Enhancing OPAC Records

Evaluating and Fitting Within Cataloguing Standards a New Proposal of Description Parameters for Historical Astronomical Resources

M. Pilar Alonso Lifante and Francisco Javier Molero Madrid

Enhancing content description of specialized resources, particularly astronomical resources, is a matter that is still unresolved in library and information science. In this paper, the authors outline deficiencies in some fields and elements of cataloging standards for description of historical astronomical resources, mainly star atlases and catalogs. Furthermore, they review their recent proposal of astronomical parameters for a better description and propose an approach for accommodating these parameters in the current criteria of MARC 21, the International Standard Bibliographic Description, and Resource Description and Access. Fourteen new parameters are considered, and recommendations are provided to standards developers for the addition of elements to accommodate attributes of celestial cartographic resources. This would improve bibliographic records for such resources in astronomical libraries' OPACs, which will have a beneficial effect on information retrieval.

Information retrieval continues to be one the most challenging topics in the field of information and documentation. Many recent publications bear witness to this fact, including monographs by Baeza-Yates and Ribeiro-Neto, Raieli, or Sallaberry, and conference proceedings such as the 32nd European Conference on Information Retrieval Research in 2010 or the 7th Information Retrieval Facility Conference in 2014.[1] This challenge is compounded when the volume of information to be managed is very large and specialized, as is the case for astronomical information.

This information may be divided into two groups according to the physical medium. There is computerized data originating from modern electronic devices (telescopes, CCD cameras, etc.) that is stored in computer-accessible databases. There is also a huge amount of information stored in noncomputerized formats (photographic plates, printed star atlases and catalogs, astrophotography images) that are preserved in astronomical libraries and archives worldwide. The following sections of this paper are devoted to management of the noncomputerized information, in particular, printed star atlases and catalogs.

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The Importance of the Astronomical Resources

Astronomical resources have played a key role throughout the history of science. Starting with the latest milestones, an example was the discovery of the Neptune's fourteenth moon, thanks to the analysis of "more than 150 archival Neptune photographs taken by Hubble from 2004 to 2009."[2] Another example relates to the impact probability on Earth of an asteroid discovered in 2004 (known as Apophis). With the help of some unpublished sky images, scientists could obtain the necessary data to better estimate the asteroid's orbit and rule out a higher impact probability at the next encounters in 2029 and 2036, as pointed out by Giorgini et al.[3]

Among older printed resources, star charts and star catalogs stand out for the following reasons. A star chart is a diagrammatic representation of the positions of the stars up to a specific magnitude from the whole or a bounded area of the celestial sphere (see figure 1). These charts have often been compiled in big atlases. The first star charts were documents where people could observe the night sky plus the path followed by planets and the Moon during the year. In the seventeenth century, navigation had become one of the most important reasons for printing celestial charts. By this time, as Perryman states, the Royal Greenwich Observatory had been founded in England "with the purpose of compiling detailed star maps for navigational purposes."[4] There was another important scientific reason behind the study of the heavens: to measure time to know the longitude coordinate when navigating, as noted by Whitfield and Sobel.[5] Currently, historical celestial cartographic resources are still used for research. In particular, Kilburn notes that "the discovery in the library of Manchester Astronomical Society of a first impression of John Bevis's *Uranographia Britannica* has led to a reappraisal of these early observations. In particular, his observations of Tycho's Star suggest a new interpretation of the supernovae responsible."[6]

According to the *Encyclopaedia Britannica*, a star catalog is a "list of stars, usually according to position and magnitude (brightness) and, in some cases, other properties (e.g., spectral type) as well" (see figure 2).[7] This information is usually shown in tables where rows contain the name of each observed star and columns represent the type of data recorded by the authors about the star. Chabás stated that these tables have "played a fundamental role in the transmission of scientific knowledge."[8] As Perryman shows, comparison of sets of data from different catalogs and different centuries has allowed us to discover previously unknown movements of the Earth and other important facts.[9] In another work, he commented that E. Halley discovered the now well-known "proper motion" of the stars when he compared their positions in contemporary observations (from the eighteenth century) with those that the Greek Hipparchus and others made in the second century CE.[10] More recently, some precision studies by Verbunt and van Gent regarding data from historical star catalogs have been published.[11] One of the goals is to enable new comparisons of this data with the most comprehensive and accurate achieved through new on-board satellite instruments used in recent and future space missions.

