

The Asteroid Lightcurve Data Exchange Format Standard

(ALCDEF) v 2.0

Unlike astrometric observations of asteroids, where a universally accepted format for data submission has been adopted, time-series photometry of asteroids can and is found in any number of formats. This makes it more difficult for archivists of such data and the researchers wanting to use them since each person must write a number of data conversion algorithms to suit their specific wants and needs. Furthermore, many of the commonly found data sets are wanting for critical information that can dramatically reduce the usefulness of archived data.

The Asteroid Lightcurve Data Exchange Format (ALCDEF; Stephens *et al.*, 2010) was created to address these problems by providing a simple data format that not only includes the raw time-series data but a minimum of critical information (i.e., metadata, or data about the data) so that any researcher can use the data correctly in his own investigations. The format also allows including a number of other key metadata values that further enhances the value of the time-series data.

The Minor Planet Center has adopted the ALCDEF standard for asteroid time-series photometry and hosts a web page (http://www.MinorPlanetCenter.net/light_curve.php) where these data can be submitted for public use.

In this document, *lightcurve* is used instead of *light curve*.

1. STANDARDIZATION

The issue of standardization has been problematic over the years. Sometimes rigorous requirements and cumbersome procedures resulted in only a small portion of all asteroid lightcurve data obtained in the past decade being readily available.

On the other hand, some core requirements are mandatory if the data are to be useful. This document outlines a proposed standard for asteroid time-series data that, while mandating a core set of information and – to some degree – data formatting, still allows considerable flexibility.

1.1. DATA STRUCTURE

The submitted data files must follow some simple rules so that the data parsing algorithms can store the data in the ALCDEF database

- All files must be standard ASCII format. Extended characters (ASCII > 127) are not allowed.
- The files must consist of multiple lines that are terminated by, preferably, CR/LF pair (ASCII 13/10, Windows) or single LF (ASCII 10, UNIX/LINUX).
- All lines follow a “FITS-like” format of *keyword=value*.
- The total length of any line – including keyword, equals sign, and value – cannot exceed 255 characters.
- There is a fixed set of recognized keywords. Non-standard keywords are not processed when

uploading the data to the MPC site but they will not necessarily cause the data to be rejected.

- The fundamental structure for time-series data is a *lightcurve block*. A *lightcurve block* consists of two mandatory blocks:

Metadata block

Data block

- A single file can contain one or more *lightcurve blocks* for one or more objects.
- Each subsequent *lightcurve block*, if any, should follow immediately after the data section of the previous block, i.e., there should be no blank lines in the file. However, a blank line between one *lightcurve block* and another will *not* cause the entire file to be rejected. See Appendix A for a sample of a single *lightcurve block*.

1.1.1. METADATA BLOCK

The *metadata block* provides core and supporting information that fully defines the time-series data.

- The first line of this block must be the single word STARTMETADATA. There is no value associated with this keyword.
- The METADATA section must include a set of *required keywords* lines using the format
- *keyword=value*.
- The *required keywords* are used to identify the lightcurve block uniquely during the anti-duplication vetting process during data upload.
- The *metadata block* must be terminated by a line containing the single word ENDMETADATA. There is no value associated with this keyword.

1.1.2. DATA BLOCK

The *data block* contains the time-series data.

- The first line must follow the METADATA section, i.e., the first line after the ENDMETADATA terminating line.
- *There is no STARTDATA keyword.*
- There must be *at least two lines* of data in a lightcurve block.
- The last line of the section must be the single word ENDDATA
- All data must be electronically-obtained, i.e., visual estimates will not be accepted.

1.1.3. DATA LINES

Each data line must be in the format

DATA=JD<Delimiter>MAG[<Delimiter>MagErr<Delimiter>AirMass]

Value	Required	Description
JD	Yes	UT Julian Date of mid-exposure. This field is required. See section 2 for formatting requirements. <i>Julian Dates must be standard JD, not modified JD.</i>
MAG	Yes	The magnitude of the object at time JD. This field is required. See section 2 for formatting requirements.
MAGERR	No	The estimated error in the MAG value, in magnitudes.
AIRMASS	No	The air mass of the target at time JD

The fields must be separated by a DELIMITER character. The allowed characters are

TAB (ASCII 9)
PIPE (ASCII 124)

The SPACE (ASCII 32) and COMMA (ASCII 44) are not used because they could be inadvertently used within words or values, e.g., it is common for those in many countries to use the comma for the decimal character, something which the ALCDEF standard does not permit but may still occur.

Consecutive delimiters will be interpreted as a NULL value.

1.2. COMPARISON STARS

Comparison star data are not mandatory. If they are included, they are part of the *metadata block*. No more than 10 comparison stars can be defined.

A comp star definition must include, at the minimum, the name (or catalog number, ID, etc.) and magnitude of the star. The color index, and RA/Dec are optional. See section 2 and Appendix A for an example of comp star data.

1.3. ASPECT DATA

Values such as Earth and Sun distances, phase angle, ecliptic longitude and latitude, and phase angle bisector longitude and latitude are called “aspect data.” By choice, only three of these were included as (optional) keyword/value pairs in the ALCDEF standard: Phase angle (PHASE) and Phase Angle Bisector Longitude/Latitude (PABL and PABL).

