 3 spaces and character &. It is not necessary to list all 29 parameters in a particular record. Only the identification code is mandatory. The order of parameters within each record is optional, except for the code.

5. Availability of the data

The new data are freely available, in an electronic form, and can be downloaded from the IAU MDC web site: `http://www.astro.sk/~ne/IAUMDC/Ph2003/`, link "2012-ADDITION".

The data on the web site are listed in triplicate: (1) the original format of the 2003 version, (2) the form of newly established format for the prepared version intended to be published in 2013, and (3) the single-line format providing the reduced and unified set of parameters on each meteor in a single line of the datafile. The last format is provided to enable an easy visual reading of the data. The examples of the formats are given, respectively, in parts I, II, and III of the Appendix.

In all formats, there are at disposal all new partial catalogues compiled into a single file as well as each partial catalogue in a separate data file. All the content can also be downloaded as a single ZIP-archive.

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A. THE FORMATS OF DATA

I. Format of 2003 version

An example of the data format in 2003 version for 3 meteors:

```
001B2     98001       46
11  16.68186  1998   0.0   153.3   22.2    0.0   70.00  40.80  71.20
0.982    0.000    0.00  0.000   161.6  169.8  234.1    43.9
0.0   0.200  116.6    0.0  103.9    0.000    0.00000     0.00   0.00

002B2     98002       31
11  16.69212  1998   0.0   153.0   22.3    0.0   70.60  41.40  71.80
0.983    0.000    0.00  0.000   161.9  171.3  234.1    45.4
-3.0   0.220  128.9  104.8  102.8    0.000    0.00000     0.00   0.00

003B2     98003       18
11  16.69326  1998   0.0   152.9   21.9    0.0   70.00  40.70  71.20
0.983    0.000    0.00  0.000   162.5  170.6  234.1    44.8
-3.0   0.250  126.9  101.4   88.1    0.000    0.00000     0.00   0.00
```

The structure of the data is described in the documentation of 2003 version (`http://www.astro.sk/~ne/IAUMDC/Ph2003/`, file *document.txt*, *document.ps*, or *document.pdf*). The missing parameters, in the given catalogue, are substituted by zeroes.

II. Format of 2013 version

An example of the data format in prepatred 2013 version for 2 of 3 meteors listed in the part I:

```
#IC: 1 0
001B2
ANo: 1 0
98001
Yr : 1 0
1998
Mn : 1 0
11
Day: 1 0
```

16.68186
mv : 1 0
0.
HB : 1 0
116.6
HM : 0 0

HE : 1 0
103.9
RA : 1 1
153.32 0.28
DEC: 1 1
22.23 0.26
Vi : 1 1
71.2 0.9
Vg : 1 0
70.0
Vh : 1 0
40.8
cZ : 1 0
0.20
Qm : 1 0
46.2
q : 1 1
0.9817 0.0015
1/a: 1 1
0.1451 0.0830
i : 1 1
161.59 0.48
arg: 1 1
169.79 1.18
nod: 1 1
234.12721 0.00000
Sh : 0 0

&
#IC: 1 0
002B2
ANo: 1 0
98002
Yr : 1 0
1998
Mn : 1 0
11

```
Day: 1 0
16.69212
mv : 1 0
-3.
HB : 1 0
128.9
HM : 1 0
104.8
HE : 1 0
102.8
RA : 1 1
152.98   0.03
DEC: 1 1
22.33   0.02
Vi : 1 1
71.8   0.0
Vg : 1 0
70.6
Vh : 1 0
41.4
cZ : 1 0
0.22
Qm : 1 0
31.0
q : 1 1
0.9834   0.0001
1/a: 1 1
0.0933   0.0033
i : 1 1
161.92   0.04
arg: 1 1
171.25   0.11
nod: 1 1
234.13763   0.00001
    &
```

The codes of the individual parameters are listed in Table 2. The set of parameters for a given meteor is separated from the set of parameters of the next meteor by the line containing only character &.

III. Single-line format

An example of the single-line data format for 3 meteors (the same as in part I):

IC	yr	mn	day	q	e	i	arg	nod	RA	DEC	Vg	Vh
001B2	1998	11	16.68186	0.982	0.858	161.6	169.8	234.1	153.3	22.2	70.00	40.80
002B2	1998	11	16.69212	0.983	0.908	161.9	171.3	234.1	153.0	22.3	70.60	41.40
003B2	1998	11	16.69326	0.983	0.849	162.5	170.6	234.1	152.9	21.9	70.00	40.70

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