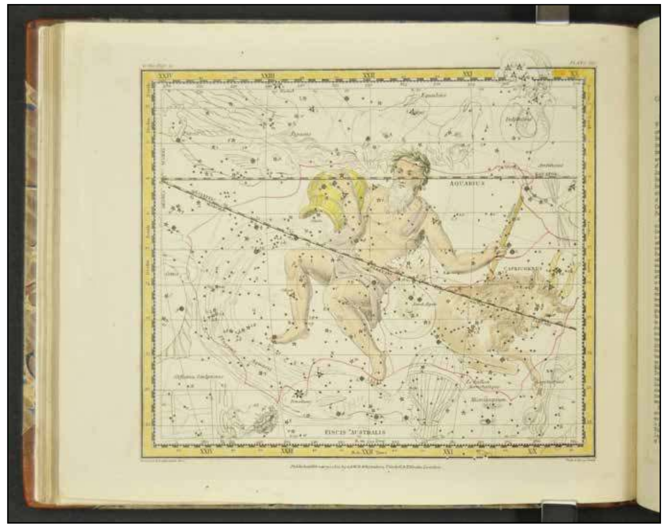

Figure 1. Example of a star chart from the Alexander Jamieson's atlas which highlights Aquarius and Capricornus constellations. Source: Alexander Jamieson, "Plate 21. Capricornus, Aquarius, Globus Aerostaticus, Pisces Austrinus, Microscopium, Corona Australis," in *A Celestial Atlas: Comprising a Systematic Display of the Heavens in a Series of Thirty Maps : Illustrated by Scientific Description of Their Contents and Accompanied by Catalogues of the Stars and Astronomical Exercises* (London: G. & W. B. Whittaker Ave Maria Lane, T. Cadell, Strand, and N. Hailes, Museum Piccadilly, 1822), accessed January 28, 2015, http://lhldigital.lindahall.org/cdm/compoundobject/collection/astro_atlas/id/2097.

Users' Information-Seeking Behavior

Astronomy is witnessing big changes in how users query specialized databases as these incorporate new functionalities focused on user needs and powerful online search engines, as indicated by Tosaka and Weng.[12] Therefore a quick way to identify the user's information-seeking behavior in these databases is to know as much as possible about their search interfaces.

Some examples of these large astronomical databases are SIMBAD (Set of Identifications Measurements and Bibliography for Astronomical Data), operated by the Strasbourg Astronomical Data Center in France and NED (NASA/IPAC Extragalactic Database) operated by the Jet Propulsion Laboratory, the California Institute of Technology, under contract with the National Aeronautics and Space Administration

2 GENERAL CATALOGUE OF STARS FOR 1890·0,

No.	Bradley or Lacaille.	Piazzi. 1800.	B.A.C. 1850.	C.G.A. 1875.	Star's Name.	Mag.	Mean Date. 1800+	No. of Obs.	Mean R.A. 1890·0.	Annual Precession. 1890·0.	Secular Variation. 1890·0.	Annual Proper Motion. μ_a.	Corr. for μ_a to 1890·0.
									h m s	s	s	s	s
1	3209	274	8370	...	86 Pegasi	5·8	87·86	9	0 0 3·094	+3·0725	+ 0·009	+0·0011	+ 0·002
2	...	...	...	...	Lalande 47250............	6·8†	92·64	6	0 0 23·565	+3·0736	+ 0·015	...	...
3	9721	...	...	32446	Lacaille 9721	5·6	94·28	6	0 0 37·379	+3·0683	— 0·033	...	...
4	9729	...	...	15	Lacaille 9729	6·9*	87·53	6	0 1 44·169	+3·0676	— 0·013	...	...
5	9735	279	2	30	Lacaille 9735	5·6	94·79	12	0 2 27·981	+3·0627	— 0·018	...	...