The point of including phase angle and phase angle bisector values is to serve as a quick guide to the usefulness of a given lightcurve block. For example, to see if data from very low or large phase angles are available or if a given data set would essentially be a duplicate of another because the viewing aspect (phase angle bisector) was about the same.

It is presumed that anyone using ALCDEF data would compute the required aspect data independently, if nothing else as a check of the original values and, more important, to use values based on the latest available orbital elements.

If a data supplier wants to include the other values in his metadata block, they should be in the form of one or more COMMENT lines in the *metadata* block, e.g.,

```
COMMENT=Heliocentric longitude / latitude: +317.11 / +30.80  
COMMENT=Sun / Earth Distance (AU): +2.0478 / +1.1324
```

2. KEYWORDS AND DATA FORMATTING

ALCDEF formatting is similar to the FITS standard in that data are expressed as lines of *keyword=value*. The data formatting rules have been deliberately kept to a minimum but there are some minimums to follow.

- Keyword lengths cannot exceed 14 characters and should be in upper case letters.
- Floating point values *must* use the period (ASCII 46) for the decimal character
- Floating point values *must* be in non-exponential form, e.g., 432.5 and *not* 4.325E+02.
- Values that are positive numbers should include a leading plus sign (+) to remove any ambiguity.
- Negative numbers *must* include a leading minus sign (-).
- Floating-point numbers $|x| < 1.0$ *must* include a leading zero. For example: +13.258 or -0.455.
- The keywords below are recognized by the ALCDEF standard and parsing code on the Minor Planet Center site. Any lines containing non-standard keywords will be ignored.
- Boolean values must be expressed as the upper case English words TRUE or FALSE.

3. RECOGNIZED KEYWORDS

Words in ***bold italics*** must appear in each metadata block or the lightcurve block will be rejected. The DATA keyword must appear at least twice in the *data block* of a *lightcurve block*.

BIBCODE	<i>CONTACTNAME</i>	MAGBAND	PHASE
CIBAND	<i>DATA</i>	MPCDESIG	PUBLICATION
CICORRECTION	<i>DELIMITER</i>	OBJECTDEC	REDUCEDMAGS
CITARGET	DIFFERMAGS	<i>OBJECTNAME</i>	REVISEDATA
COMMENT	<i>ENDDATA</i>	<i>OBJECTNUMBER</i>	<i>SESSIONDATE</i>
COMPXI{X}	<i>ENDMETADATA</i>	OBJECTRA	<i>SESSIONTIME</i>
COMPDEC{X}	<i>FILTER</i>	<i>OBSERVERS</i>	STANDARD
COMPNAME{X}	LTCAPP	OBSLATITUDE	<i>STARTMETADATA</i>
COMPMAG{X}	LTCDDAYS	OBSLONGITUDE	UCORMAG
COMPRA{X}	LTCTYPE	PABB	
<i>CONTACTINFO</i>	MAGADJUST	PABL	

In the keyword descriptions below, the keyword is followed by:

[Required]	The keyword <i>must</i> be used at least once in a lightcurve block.
[Optional]	The keyword <i>is not required</i> and can missing entirely
[Optional/Required]	The keyword <i>may be</i> required to cross-check other keyword/value pairs.

4. DATA VETTING

As each file is uploaded, a number of checks and validations are made to assure that the incoming data as free of errors as possible and to avoid unintended data duplication. *The data vetting checks are done at the lightcurve block level.* If one lightcurve block fails the test, this does not automatically cause the others, if any, in the file to be rejected.

4.1. NUMBER, NAME, DESIGNATION CHECK

The first check is to validate the OBJECTNUMBER, OBJECTNAME, and MPCDESIG values against one another. For example, a *lightcurve block* is rejected assuming the following combinations

Number/Name Mismatch
OBJECTNUMBER=150
OBJECTNAME=Ceres
MPCDESIG= (no entry)

Number/Name vs. Designation Mismatch
OBJECTNUMBER=70030
OBJECTNAME=Margaretmiller
MPCDESIG=2000 AA1

If MPCDESIG is blank or missing from the metadata block and the OBJECTNUMBER-OBJECTNAME combination has been validated, the MPCDESIG value, if available, is automatically assigned.

4.2. DUPLICATE DATA CHECK

The combination of values for some of the required keywords in the *metadata block* is checked to see if that same combination already exists in the database.

If the incoming data appear to be for an existing object (based on OBJECTNUMBER, OBJECTNAME, and/or MPCDESIG) and the CONTACTNAME, SESSIONDATE, SESSIONTIME, and FILTER keyword values are *exactly the same*, the lightcurve block is rejected *unless* the metadata block includes REVISEDATA=TRUE. In this case, *the existing metadata, comp star, and time-series data are deleted and then replaced by the new data.*

Since the above keywords are used to avoid duplication, it is *vital* that the submitting author use the *exact same entry* for CONTACTNAME for every submission. This can easily be achieved if using a script or program.

