

# The Asteroid Lightcurve Data Exchange Format (ALCDEF) Standard

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V1.09

In order to facilitate the availability of asteroid lightcurve data involving a universally-accepted clearing house, e.g., the Minor Planet Center, which would receive and make data available, the following document outlines the structure and format of the Asteroid Lightcurve Data Exchange Format (ALCDEF). Adoption of this format would allow any researcher to write export and/or import programs knowing that certain data minimums are met and that have full-control over the outgoing and incoming data.

## 1. IMPLEMENTATION AND GOALS

As part of the adoption of the ALCDEF, a temporary upload site and database will be initiated to receive asteroid lightcurve data. The incoming data following the ALCDEF standard will be immediately imported into the database. The database will then be used to create files that are uploaded to the Strasbourg site on a regular basis.

Those data that are not in ALCDEF format will be accepted and volunteers will, if possible, convert the data so that it can be included in the database and be part of the files on the Strasbourg site.

Eventually, it is hoped that a central agency will take charge of the system, from upload, to storage, to public access. Such an agency could then encourage broader acceptance and use of the ALCDEF in addition to providing a stable, long-term repository for all future asteroid lightcurve data.

## 2. STANDARDIZATION

The issue of standardization has been problematic over the years. Overly rigorous requirements and cumbersome procedures have resulted in only 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 database is to have any useful purpose. This document will outline a input process and structure that includes core requirements and yet allows flexibility in what data are provided.

An essential element of this process is getting the providers of the most common photometry programs as well as the professional community to adopt the ALCDEF standard such that those programs store and can report, at the minimum, core metadata and data.

### 2.1. DATA INPUT

Under the idealized goal of a central repository of asteroid lightcurve data, an observer would submit his data to the repository via email with plain ASCII file attachments (to avoid word wrap issues). These files will have a specific structure, much as now occurs with astrometric data submitted to the Minor Planet Center. The structure of the astrometric data is well-defined and has been readily adopted by numerous data providers. The same should be possible for photometric data.

The data being submitted should not include composite lightcurves, i.e., a single lightcurve based on several nights of observing that have been forced to fit a specific period or meet other expectations. To match multiple curves properly requires correcting for changing phase angle, which presupposes knowledge of the true value of  $G$ , the phase slope parameter, or “phasing” the data to a period that may be wrong.

Each observing run should be treated as an independent entity with corrections that are not based on any presumptions. In other words, the data can be corrected for light-time, color index differences between the target and one or more comparisons, and changing distance by correcting them to “unity distance” via  $-5 \cdot \log(rR)$ .

## 2.2. DATA STRUCTURE

The submitted data files must follow a specific format in order to allow efficient processing by a universal parsing program.

- All files must be standard ASCII format. Extended characters are not allowed.
- The files must consist of multiple lines that are terminated by CR/LF pair (ASCII 13/10, Windows) or single LF (ASCII 10, LINUX).
- All lines follow a format of KEYWORD=DATA. The total length of a line, including keyword and value, cannot exceed 255 characters. Some values are further restricted in length in order to maximize data storage efficiency.
- There is a fixed set of recognized keywords. Non-standard keywords are not allowed.
- Each lightcurve must be defined in the METADATA section by a minimum set of mandatory keywords.
- In some cases, a default value is allowed for a missing mandatory keyword. See section 3 for additional information.
- All other keywords are optional, meaning that they do not have to be included.
- The file cannot contain blank lines.
- Multiple lightcurves can be submitted in a single file. Each lightcurve constitutes a “lightcurve block”.
- A lightcurve block must have two sections: METADATA and DATA.

### 2.2.1. METADATA

This provides supporting information for the actual lightcurve 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 no less than the number of “required” keywords lines using the format KEYWORD=VALUE.
- The section must be terminated by a line containing the single word, ENDMETADATA. There is no value associated with this keyword.

### 2.2.2. DATA

This section provides the actual lightcurve data.

- The first line must follow the METADATA section, i.e., the first line after the ENDMETADATA terminating line.
- There must be at least one line 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.
- All data in the lightcurve block must be uniquely defined by the METADATA block. For example, if FILTER=V, then all data must have been obtained using the V filter. If multiple filters were used, then there must be multiple lightcurve blocks, each defined by a unique filter.