FROM OBSERVATIONS AT THE ROYAL OBSERVATORY, CAPE OF GOOD HOPE. 3

No.	Mean Date. 1800+	No. of Obs.	Mean Dec. 1890·0.	Sec. of Final Dec.	Annual Precession. 1890·0.	Secular Variation. 1890·0.	Annual Proper Motion. μ_δ.	Corr. for μ_δ to 1890·0.	Fallows and Henderson.	Johnson.	Cape Catalogues. 1840.	1850.	1860.	1880.	1885.	Melbourne, 1870 and 1880.
			° ′ ″	″	″	″	″	″								
1	87·86	9	+ 12 47 2·79	2·46	+ 20·053	— 0·01	+ 0·003	+0·01	...	...	...	...	...	...	...	...
2	92·64	6	+ 24 18 16·57	16·33	+ 20·053	— 0·01	...	...	...	...	...	...	...	...	...	...
3	94·28	6	— 49 41 11·33	11·46	+ 20·053	— 0·01	...	...	...	...	...	...	...	1	...	...
4	87·53	6	— 25 57 53·22	53·40	+ 20·052	— 0·01	...	...	...	...	...	...	...	8	...	...
5	94·79	12	— 34 8 30·38	30·59	+ 20·052	— 0·01	...	...	...	...	2892	2	...	15	...	4

Figure 2. Example of the main table of the Gill's star catalog. Source: David Gill, *A Catalogue of 3007 Stars, for the Equinox 1890.0, from Observations Made at the Royal Observatory, Cape of Good Hope during the Years 1885 to 1895* (London: Darling & Son, 1898). Image from: The Library of the Royal Institute and Observatory of the Spanish Navy.

(NASA).[13] The authors have chosen these because both are linked by the software Google Sky (www.google.com/earth/explore/showcase/sky.html) to provide more information when searching for any celestial body. Google Sky is an integrated tool in Google Earth that allows users to explore the universe through stellar images and to navigate by following the motions of celestial bodies in time and space.

These databases' interfaces provide options for users to find what they need. For instance, it is possible to search an object or a list of objects directly by their coordinates or by distinct criteria ranging from coordinates to speeds, including combinations of all of them through specific search expressions. It is also possible to search by bibliographic references and even to retrieve information that users can add to the database through posts. Therefore users may now be interested not only in retrieving certain information about a celestial object but also, for example, obtaining information about all those objects that, moving at a certain velocity, are within a certain distance from the Earth.

A more direct way to understand user behavior is to ask database administrators to identify the most common types of searches performed. This gives objective information about researchers' needs. For instance, between the months of October 2011 and August 2012, the most performed query in SIMBAD was a combined search by different criteria (54 percent). Regarding NED, searches by parameters related to object names were preferred by users (26 percent). This behavior highlights a key aspect to consider: astronomers and astrophysicists are now more interested in the "data" than in the "document."[14]

Problem Statement

Numerous search options in astronomical databases allow users to retrieve almost any datum from thousands or even millions of resources. However, when these users want to query an astronomical library's OPAC in the same way, a major difficulty arises: the search interfaces do not allow specialized queries by well-known parameters such as coordinates, magnitudes of brightness, proper motions, etc. The problem lies, therefore, in the great difficulty of retrieving those documents that contain the desired data. Indeed, users will find these documents only if catalogers have indicated the presence of the desired data in the bibliographic record for each document.

Prevailing cataloging standards (MARC 21, ISBD, ISAD(G), RDA, etc.), are general and do not provide the elements needed to create sufficiently specialized content descriptions. This is true despite the fact that bibliographic agencies have made some efforts to incorporate new elements for celestial cartographic resources. For example, in 2006, the Library of Congress (LC) staff who develop MARC 21 incorporated the subfield "Extraterrestrial area" (662 $h), to accommodate the names of celestial bodies other than the Earth.