For those submitting multiple lightcurve blocks for the same object/filter combination with the same SESSIONDATE, e.g., for a fast-moving near-Earth asteroid or pre- and post-meridian flip of a German Equatorial mount, *it is vital that the SESSIONTIME value be unique for each lightcurve block.*

As of this version, there is no provision to resubmit data that uses a different value for the core keywords covered in this section. To do so would require registration, user accounts, and significantly more involved programming to prevent security breaches.

4.3. KEYWORD DEPENDENCIES CHECK

There are a number of keyword/value pairs that require that another keyword exists and it have a compatible value. For example, if CICORRECTION=TRUE, then CIBAND must be something other than NONE and CITARGET must have a non-zero value. If any one of these cross-checks fails, the *lightcurve block* is rejected. The dependencies are covered under the individual keywords.

5. KEYWORD DEFINITIONS

BIBCODE [Optional]

The 19-character universal BibCode for the publication in which the data were used for analysis or presented. This is different from PUBLICATION, which gives a brief citation, e.g., PUBLICATION=Minor Planet Bul. 37, 169.

Value Type: String. No surrounding quotes.

Max Length: 25 characters.

Example: 2010MPBu...37..169W

Notes: The current standard length for a BibCode is 19 characters. The field allows up to 25 characters for future expansion. Trailing blanks beyond 19 characters are dropped.

CIBAND [Optional/Required]

The color index bands for the color index values of the target and comparison stars.

Value Type: String. No surrounding quotes.

Max Length: 5 characters.

Allowed Values: BV, VR, VI, SGU, SGR, SRI, SIZ (case-sensitive), NONE (not case-sensitive)

The BVRI-derived values are on the Johnson-Cousins system. The SXY values are based on the u' g 'r' i' z' magnitudes of the Sloan Digital Sky Survey (SDSS) system.

Example: CIBAND=VR

Notes: If CICORRECTION=TRUE, this keyword must be present in the metadata block and assigned a value other than NONE. Otherwise, the *lightcurve block* is rejected.

CICORRECTION [Optional]

Indicates whether or not a color index correction has been applied to the magnitudes in the DATA section.

Value Type: Boolean

Max Length: 5 characters

Allowed Values: TRUE, FALSE

Example: CICORRECTION=TRUE

Notes: If CICORRECTION=TRUE, then CIBAND must have a value other than

NONE *and* the CITARGET keyword must be in the *metadata block* and have a non-zero value. Otherwise, the *lightcurve block* is rejected.

❖ *This is one of the core keywords used to check for duplicate submissions. See section 4.2.*

CITARGET [Optional/Required]

Indicates the color index of the target.

Value Type: Floating Point up to 3 decimal places.

Format: See the numeric formatting guidelines at the start of this section.

Example: CITARGET=+0.450

Notes: If CICORRECTION=TRUE, then CIBAND must have a value other than NONE *and* the CITARGET keyword must be in the *metadata block* and have a non-zero value. Otherwise, the *lightcurve block* is rejected.

COMMENT [Optional]

Provides additional information that is not covered by one of the recognized keywords.

Value Type: String. No surrounding quotes.

Max Length: 2048 characters (see Notes)

Example: COMMENT=Asteroid was in a very crowded field.

Notes: More than one comment line can be included in a *metadata block*. Each COMMENT line *must* be 255 characters or less, *including* COMMENT=.

The combined length of all COMMENT *values* must be less than 2048 characters. This includes CR/LF or LF characters but not COMMENT=.

COMPCI{X} [Optional]

The color index of comparison star X.

Value Type: Floating Point up to 3 decimal places.

Format: See the numeric formatting guidelines at the start of this section.

Example: COMPCI2=+0.319

Notes: This value must be the one given by the CIBAND keyword value, e.g., if CIBAND=VR, then this value must be the V-R color index of the comparison star.

This keyword does not have a dependency on CICORRECTION and so is not part of the cross-checks during the data upload vetting. It is strictly an informational value in the *metadata block*.

COMPDEC{X} [Optional]

The Declination of comparison star X.

Value Type: String. No surrounding quotes.

Max Length: 11 characters.

Format: The value must be in the format: \pm dd:mm:ss[.s], i.e., use colons to separate the subfields.

Leading zeros must be used to fill each subfield.

Example: COMPDEC2=+05:45:55

COMPDEC2=-15:02:01.2

Notes: The Declination is assumed to be J2000. If a different epoch, use a COMMENT line to indicate the epoch.

This keyword does not have a dependency on any other keyword and so is not part of the cross-checks during the data upload vetting. It is strictly an informational value in the *metadata block*.

COMPMAG{X} [Optional]

The magnitude for comparison star X.

Value Type: Floating point up to 3 decimal places.

Format: See the numeric formatting guidelines at the start of this section.

Example: COMPMAG2=+12.913

COMPMAG2=-0.913

Notes: The value should match the MAGBAND keyword value.

For example, if MAGBAND=V, then this value should be the V magnitude of the comparison star.

This keyword does not have a dependency on any other keyword and so is not part of the cross-checks during the data upload vetting. It is strictly an informational value in the *metadata block*.

COMPNAME{X} [Optional]

The name for comparison star X.

Value Type: String. No surrounding quotes.