### 2.2.3. DATA LINES

Each data line shall be in the format

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

Where:

Value	Required	Description
JD	Yes	UT Julian Date of mid-exposure. This field is required. See section 3 for formatting requirements.
MAG	Yes	The magnitude of the object at time JD. This field is required. See section 3 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 shall 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 must be interpreted as a NULL value.

A 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. See Appendix A for a sample of a single lightcurve block.

### 2.3. COMPARISON STARS

Comparison star data are not mandatory.

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 3 and Appendix A for an example of comp star data.

### 2.4. ASCPECT 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 were 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 a COMMENT, e.g.,

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

### 3. KEYWORDS AND DATA

Keyword lengths cannot exceed 14 characters and must be in upper case letters.

Floating point values must use the period (ASCII 46) for the decimal character and be in non-exponential form, e.g., 432.5 and not 4,325E+02.

In most cases, numbers as values for keywords must include a leading plus or minus sign (+ / -) and floating-point numbers  $|X| < 1.0$  must include a leading zero. For example: +13.258; -0.455.

The keywords below are recognized by the ALCDEF. Any lines containing non-standard keywords will be ignored.

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

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**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.

MaxLength: 19 characters.

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

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**CIBAND [Optional]**

Indicates the color index bands for the color index values of the target and comparison stars. This value has meaning only if CICORRECTION=TRUE.

Value Type: String. No surrounding quotes.

Max Length: 5 characters.

Allowed Values: NONE, BV, VR, VI, SGU, SGR, SRI, SIZ

The B, V, R, I are on the Johnson-Cousins system. SU, SG, SR, SI, and SZ values are the u'g'r'i'z' magnitudes of the Sloan Digital Sky Survey (SDSS) system.

Example: CIBAND=VR

---

**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 (case-insensitive)

Example: CICORRECTION=TRUE

Notes: If CICORRECTION=TRUE, a check must be made to confirm that CIBAND  $\neq$  NONE and, at the least, CITARGET be present and have a valid value. The lightcurve block must be rejected if the test fails.

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CITARGET [Optional]

Indicates the color index of the target. This value is tied to value for CIBAND, e.g., if CIBAND=VR, then the CITARGET value must be the V-R color index of the target.

Value Type: Floating Point to 3 (or 4) decimal places.

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

Example: CITARGET=+0.450

---

COMMENT [Optional]

Provides additional information that is not covered by one of the allowed keywords. More than one comment can be included in a METADATA section.

The combined length of all COMMENT *values* must be less than 2048 characters. This includes CR/LF or LF characters.

Value Type: String. No surrounding quotes.

Max Length: 2048 characters.

Example: COMMENT=The asteroid was in a very crowded field.

---

COMPCI{X} [Optional]

The color index of comparison star X. 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.

Value Type: Floating Point to 3 (or 4) decimal places.

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

Example: COMPCI2=+0.319

---

COMPDEC{X} [Optional]

The J2000 Declination of comparison star X.

Value Type: String. No surrounding quotes.

Max Length: 12 characters.

Format: The value must be in the format: ±dd:mm:ss[.ss]. Leading zeros must be used to fill each subfield.

Example: COMPDEC2=+05:45:55  
COMPDEC2=-15:02:01.22

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#### COMP MAG {X} [Optional]

The magnitude for comparison star X. The value must match the MAGBAND keyword value. For example, if MAGBAND=V, then this value must be the V magnitude of the comparison star.

Value Type: Floating Point to 3 (or 4) decimal places.

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

Example: COMP MAG 2=+12.913  
COMP MAG 2=-0.913

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#### COMP NAME {X} [Optional]

The name for comparison star X. A maximum of 10 comp stars will be recognized. A minimum of 3 comp stars is recommended when using ensemble differential photometry.

Value Type: String. No surrounding quotes.

Max Length: 30 characters.

Example: COMP NAME 2=UCAC3 102445789

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#### COMP RA {X} [Optional]

The J2000 RA of comparison star X.

Value Type: String. No surrounding quotes.

Max Length: 12 characters.

Format: The value must be in the format: hh:mm:ss[.sss]. Leading zeros must be used to fill each subfield.

Example: COMP RA 2=04:05:12  
COMP RA 2=16:23:03.01

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#### CONTACT INFO [REQUIRED]

Contact information for the person submitting the data. This is usually an email but it can also be a physical mailing address. Do not include the name of the submitter. That is given by the CONTACTNAME keyword.

Value Type: String. No surrounding quotes.