Settlement Proposal

The authors identified two possible solutions for this problem. The first is Optical Character Recognition (OCR) digitization. This would allow users to search for any string inside the documents and get access to a digital copy of the document without the need to go to where the original item is preserved. This would be an ideal solution for very small archives. However, since there are astronomical libraries with tens of thousands of documents, each one with hundreds of pages, millions of pages would have to be digitized, which would be very expensive. This is one reason why very few atlases and catalogs have been digitized. Additionally, it is recognized that digitization itself is not the complete solution for better information retrieval.[15]

The second solution is to incorporate new descriptive metadata to create more complete and acceptable bibliographic records for the resources. Only in this way will users be able to retrieve those documents containing exactly the desired data. This would represent an essential improvement in the complex description process for highly specialized resources. Consequently, astronomers and astrophysicists will be able to perform searches in the OPAC similar to those executed in their databases.

These two solutions are not mutually exclusive. The ideal situation would be to describe resources using richer metadata and to scan them later. In addition, if technology such as linked data is used to declare metadata as part of an ontology, descriptions could be enriched to offer the opportunity to mark data within the digitized document. Marking and labeling the information within the document with the appropriate metadata will increase retrieval and improve semantic linkage with other related information, not only by humans but also by other agents.

There is another important consideration. As noted below, since there is information that cannot be recorded in the existing descriptive fields or elements of the prevailing bibliographic standards, it can only be recorded in note fields. Griffis and Ford pointed out in 2009 that

> these fields could be utilized for specific terms relating to database content not adequately covered by the Library of Congress Subject Headings (LCSH). Subject liaisons have specialized knowledge of which databases work best for unique content areas, class assignments, and information needs. This user-centric knowledge can be used to enhance database discovery if liaisons were to provide catalogers with information and descriptors to add to the record.[16]

However, if the OPAC interface is not designed to search for information in note fields, it will never emulate the functionalities of the specialized databases, and the cataloging effort will be fruitless. This situation unfortunately happens often, hence we favor creating new fields and elements to provide new technical information that would ensure higher rates of information retrieval. A solution might be to use fields such as the MARC 653, Index Term-Uncontrolled, which is indexed by default in most OPACs. However, the information we propose to record is more complex than simple terms and names, shown as examples for the MARC field 653 in the MARC 21 documentation.

Literature Review

Cataloging cartographic materials has been a topic in the literature for decades (see the 1982 monograph *Cartographic Materials: A Manual of Interpretation for AACR2* and its modern revision 2004).[17] However, as Gardner notes, "very few articles [have] addressed the unique concerns of cataloging and classification in public and special libraries."[18] The difficulties that arise from organizing and describing cartographic materials have been deeply considered by well-known authors such as Ehrenberg or Corsaro, and more recently by Larsgaard through several publications that the authors highlight: *Map Librarianship* (1998), *Maps and Related Cartographic Materials* (1999), *Cataloguing Electronic Cartographic Materials* (2006), *FRBR and Cartographic Materials* (2007), and *RDA and Cartographic* Resources (2015).[19]

It is important to note that not all astronomical resources are considered cartographic materials. Whereas star charts (and atlases as compilations of star charts) are purely cartographic resources, star catalogs are sets of alphanumeric data, not a graphical expression. Moreover, this data can be cartographic and noncartographic, another reason why these resources are not strictly considered cartographic materials.[20]

Though new encoding and cataloging standards have emerged over the last few decades, none provide perspectives to improve content descriptions for cartographic resources. A recent publication by Novotná, together with very recent works on RDA by Andrew, Moore, and Larsgaard support this fact.[21] None of the changes introduced by RDA provide better content descriptions through new fields or elements, but rather nuances and improvements have been incorporated into the existing ones, such as scale, projection or coordinates. The authors believe instead that the key to better information retrieval is to improve content description. This has been proven to produce additional benefits resulting from better quality records, which generates higher retrieval and circulation rates for libraries.[22]

In addition to these difficulties to enhance content descriptions, OPACs lack proper interfaces to perform specialized queries. Although OPAC designers have invested time and effort to enhance the search experience, as Moulaison and Zavalina note, Mi and Weng point out that "Internet search engines have become the preferred tool over the library online public access catalog (OPAC) for finding information."[23] This is one of the main reasons why users cannot deeply exploit the astronomical resources preserved in libraries and archives.