Max Length: 30 characters.

Example: COMPNAME2=UCAC3 102445789

Notes: A maximum of 10 comp stars will be recognized. A minimum of 2 comp stars is recommended when using ensemble differential photometry, although 3 or more is better.

This keyword does not have a dependency on any other keyword and so is not part of the cross-checks during the data upload vetting. It is strictly an informational value in the *metadata block*.

COMPRA {X} [Optional]

The J2000 RA of comparison star X.

Value Type: String. No surrounding quotes.

Max Length: 11 characters.

Format: The value must be in the format: hh:mm:ss[.ss], i.e., use colons to separate the subfields.

Leading zeros must be used to fill each subfield.

Example: COMPRA2=04 : 05 : 12

COMPRA2=16 : 23 : 03 . 01

Notes: The RA is assumed to be J2000. If a different epoch, use a COMMENT line to indicate the epoch.

This keyword does not have a dependency on any other keyword and so is not part of the cross-checks during the data upload vetting. It is strictly an informational value in the *metadata block*.

CONTACTINFO [Required]

Contact information for the person submitting the data.

Value Type: String. No surrounding quotes.

Max Length: 120 characters.

Default: None.

Example: CONTACTINFO= [jgastronomer@adomain.com]

Notes: This is usually an email but it can also include a physical mailing address or web site. It is not necessary (but not wrong) to include the name of the submitting author since that is given by the CONTACTNAME keyword.

There are no strict formatting rules but some common conventions are worth considering. For example, surround an email with square brackets as shown above and in Appendix A and put it before a physical (snail mail) address.

CONTACTNAME [Required]

The name of the person submitting the data.

Value Type: String. No surrounding quotes.

Max Length: 80 characters.

Format: First [middle] initials, surname

Default: None.

Example: CONTACTNAME=J.Q. Astronomer

Notes: This is the person who can provide additional information about the data and contact information for the observers.

This person and any others listed in the OBSERVERS lines are those to whom credit should be given for the data.

Do not include contact information, e.g., an email or mailing address. That is given by CONTACTINFO.

❖ *This is one of the core keywords used to check for duplicate submissions. See section 4.2.*

DATA [Required]

Indicates the data for a single observation.

Value Type: String. No surrounding quotes.

Format: Multiple floating point values separated by the DELIMITER character.

The JD should *not* include a leading plus sign (+) and have a precision of at least 5 decimal places (~ 1 s). The MAG, MAGERR, and AIRMASS values should be given to a precision of up to 3 decimal places.

Default: <blank>

Example: DATA=2451286.32958|+9.775|+0.012|1.773

Notes: The value string must contain a minimum of, in order, the full Julian Date (*not* MJD) and a magnitude value in the same band as given in the MAGBAND keyword.

Additional fields, in order, are the magnitude error and air mass.

There must be at least two data lines per *lightcurve block*. For non-time series observations, e.g., a single data point for phase curve observations, submit the several observations that were used to derive an average value. This allows independent confirmation.

See the discussion for the DELIMITER keyword. If the DELIMITER value is missing or invalid, the *lightcurve block* will be rejected. See section 1.1 and, in particular, section 1.1.3.

DELIMITER [Required]

Specifies the character used to separate data fields in a DATA line.

Value Type: String. No surrounding quotes.

Max Length: 10 characters.

Allowed Values: TAB (ASCII 9)
PIPE (ASCII 124)

Default: PIPE

Example: DELIMITER=PIPE

Notes: The value is the *name for the character* to be used and not the actual character since, for example, an actual space or tab character may not be correctly interpreted when parsing the *metadata block*.

Consecutive delimiters will be interpreted as a NULL value. See the discussion for the DATA keyword.

If the DELIMITER value is missing or invalid, the *lightcurve block* will be rejected.

DIFFERMAGS [Required]

Indicates if the magnitude values for the target are differential or “standard” (or “catalog”) magnitudes.

Value Type: Boolean

Max Length: 5 characters

Allowed Values: TRUE, FALSE

Default: FALSE

Example: DIFFERMAGS=FALSE

Notes: A “Standard” or “catalog” magnitude is defined as the magnitude that would be determined by comparing the brightness of the target against magnitudes from a catalog, e.g., Landolt standards, etc. and assigning a “standard” value, as opposed to a value that is the difference between the target and a comparison star.

This and the STANDARD keyword are tied to one another. If DIFFERMAGS=TRUE, then STANDARD *must* be set to NONE, i.e., STANDARD=NONE.

If DIFFERMAGS=FALSE, then STANDARD must be set to one of two values, INTERNAL or TRANSFORMED.

If this cross-dependency check fails, the *lightcurve block* is rejected.

ENDDATA [Required]

Indicates the end of the data block in a lightcurve block. There is no associated value.

Example: ENDDATA

Notes: See Appendix A for a sample lightcurve block.

This keyword must appear by itself immediately following the last DATA line in a lightcurve block.

If any keyword other than ENDDATA or STARTMETADATA follows the last DATA line, the *lightcurve block* is rejected and *may* cause the rest of the file to be rejected.

ENDMETADATA [Required]

Indicates the end of the *metadata block* in a *lightcurve block*.