Max Length: 120 characters.

Default: None. The lightcurve block must be rejected if the keyword and/or value are missing. It is up to the parsing program to determine if any non-blank string is valid or if it will attempt to validate the entry by some set of rules.

Example: CONTACTINFO=jgastronomer@adomain.com

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#### CONTACTNAME [REQUIRED]

The name of the person submitting the data. This is not the person to whom credit should be given for the data (unless his name is also in the list under OBSERVERS) but the one who can provide additional information about the data and contact information for the observers.

Value Type: String. No surrounding quotes.

Max Length: 80 characters.

Format: Use the format: initials, surname

Default: None. The lightcurve block must be rejected if the keyword and/or value are missing. It is up to the parsing program to determine if any non-blank string is valid or if it will attempt to validate the entry by some set of rules.

Example: CONTACTNAME=J.Q Astronomer

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

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#### DATA [REQUIRED]

Indicates the data for a single observation. It must contain a minimum of, in order, 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.

ValueType: String. No surrounding quotes.

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

See the numeric formatting guidelines at the start of this section. The JD should be given to at least 5 decimal places (~ 1 s). The MAG, MAGERR, and AIRMASS values should be given to 3 (or 4) decimal places.

Default: None. The lightcurve block must be rejected if the keyword and/or value are missing.

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

Notes: See section 2.2 and, in particular, section 2.2.3 for additional information.

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#### DELIMITER [REQUIRED]

Specifies the character used to separate data fields in a DATA line. The value is the name for the character to be used and not the actual character since, for example, a space and tab character may not be correctly interpreted when parsing the METADATA section.

Value Type: String. No surrounding quotes.

Max Length: 10 characters.

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

Default: TAB

Example: DELIMITER=TAB

Notes: Consecutive delimiters will be interpreted as a NULL value. The SPACE (ASCII 32) and COMMA (ASCII 44) are not allowed since they may be naturally embedded within values.

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#### DIFFERMAGS [REQUIRED]

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

Value Type: Boolean

Max Length: 5 characters

Allowed Values: TRUE, FALSE (case-insensitive)

Default: FALSE

Example: DIFFERMAGS=FALSE

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#### ENDMETADATA [REQUIRED]

This keyword must appear by itself immediately following the last line with a KEYWORD=VALUE pair in the METADATA section.

There is no associated value.

Example: ENDMETADATA

See Appendix A for a sample lightcurve block.

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#### 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 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, C (for Clear/No), SU, SG, SR, SI, SZ (case-insensitive)

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

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#### 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 (case-insensitive)

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 LightTime correction given by the LTCDDAYS value from all observations to obtain the uncorrected JD. If using POINT, the LTCDDAYS value is valid only for approximately the middle of the lightcurve 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, a cross-check must be made to determine if a valid value for LTCDDAYS has been provided and that LTCTYPE = LightTime. If not, the lightcurve block should be rejected.

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#### LTCDDAYS [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: LTCDDAYS=-0.01099

Notes: If LTCAPP=AVERAGE (or POINT), this value is required. If it is missing, a parsing program must reject the lightcurve block.

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

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

Therefore,

$$LTCDDAYS = -0.005772 * \text{AsteroidDistance (A.U.)}$$

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 LTCTYPE must be LightTime. Otherwise, the lightcurve block must be rejected.

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#### 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 (case-insensitive)

Default: NONE

Example: LTCTYPE=LightTime

Notes: If LTCTYPE=LightTime, then the keyword LTCDAYS must have a valid value and LTCAPP must be AVERAGE or POINT. Otherwise, the lightcurve block must be rejected.

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#### MAGBAND [REQUIRED]

Indicates the filter band of the magnitudes for the target.

This is *not* necessarily the same value as for the FILTER keyword. For example, if the data were acquired using a CLEAR filter but V magnitudes were used to determine the magnitude of the target, then this value would be V.

Value Type: String. No surrounding quotes.

Max Length: 5 characters

Allowed Values: B, V, R, I, SU, SG, SR, SI, SZ

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

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#### MPCDESIG [Optional]

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.

If the object has no number and/or name but does have an MPC designation, enter that value under this keyword *and* the OBJECTNAME keyword value. The record's OBJECTNAME field can be updated when/if the object is named.

If no designation is available, enter no value (for NULL). In this case, the OBJECTNAME keyword must have a valid value.