Significant efforts have been made in astronomy by astronomers and librarians to improve information management.[24] Increasing collaboration between these professionals is captured in a series of LISA (Library and Information Services in Astronomy) conferences.[25] In this regard, Corbin and Grothkopf published a work in which they "give an overview of the history of LISA meetings and describe their logistics."[26] Unfortunately, most actions undertaken have been devoted to electronic information. The authors have not yet found a similar initiative with the aim of enhancing retrieval of printed historical information in astronomy. However, this kind of research has been resolved by other groups such as the International Association of Music Libraries, Archives and Documentation Centres (IAML) whose members have successfully advocated for specialized elements in ISBD (Section 3.2 Music format statement (Notated music)) and RDA (Section 7.13.3 Form of Musical Notation) for music resources.[27]

Since there are many astronomical parameters of great interest for astronomers and astrophysicists that are not recorded by catalogers in the bibliographic descriptions, two studies on historical star atlases and catalogs were conducted to consider new descriptive fields and to demonstrate the importance of some fields for better bibliographic description of these resources.[28] The purpose was to identify the most frequently supplied scientific information and to develop a proposal of description parameters for star charts, atlases, and catalogs. Guidelines for easily identifying those parameters in astronomical resources are also given. However, the accommodation of this set of parameters in the aforementioned standards cannot easily be achieved. Starting with one of the most basic elements, the authorship of a star catalog cannot be attributed to a single person named on the title page as is the case for traditional monographs. It is therefore necessary to look inside the monograph to determine the group of astronomers, observers, and collaborators who make up the whole authorship of the catalog.

Objectives and Method

The goal of this paper is to propose incorporating new descriptive parameters for astronomical resources within existing encoding and cataloging standards. An initial proposal was developed in the aforementioned two previous works where a set of description parameters for star charts, atlases, and catalogs was outlined. The aim of this paper is to determine the most appropriate fields to fit these new parameters within cataloging standards.

Enhancing bibliographic description of any resource necessarily involves deep knowledge of its content. This requires a careful analysis of the resource to identify data of interest to researchers. The authors focused on resources from library of the Royal Institute and Observatory of the Spanish Navy, where a large volume of historical astronomical information is preserved. Specifically, the authors analyzed a set of twenty-two star atlases and twenty-eight star catalogs from different countries that were compiled between the eighteenth and twentieth centuries. Older resources were ruled out because their data are known to be less precise.

The search for resources was accomplished by querying both the Union Catalogue of Defence Library Network (commonly known as Bibliodef) and the printed catalog of the map collection.[29] Analysis of each resource consisted first of a comprehensive study of its content (title pages, table of contents, introduction, etc.) searching for the most frequently supplied information for star atlases and catalogs. Next, the authors wanted to demonstrate the importance of certain fields in cataloging standards that are not currently being widely used in bibliographic description. Because of this analysis, many parameters were determined.

After this process, three encoding and cataloging standards were analyzed: the MARC 21 Format for Bibliographic Data, the International Standard Bibliographic Description (ISBD) consolidated edition, and Resource Description and Access (RDA). This analysis does not suggest any comparison between content standards (ISBD, RDA) and the encoding standard MARC 21 because of the different purposes of the two types of standards. This new study was aimed at determining which fields could accommodate astronomical parameters. The entire set of parameters has been classified into three groups: (1) those that are currently accommodated by specific description elements other than general note fields; (2) new parameters that could be recorded in descriptive elements; and (3) new parameters that could be recorded only in general note fields. The fourth section is dedicated to the presentation and treatment of each of these groups. In turn, a proposal on how to record the information provided by the identified astronomical parameters is provided in the fifth section.