Value Type: There is no associated value

Example: ENDMETADATA

Notes: See Appendix A for a sample lightcurve block.

This keyword must appear by itself at the end of a *metadata block* and followed immediately by a DATA line. If it is missing or any other keyword than DATA immediately after ENDMETADATA, the *lightcurve block* is rejected.

FILTER [Required]

The filter used to make the observations.

This is *not* necessarily the same value as given for the MAGBAND keyword. For example, if the data were acquired using a clear (or no) filter but V magnitudes were used to determine the magnitude of the target, this value would be 'C' (without the quotes).

Value Type: String. No surrounding quotes.

Max Length: 5 characters

Allowed Values: B, V, R, I, SU, SG, SR, SI, SZ (case-sensitive) for standard filters

C (case-sensitive) if no or a clear filter

The R and I values are understood to be Rc, Ic (Cousins). If not, use a COMMENT line to indicate otherwise. The SX values are the u' g' r' i' z' Sloan (SDSS) magnitudes.

Default: V

Example: FILTER=V

Notes: For legacy purposes, this value can also be ‘Clear’ or ‘None’ (case-insensitive). New submissions should use ‘C’ if no or a clear filter was used.

All observations in a given *lightcurve block* must have been made using the filter specified by this keyword. If multiple filters were used, multiple *lightcurve blocks* should be defined, each with a unique filter in the *metadata block*.

❖ *This is one of the core keywords used to check for duplicate submissions. See section 4.2 for more information*

LTCAPP [Required]

Indicates how light-time corrections, if any, were applied.

Value Type: String. No surrounding quotes.

Max Length: 10 characters. Default: NONE

Allowed Values: NONE, AVERAGE, POINT

NONE	No corrections for asteroid-Earth light-time applied, i.e., the JD are Earth-based.
AVERAGE	A fixed value was applied to all JD values. This is usually the light-time correction for the UT date/time given by SESSIONDATE and SESSIONTIME. If a different time was used, a COMMENT line should be used to indicate the UT date/time used to compute the fixed-value correction.
POINT	Corrections were applied point-by-point, i.e., the light-time correction was computed for the JD of the each observation and applied only to that one observation.

If any correction is applied, it is strongly encouraged that AVERAGE be used instead of POINT. This allows the data user, if he so wants, to remove the fixed light-time correction given by the LTCDAYS value from all observations to obtain the uncorrected JD. If using POINT, the LTCDAYS value is valid only for the SESSIONDATE and SESSIONTIME in the *metadata block*. For near-Earth asteroids, the difference between the AVERAGE and POINT value can be significant.

Example: LTCAPP=AVERAGE

Notes: If this value is AVERAGE or POINT, then LTCDAYS in the *metadata block* and have a non-zero value. In addition, LTCTYPE=LIGHTTIME must be in the *metadata block*.

If the cross-check fails, the *lightcurve block* is rejected.

LTCDAYS [Required/Optional]

The light-time correction at the UT date/time given by SESSIONDATE and SESSIONTIME.

Value Type: Floating point; the value *must* contain a leading plus or minus sign.

Format: See the numeric formatting guidelines at the start of this section. The precision of this value should be at least equal to that used for the JD value in a DATA line.

Example: LTCDAYS=-0.01099

Notes: If LTCAPP=AVERAGE or POINT, this value is required or the *lightcurve block* is rejected.

The keyword LCTYPE indicates the type of correction, none or light-time. The latter is based on asteroid-Earth distance.

The value must be such that

$$\text{JD(at asteroid)} = \text{JD(at Earth)} + \text{LTCDAYS}$$

Therefore,

$$\text{LTCDAYS} = -0.005772 * \text{AsteroidDistance (AU)}$$

since the light left the asteroid before it was seen on Earth.

Notes: If LTCAPP is AVERAGE or POINT, this value must be non-zero and LCTYPE must be LIGHTTIME. Otherwise, the *lightcurve block* is rejected.

LTCTYPE [Required]

Indicates the type of light-time correction applied to the raw Julian Dates of the observations.

Value Type: String. No surrounding quotes.

Max Length: 15 characters

Allowed Values: NONE, LIGHTTIME

Default: NONE

Example: LTCTYPE=NONE

Notes: If LTCTYPE=LIGHTTIME, then the keyword LTCDAYS must be in the *metadata block* and have a non-zero value. In addition, LTCAPP must be in the *metadata block* and be assigned a value of AVERAGE or POINT. Otherwise, the *lightcurve block* is rejected.

MAGADJUST [Optional]

Value to add to the object magnitudes to obtain the correct value.

Value Type: Floating point; the value *must* contain a leading plus or minus sign.

Format: Use up to 3-decimal precision.

Default: 0.000

Example: MAGADJUST=+13.214

MAGADJUST=+0.023

Notes: When DIFFERMAGS=TRUE, this would be the value to add to the differential magnitudes in the lightcurve block to put them onto a standard system. For example, if the differential value is referenced against a single comparison star (or average of several), then MAGADJUST would be set to the catalog magnitude of the comparison (or average of the several comparisons) to obtain the target magnitude in the same band as specified by MAGBAND.