Value Type: String. No surrounding quotes.

Max Length: 30 characters.

Example: MPCDESIG=1999 CZ1

Notes: A cross-check must be made when the metadata are parsed to confirm that the OBJECTNAME, OBJECTNUMBER, and MPCDESIG (when provided) are mutually consistent with one another. For example, a lightcurve block for 2 Ceres must be rejected as must one be for 70030 Margaretmiller with a MPCDESIG = 2002 RN1.

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#### OBJECTDEC [Optional]

The approximate Declination of the object at SESSIONDATE / SESSIONTIME.

Value Type: String. No surrounding quotes.

Max Length: 3 characters.

Format: See the numeric formatting guidelines at the start of this section. Include leading zero when  $|\text{OBJECTDEC}| < 10$ .

Default: <BLANK>

Example: OBJECTDEC=+03

---

#### OBJECTNAME [REQUIRED]

The name assigned by the IAU. If no name has been assigned but the object has an MPC designation, enter that value under this keyword *and* under the MPCDESIG keyword. This field can be updated when/if a name is assigned.

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: A cross-check must be made when the metadata are parsed to confirm that the OBJECTNAME, OBJECTNUMBER, and MPCDESIG (when provided) are mutually consistent with one another. For example, a lightcurve block for 2 Ceres must be rejected as must one be for 70030 Margaretmiller with a MPCDESIG = 2002 RN1.

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#### OBJECTNUMBER [REQUIRED]

The number assigned by the MPC to the asteroid. If no number has been assigned, the value should be empty (for NULL).

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: A cross-check must be made when the metadata are parsed to confirm that the OBJECTNAME, OBJECTNUMBER, and MPCDESIG (when provided) are mutually consistent with one another. For example, a lightcurve block for 2 Ceres must be rejected as must one be for 70030 Margaretmiller with a MPCDESIG = 2002 RN1.

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#### OBJECTRA [Optional]

The approximate Right Ascension of the object at SESSIONDATE / SESSIONTIME

Value Type: String. No surrounding quotes.

Max Length: 5 characters

Format: hh:mm. 24-hour time format. Use leading zeros.

Default: <BLANK>

Example: OBJECTRA=03:48

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#### OBSERVERS [REQUIRED]

The name 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. Those who analyzed the data, e.g., to find the period, should not be included – unless they were also an observer.

Value Type: String. No surrounding quotes.

Max Length: 1024

Format: Multiple names must be separated by semicolons.

Names should use the format: surname, initials. See the example below.

Default: None. The lightcurve block must be rejected if the keyword and/or value are missing. It is up to the parsing program to determine if any non-blank string is valid or if it will attempt to validate the entry by some set of rules.

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

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#### 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: The value should be less than 0 for the Southern Hemisphere.

*If a lightcurve block has multiple observers, the longitude and latitude of the CONTACTNAME location is given.*

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#### 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. This is contrary to some conventions but was adopted to maintain agreement with the software used to produce the large majority of asteroid lightcurves from 2000 to the present (2010 October).

*If a lightcurve block has multiple observers, the longitude and latitude of the CONTACTNAME location is given.*

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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

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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

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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

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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.

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REDUCEDMAGS [REQUIRED]

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

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

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 UNITYCOR value from all observations. For near-Earth asteroids, the difference between the fixed UNITYCOR value and the actual (unknown) correction as applied when using POINT can be significant.

If this value is AVERAGE or POINT, a cross-check must be made to confirm that the UCORMAG keyword is present and a valid value given. The lightcurve block must be rejected if the test fails.

Default: NONE

Example: REDUCEDMAGS=AVERAGE

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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 (case-insensitive)

TRUE	An attempt to match the SESSIONDATE, SESSIONTIME, [OBJECTNAME and/or OBJECTNUMBER and/or MPCDESIG], and OBSERVERINFO must be made when adding to an existing data base. If a match is found, the incoming metadata and data must either replace the existing data with the new or reject the lightcurve block.  The OBSERVERINFO value must be the same as in the original record.
FALSE or keyword missing	The data are presumed to be new and so appended to an existing data base. It is recommended that the same check as when this value is TRUE be made. If the check finds a duplicate, appropriate action should be taken.

Example: REVISEDATA=TRUE

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#### SESSIONDATE [REQUIRED]

Gives the approximate mid-UT date/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. A parsing program should flag this lightcurve with an error.