Proposal for Description Parameters for Historical Star Charts, Atlases, and Catalogs

Parameters that can be Accommodated by Specific Description Elements in Cataloging Standards

Table 1 summarizes the areas of the cataloging standards that could accommodate the proposed parameters. Two of them are similar to those used in terrestrial cartography: projection and scale. Projection is the method used to make a two-dimensional representation (a chart or map) from a three-dimensional representation (a celestial globe). Many of these methods may be found in specialized books about classical and modern cartography.[30] The official name of the projection system is usually the item to be registered by the three standards. ISBD allows us to record "associated phrases related to the statement of projection . . . , phrases usually consist of statements pertaining to properties of the projection . . . and standard abbreviations."[31] RDA provides an option to record "phrases about meridians and/or parallels that are associated with the projection statement."[32] With respect to MARC 21, field 255 $b is used to record the entire projection statement. Instructions are provided for recording projection following the ISBD principles.

The concept of scale in celestial cartography is slightly different from the classical linear scales used for cartographic resources. In this case, the scale is angular and is usually recorded as linear distance per angular distance. ISBD indicates that the scale "is expressed as an angular scale in millimeters per degree."[33] MARC 21 also refers to "angular scale" in the 034 field, Coded Cartographic Mathematical Data, but neither standard provides instructions about how to record it or examples. In contrast, RDA uses the term "nonlinear scale" and provides an example showing how the angular scale is expressed as degree per centimeter. It is important to note that many resources include their statement of scale in a short statement that should be recorded as it appears without estimating, according to RDA.

The third parameter is commonly known as epoch or equinox. The epoch is a date that refers to astronomical observations, while equinoxes correspond to two special dates during the year.[34] This parameter is used exclusively for celestial cartography. The parameter "epoch" appears together with "equinox" in MARC 21 (034 $p and 255 $e) and ISBD (3.1.3.4), while RDA provides two separate instructions (7.5 Equinox and 7.6 Epoch). Both RDA and ISBD note that the equinox is expressed as a year, but neither standard explains how to record the epoch. RDA and ISBD point out only that epoch is recorded when it is known to differ from the equinox. Moreover, these two astronomical dates can be given as a Besselian or Julian year, hence these dates can appear accompanied by decimals. This peculiarity is considered by MARC 21 in the field 034, namely, "Equinox or epoch for a celestial chart. Usually recorded in the form yyyy (year) according to the Gregorian calendar, but may include a decimal including the month in the form yyyy.mm (year-month)."

The last parameter corresponds to one of the most frequently used bits of data used for cartographic materials: coordinates. Concerning celestial coordinates, it is important to note that only equatorial coordinates (right ascension and declination) can be recorded using the cataloging standards discussed here, hence when a different system of coordinates is used in astronomy, these standards do not accommodate it. This could become a serious problem when cataloging because astronomers typically use several systems of coordinates plus the equatorial. Therefore these new systems should be included in the cataloging standards or, perhaps, the field for recording coordinates should be generic, i.e., to provide the numerical values of the longitude and latitude together with another subfield so that catalogers can indicate the system of reference for those values.

New Potential Parameters for Current Description Fields

Apart from the previous set of parameters, there is a second set of parameters that do not belong in existing fields but could be recorded in some specific fields. These should be regarded as the most appropriate places to include each parameter in accordance to the definitions provided by the standards.

From our point of view, recording the constellation name shown in charts or maps is of great importance. Indeed, in the same way that the majority of landforms are recorded by catalogers who handle terrestrial maps, constellations are landforms associated with celestial maps, hence they should naturally be taken into account. Moreover, it is quite common for astronomers to provide constellation names when new celestial objects are discovered. Therefore this parameter enables the first recording of the location of those objects.