If DIFFERMAGS=TRUE, this value is strongly suggested, since be impossible to place the data set on a common system without arbitrary offsets for each *lightcurve block*.

If DIFFERMAGS=FALSE, then this would be the correction to apply to the magnitudes within each lightcurve block to put them onto a common zero point. For example, the data in a lightcurve block might need to be offset by +0.040 mag to correct for an error in the nightly zero point used in the original measurements.

This value should *not* be used to record an arbitrary offset used to force a specific period solution. It is intended strictly for the purpose of referencing all data to a single zero point on a photometric system, be it instrumental (INTERNAL) or, e.g., Johnson-Cousins (STANDARD).

MAGBAND [Required]

Indicates the color band of the magnitudes for the target.

Value Type: String. No surrounding quotes.

Max Length: 5 characters

Allowed Values: B, V, R, I, SU, SG, SR, SI, SZ (case-sensitive)

The R and I values are understood to be Rc, Ic (Cousins). If not, use a COMMENT line to indicate otherwise. The SX values are the u' g' r' i' z' Sloan (SDSS) magnitudes.

Default: V

Example: MAGBAND=R

Notes: This is *not* necessarily the same value as for the FILTER keyword. For example, if the data were acquired using a clear (or no) filter but V magnitudes were used to determine the magnitude of the target, then this value would be V.

MPCDESIG [Optional/Required]

This is the original MPC designation for an object that has been subsequently numbered and named. This is the full designation, not the MPC-packed value, e.g., 1999 CZ1 and not J99C01Z.

For un-numbered objects with no name, this keyword becomes required instead of optional. In this case, set OBJECTNUMBER=0 and then set MPCDESIG *and* OBJECTNAME to the MPC designation, i.e., OBJECTNAME must always have a value.

If no designation is available or assigned (as for the first 300 or so numbered asteroids), either omit the keyword entirely or set the value to an empty string, i.e., MPCDESIG=

Value Type: String. No surrounding quotes.

Max Length: 30 characters.

Example: MPCDESIG=1999 CZ1

❖ *This is one of the core keywords used to check for duplicate submissions and cross-check values. See section 4.2 for more information*

OBJECTDEC [Optional]

The approximate Declination of the object at the given SESSIONDATE and SESSIONTIME.

Value Type: String. No surrounding quotes.

Max Length: 3 characters.

Format: The value should include a leading plus (+) or minus (-) to avoid any uncertainty. Also, use a leading zero when $|\text{OBJECTDEC}| < 10$.

If the declination rounds to 0 degrees, use +00.

Default: <BLANK>

Example: OBJECTDEC=+03

OBJECTNAME [Required]

The name assigned by the IAU.

Value Type: String. No surrounding quotes.

Max Length: 30 characters.

Default: None. The *lightcurve block* should be rejected if this keyword and/or value are missing.

Example: OBJECTNAME=Lucia

Notes: For un-numbered objects with no name but with an MPC designation, set OBJECTNUMBER=0 and then set OBJECTNAME *and* MPCDEESIG to the MPC designation, i.e., OBJECTNAME must always have a value.

❖ This is one of the core keywords used to check for duplicate submissions and cross-check values. See section 4.2 for more information.

OBJECTNUMBER [Required]

The number assigned by the MPC to the asteroid.

Value Type: Integer. Do not use a leading plus sign since this value is always positive.
Maximum Value: 4294967295

Default: 0

Example: OBJECTNUMBER=222

Notes: If no number has been assigned, the value should be set to 0, i.e., OBJECTNUMBER=0.

❖ This is one of the core keywords used to check for duplicate submissions and cross-check values. See section 4.2 for more information.

OBJECTRA [Optional]

The approximate Right Ascension of the object at the given SESSIONDATE and SESSIONTIME.

Value Type: String. No surrounding quotes.

Max Length: 5 characters

Format: hh:mm. 24-hour format. Use leading zeros. Use a colon to separate hours and minutes.

Default: <BLANK>

Example: OBJECTRA=03 : 48

OBSERVERS [Required]

The names of those who acquired the data, usually the person working the telescope and/or who measured the images. These are the persons to whom credit should be given for the data.

Value Type: String. No surrounding quotes.

Max Length: 1024 (see Notes)

Format: The names can be given as either initials surname or surname, initials. See the examples below.

Default: <BLANK>

Example: OBSERVERS=Astronomer, J.Q; Assistant, H.I.S.

OBSERVERS=J.Q. Astronomer; H.I.S. Assistant

Notes: Multiple names *must* be separated by semicolons, not commas, since commas are used when surname is given first.

The *metadata block* can contain one or more OBSERVERS lines. Each line, including 'OBSERVERS=', *must* be 255 characters or less. The maximum value is for the total number of characters in the *values*.

Three characters are added internally to the end of each OBSERVERS line value. When retrieving data, these allow parsing the data block into the original lines. These 3 characters per line count against the maximum length.

OBSLATITUDE [Optional]

The latitude from which the observations were made.

Value Type: Floating point, non-exponential

Format: See the numeric formatting guidelines at the start of this section. Use up to 0.000001 degree (0.0036 s) precision.