Example: SESSIONDATE=1999-04-17

---

#### SESSIONTIME [REQUIRED]

Gives the approximate mid-UT date/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. A parsing program should flag this lightcurve with an error.

Example: SESSIONTIME=07:00:00

---

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.  <i>A parsing program should reject the lightcurve block if DIFFERMAGS=FALSE and STANDARD=NONE.</i>
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.
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.  <i>A parsing program should reject the lightcurve block if DIFFERMAGS=TRUE and STANDARD is present and its value is INTERNAL or TRANSFORMED.</i>

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

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. If the keyword and/or value are missing, the lightcurve block must be rejected.

## REQUIRED KEYWORDS

By “Required” it is meant that, at a minimum, the METADATA section should include the keywords listed below.

Some of the keywords have default values defined in the standard. Should a required keyword and/or its value be missing, a parsing program should assign the default value to the keyword.

CONTACTINFO*	MAGBAND
CONTACTNAME*	OBJECTNAME*
DELIMITER	OBJECTNUMBER
DIFFERMAGS	OBSERVERS*
ENDMETADATA**	REDUCEDMAGS
FILTER	SESSIONDATE*
LTCAPP	SESSIONTIME*
LTCTYPE	STARTMETADATA**

\* No default value. If the keyword and/or value are missing, a parsing program should reject the lightcurve until the missing data are made available.

\*\* No value associated with keyword, which *must* be in the METADATA block since it defines the block’s start or end point.

The Data section consists of one or more lines using the DATA keyword. No other keywords (required, optional, or user-defined) are allowed in the Data section.

## APPENDIX A: SAMPLE LIGHTCURVE BLOCK

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

```
STARTMETADATA
REVISEDATA=FALSE
OBJECTNUMBER=48707
OBJECTNAME=1996 KR1
MPCDESIG=
CONTACTNAME=B. D. Warner
CONTACTINFO=brian@MinorPlanetObserver.com
OBSERVERS=Warner, B.D.
OBSLONGITUDE=-104.750000
OBSLATITUDE=+39.083333
PUBLICATION=
SESSIONDATE=2010-10-14
SESSIONTIME=07:00:00
FILTER=C
MAGBAND=R
DIFFERMAGS=FALSE
STANDARD=INTERNAL
LTCTYPE=NONE
LTCDDAYS=-0.004313
LTCAPP=NONE
REDUCEDMAGS=NONE
UCORMAG=-0.5613
OBJECTRA=01:19
OBJECTDEC=+21
PHASE=+7.73
PABL=+24.9
PABB=+8.7
COMPNAME1=012016.62 +213547.7
COMPMA1=+13.848
COMPMA11=+0.408
COMPRA1=01:20:16.61
COMPDEC1=+21:35:47.6
COMPNAME2=011944.74 +213415.2
COMPMA2=+15.429
COMPMA21=+0.387
COMPRA2=01:19:44.75
COMPDEC2=+21:34:15.4
COMPNAME3=011954.62 +213335.8
COMPMA3=+14.313
COMPMA31=+0.439
COMPRA3=01:19:54.61
COMPDEC3=+21:33:35.7
COMPNAME4=011935.18 +213220.6
COMPMA4=+14.053
COMPMA41=+0.492
COMPRA4=01:19:35.17
COMPDEC4=+21:32:20.4
COMPNAME5=011930.50 +213218.0
COMPMA5=+14.558
COMPMA51=+0.486
COMPRA5=01:19:30.50
COMPDEC5=+21:32:17.9
CICORRECTION=FALSE
CIBAND=NONE
CITARGET=+0.450
DELIMITER=PIPE
COMMENT=Canopus MPC Contact1: CONTACT1=B. D. Warner, 17995 Bakers Farm Rd., Colorado Springs, CO,
USA [brian@MinorPlanetObserver.com]
ENDMETADATA
DATA=2455320.64412|+14.906|+0.033|2.108
DATA=2455320.64718|+14.917|+0.032|2.052
DATA=2455320.65338|+14.912|+0.031|1.949
DATA=2455320.69620|+14.864|+0.027|1.484
ENDDATA
```

## REVISIONS

V1.07 (2011 January 18)

Corrected documentation errors. No changes to standard.

V1.08 (2011 March 21)

Added section (2.4) on “aspect data.” No changes to standard.

V1.09 (2011 May 9)

Corrected typos and documentation errors.