As shown in table 2, the parameter "constellation name" could be recorded in the MARC 21 662, Subject Added Entry—Hierarchical Place Name. Despite this field being used to record the "hierarchical form of a geographic name

Table 1. Parameters that Can be Accommodated by Specific Description Elements in Cataloging Standards

Parameters	Standards	Description fields
Coordinates	MARC 21	034—Coded cartographic mathematical data (R) $j—Declination—northern limit (NR) $k—Declination—southern limit (NR) $m—Right ascension—eastern limit (NR) $n—Right ascension—western limit (NR) 255—Cartographic mathematical data (R) $d—Statement of zone (NR)
	ISBD consolidated	3.1.3.3. Right ascension and declination
	RDA	7.4.4. Right Ascension and Declination
Epoch/ Equinox	MARC 21	034—Coded Cartographic Mathematical Data (R) $p—Equinox (NR) Equinox or epoch for a celestial chart. 255—Cartographic mathematical data (R) $e—Equinox. Statement of equinox or epoch.
	ISBD consolidated	3.1.3.4. Equinox The equinox is expressed as a year preceded by equinox [. . .] the epoch is designated by epoch.
	RDA	7.5. Equinox Equinox is one of two points of intersection of the ecliptic and the celestial equator, occupied by the sun when its declination is 0º. 7.6. Epoch Epoch is an arbitrary moment in time to which measurements of position for a body or orientation for an orbit are referred.
Projection	MARC 21	008—Maps (NR) 22–23—Projection (006/05–06) ##—Projection not specified 255- Cartographic mathematical data (R) $b—Statement of projection (NR)
	ISBD consolidated	3.1.2. Statement of projection
	RDA	7.26. Projection of cartographic content
Scale	MARC 21	034- Coded cartographic mathematical data (R) $h—Angular scale Scale, if known, for celestial charts. 255- Cartographic mathematical data (R) $a—Statement of scale Entire scale statement including any equivalency statements, vertical scales or vertical exaggeration statements for relief models and other three-dimensional items.
	ISBD consolidated	3.1.1.9. The scale for celestial charts is expressed as an angular scale in millimetres por degree.
	RDA	7.25.1.5. Nonlinear Scale Record a statement of scale for an image, map, etc., with a nonlinear scale (e.g., celestial charts; some maps of imaginary places) only if the information appears on the resource. If no scale statement appears on the resource, record Scale not given. Do not estimate a scale. 1º per 2 cm.

used as a subject added entry," it also includes the "name of any extraterrestrial entity or space." Constellations are probably the main extraterrestrial entities to be noted by astronomers. Another option is to use field 751 Added Entry-Geographic Name, subfield $a—Geographic name, but a constellation is not a geographic name but rather a celestial name. In other words, geography is a branch of science concerned with Earth landforms and astronomical geography is commonly known as cosmography. It is also possible to record it in field 754 Added Entry-Taxonomic Identification. Nevertheless, this astronomical parameter can only be recorded in note fields in the case of ISBD (section 7.10.1) and RDA (7.27).

Celestial hemisphere is an astronomical parameter closely related to the coordinates of celestial objects. As shown below, in astronomy there are several types of coordinates apart from the classical ecliptic and equatorial systems. Interpretation of the celestial hemisphere is trivial