Value Range: -90.0 to +90.0

Example: OBSLATITUDE=+39.083333

Notes: Use a negative value for locations in the Southern Hemisphere.

If a lightcurve block has multiple observers at different longitudes and/or latitudes, the longitude and latitude of the first observer in the list should be given and COMMENT lines added to indicate the locations for the other observers.

OBSLONGITUDE [Optional]

The longitude from which the observations were made.

Value Type: Floating point, non-exponential

Format: See the numeric formatting guidelines at the start of this section. Use up to 0.000001 degree (0.0036 s) precision.

Value Range: -180.0 to +180.0

Example: OBSLONGITUDE=-104.757773 (indicates a position in Colorado, USA).

Notes: ALCDEF uses negative longitudes for positions in the Western Hemisphere.

If a lightcurve block has multiple observers at different longitudes and/or latitudes, the longitude and latitude of the first observer in the list should be given and COMMENT lines added to indicate the locations for the other observers.

PABB [Optional]

The phase angle bisector (PAB) latitude for the UT date/time given by the SESSIONDATE and SESSIONTIME keywords.

Value Type: Floating point, non-exponential.

Format: See the numeric formatting guidelines at the start of this section. Use 0.1 degree precision.

Value Range: -90.0 to +90.0

Example: PABB=+2.4

PABL [Optional]

The phase angle bisector (PAB) longitude for the UT date/time given by the SESSIONDATE and SESSIONTIME keywords.

Value Type: Floating point, non-exponential.

Format: See the numeric formatting guidelines at the start of this section. Use 0.1 degree precision.

Value Range: +0.0 to +359.9

Example: PABL=+193.5

PHASE [Optional]

The solar phase angle (Earth-Sun angle as seen from the asteroid) at the UT date/time given by the SESSIONDATE and SESSIONTIME keywords.

Value Type: Floating point, non-exponential.

Format: See the numeric formatting guidelines at the start of this section. Use no more than 0.01 degree precision.

Value Range: +0.00 to +180.00

Example: PHASE=+5.63

PUBLICATION [Optional]

The citation for the work where the data and/or analysis based on the data appeared. This is different from BIBCODE, which gives the universal 19-character publication reference, e.g., BIBCODE=2010MPBu...37..169W

Value Type: String. No surrounding quotes.

Max Length: 60

Example: PUBLICATION=Minor Planet Bul. 37, 169-171.

REDUCEDMAGS [Required]

Indicates whether or not the target magnitudes have been corrected to “unity distance” using the formula

$$\text{Mag}(\text{reduced}) = \text{Mag}(\text{observed}) - 5 * \log(rR)$$

Value Type: String. No surrounding quotes.

Allowed Values: NONE, AVERAGE, POINT

NONE	The magnitudes given the data lines have not been corrected to unity distance.
AVERAGE	The fixed value given by the UCORMAG keyword was applied to all target magnitudes in the data lines.
POINT	The unity correction was computed by finding the Earth-asteroid and Sun-asteroid distance at the JD for each data line and then applied to the observed magnitude.

If any correction is applied, it is strongly encouraged that AVERAGE be used instead of POINT. This allows the data user, if he wants, to remove the fixed UCORMAG value from all observations. For near-Earth asteroids, the difference between the fixed UCORMAG value and the actual (unknown) correction as applied when using POINT can be significant.

Default: NONE

Example: REDUCEDMAGS=AVERAGE

Notes: If REDUCEDMAGS is AVERAGE OR POINT, then the UCORMAG keyword must be present in the *metadata block* and have a non-zero value. Otherwise, the *lightcurve block* is rejected.

If REDUCEDMAGS=NONE, the UCORMAG value can still be included in the *metadata block*. In this case, it should be the value that would be used if REDUCEDMAGS=AVERAGE.

REVISEDATA [Required/Optional]

Indicates if the data being submitted should replace existing data, if a match can be found.

Value Type: Boolean

Max Length: 5 characters

Allowed Values: TRUE, FALSE

TRUE

Replace existing data, if found. If not found, add new *lightcurve block*.

FALSE (or keyword missing)

Add new *lightcurve block* only if an existing *lightcurve block* is not found.

See section 4.2 for the criteria used to check for an existing lightcurve block.

Example: REVISEDATA=TRUE

❖ This is one of the core keywords used to check for duplicate submissions. See section 4.2 for more information.

SESSIONDATE [Required]

The UT date for the approximate mid-time of the data set in the current *lightcurve block*.

Value Type: String. No surrounding quotes.

Format: yyyy-mm-dd

All digits must be used for year, month, and date. Use leading zeros as required to fill a given subfield.

Default: None.

Example: SESSIONDATE=1999-04-17

Notes: The *lightcurve block* is rejected if this value is missing or has an invalid format.

❖ This is one of the core keywords used to check for duplicate submissions. See section 4.2 for more *information*.

SESSIONTIME [Required]

The UT time for the approximate mid-time of the data set in the current *lightcurve block*.

Value Type: String. No surrounding quotes.

Format: hh:mm:ss

Use 24-hour format, e.g., 1 PM = 13:00. All digits must be used for hours, minutes, and seconds. Use leading zeros as required to fill a given subfield.

Default: None.

Example: SESSIONTIME=07:00:00

Notes: The *lightcurve block* is rejected if this value is missing or has an invalid format.

❖ This is one of the core keywords used to check for duplicate submissions. See section 4.2 for more information.

STANDARD [Required/Optional]

Defines the system on which the magnitudes are based.

Value Type: String. No surrounding quotes.

Max Length: 12 characters

Allowed Values: NONE, INTERNAL, TRANSFORMED

NONE	The magnitudes are not referenced to a specific system. In this case, it is required that DIFFERMAGS=TRUE. If DIFFERMAGS=FALSE and STANDARD=NONE, the <i>lightcurve block</i> is rejected.
INTERNAL	The magnitudes are referenced to catalog magnitudes of the MAGBAND setting but have not been formally transformed to the standard system that defines that magnitude system. If DIFFERMAGS=TRUE and STANDARD=INTERNAL, the <i>lightcurve block</i> is rejected.
TRANSFORMED	The magnitudes are referenced to catalog magnitudes of the MAGBAND setting and have been formally transformed to the standard system that defines that magnitude system. If DIFFERMAGS=TRUE and STANDARD=TRANSFORMED, the <i>lightcurve block</i> is rejected.

Default Value: NONE (DIFFERMAGS=TRUE) or INTERNAL (DIFFERMAGS=FALSE).

Example: STANDARD=INTERNAL

Notes: The specific catalog from which the magnitudes are derived is not given since there are too many combinations, versions within a given catalog, etc.

It is implied that the combination of the values MAGBAND and STANDARD keywords gives the standard system on which the magnitudes are based.

For example, if MAGBAND=V and STANDARD=INTERNAL (or TRANSFORMED), then the magnitudes should be presumed to be Johnson V. If the data provider wants to give more specifics, the COMMENT keyword is available for that purpose.

STARTMETADATA [Required]

This keyword must appear by itself (with no value) on the first line starting a lightcurve block.

Example: STARTMETADATA

Notes: See Appendix A for a sample lightcurve block using this keyword.

UCORMAG [Required/Optional]

Gives the $-5*\log(rR)$ correction at the UT date/time given by the SESSIONDATE and SESSIONTIME keywords.

Value Type: Floating point, non-exponential.

Format: The value must include a leading plus or minus sign. The recommended precision is one decimal place more than the precision of the reported target magnitudes.

Example: UCORMAG=-3.697

UCORMAG=+0.044

Notes: If the value for the required keyword REDUCEDMAGS is AVERAGE or POINT, this keyword is required and so, if missing or not assigned a value, the *lightcurve block* is rejected.

APPENDIX A: SAMPLE LIGHTCURVE BLOCK

The following is a sample lightcurve block that uses all required and most optional keywords.

```
STARTMETADATA
REVISEDATA=FALSE
OBJECTNUMBER=24654
OBJECTNAME=Fossett
MPCDESIG=
CONTACTNAME=B. D. Warner
CONTACTINFO=[brian@MinorPlanetObserver.com] 446 Sycamore Ave., Eaton, CO, USA
OBSERVERS=B. D. Warner
OBSLONGITUDE=-116.383333
OBSLATITUDE=+34.250000
SESSIONDATE=2014-11-04
SESSIONTIME=09:06:00
FILTER=C
MAGBAND=V
STANDARD=INTERNAL
DIFFERMAGS=FALSE
LTCTYPE=NONE
LTCDAYS=-0.006747
LTCAPP=NONE
REDUCEDMAGS=NONE
UCORMAG=-1.9508
OBJECTRA=04:08
OBJECTDEC=+00
PHASE=+12.44
PABL=+55.6
PABB=-15.8
CICORRECTION=FALSE
CIBAND=NONE
CITARGET=+0.000
PUBLICATION=
BIBCODE=
COMPNAME1=040836.38 +001547.2
COMPAG1=+14.365
COMPCL1=+0.445
COMPRA1=04:08:36.37
COMPDEC1=+00:15:47.1
COMPNAME2=040815.78 +001512.6
COMPAG2=+14.580
COMPCL2=+0.379
COMPRA2=04:08:15.77
COMPDEC2=+00:15:12.1
COMPNAME3=040829.69 +001901.9
COMPAG3=+15.109
COMPCL3=+0.407
COMPRA3=04:08:29.70
COMPDEC3=+00:19:01.7
COMPNAME4=040846.74 +000840.3
COMPAG4=+15.369
COMPCL4=+0.479
COMPRA4=04:08:46.74
COMPDEC4=+00:08:40.1
DELIMITER=PIPE
COMMENT=Heliocentric ecliptic longitude/latitude: +60.02/-20.38
COMMENT=Earth/Sun distances (AU): +2.1007/+1.1689
COMMENT=Observer Instrumentation: 0.30m f/9.6 SCT/ML-1001E
ENDMETADATA
DATA=2456965.735795|+17.521|+0.091|1.881
DATA=2456965.738778|+17.491|+0.091|1.840
DATA=2456965.741760|+17.332|+0.073|1.802
ENDDATA
```