Table 2. New Potential Parameters for Current Description Fields

Parameters	Standards	Description fields
Constellation name	MARC 21	662—Subject Added Entry-Hierarchical Place Name (R) $h—Extraterrestrial area Name of any extraterrestrial entity or space and includes solar systems, galaxies, star systems, and planets as well as geographic features of individual planets, etc. Subfield $h may be repeated for hierarchies when multiple levels are given, retaining the order highest-to-lowest. 662 ##$hMars$hValles Marineris.$2MARC code for Gazetteer of Planetary Nomenclature 751—Added Entry-Geographic Name (R) Added entry in which the entry element is a geographic name that is related to a particular attribute of the described item. $a—Geographic name (NR) 754—Added Entry-Taxonomic Identification (R) Added entry in which the entry element is the taxonomic name or category associated with the described item. $a—Taxonomic name (R) $c—Taxonomic category (R) $2—Source of taxonomic identification (NR)
	ISBD	7.10 Other notes 7.10.1 Any other notes that are particular to the specialized material or considered important to users of the catalogue may be given.
	RDA	7.27. Other details of cartographic content Other details of cartographic content include mathematical data and other features of the cartographic content of a resource not recorded in statements of scale, projection, and coordinates.
Celestial Hemisphere	MARC 21	034—Coded Cartographic Mathematical Data (R) $j—Declination—northern limit $k—Declination—southern limit $m—Right ascension—eastern limit $n—Right ascension—western limit Subfields $j, $k, $m, and $n are used with celestial charts or celestial charts in atlases and contain the limits of the declination and the right ascension. Subfields $j and $k are each eight characters in length and record the declination in the form hdddmmss (hemisphere-degrees-minutes-seconds). 0340 #abjN0300000$kN0300000$m021800$n021800 651—Subject Added Entry-Geographic Name (R) Subject added entry in which the entry element is a geographic name. 662—Subject Added Entry-Hierarchical Place Name (R) $a—Country or larger entity (R) Name of a country or a larger political jurisdiction. It also contains the names of geographical areas/entities such as continents or hemispheres at a country level or higher. 751—Added Entry-Geographic Name $a—Geographic name Geographic name that has a relationship with the described item.
	ISBD	3.1.3.3. Right ascension and declination The declination is desiganted by Decl. or its equivalent in another language, followed by the degrees (º) and, when necessary, minutes (‘) and seconds (“) of the sexagesimal system (360º circle), using a plus sign (+) for the northern celestial hemisphere and a minus sign (-) for the southern celestial hemisphere.
	RDA	7.4.4.3. Recording Right Ascension and Declination Designate the declination by Declination, followed by the degrees (º) and, when necessary, minutes (‘) and seconds (“) of the sexagesimal system (360º circle), using a plus sign (+) for the northern celestial hemisphere and a minus sign (-) for the southern celestial hemisphere. If the cartographic content is centered on a pole, record the declination limit.
Table of Contents	MARC 21	505—Formatted Contents Note (R) Titles of separate works or parts of an item or the table of contents.
	ISBD	7.7 Notes relating to the contents 7.7.1 Notes relating to the contents may include the list of contents and notes on other inclusions, such as indexes, inserts, bibliographies, discographies, etc.
	RDA	7.16. Supplementary content Supplementary content is content (e.g., an index, a bibliography, an appendix) designed to supplement the primary content of a resource.

Table 2. New Potential Parameters for Current Description Fields (cont.)

Parameters	Standards	Description fields
Magnitude	MARC 21	500—General Note (R) General information for which a specialized 5XX note field has not been defined.
	ISBD	7.3 Notes on the material or type of resource specific area 7.3.1 Mathematical data (cartographic resources) 7.3.1.1 For celestial charts, the first note related to the mathematical data area is the note on magnitude. The term limiting magnitude or its equivalent in another language is followed by a number that may reach a maximum of 22.
	RDA	7.27.1.3. Recording other details of cartographic content For celestial cartographic content, record the magnitude of the cartographic content.
Observation period	MARC 21	033—Date/Time and Place of an Event (R) Formatted date/time and/or coded place of creation, capture, recording, filming, execution, or broadcast associated with an event or the finding of a naturally occurring object. This information in textual form is contained in field 518 (Date/Time and Place of an Event Note). First Indicator—Type of date in subfield $a Type of date information contained in subfield $a. 2—Range of dates Used, for example, when the period of capture, execution, etc., spanned more than two consecutive days, and the individual dates are unknown or too numerous to be specified. Second Indicator—Type of event Specifies the type of event information found in the field. 0—Capture Pertains to the recording of sound, the filming of visual images, the making or producing of an item, or other form of creation of an item. $a—Formatted date/time Seventeen characters, recorded in the pattern yyyymmddhhmm+-hmm, that indicate the actual or approximate date (yyyymmdd)/time (hhmm) of capture, finding, or broadcast and Time Differential Factor (+-hhmm) information. A hyphen (-) is used for unknown digits in the year/month/day segment. Within each segment, the data are right justified and any unused position contains a zero. The first eight characters yyyymmdd (4 for the year, 2 for the month, and 2 for the day) represent the date and are mandatory if the subfield is used. The following four characters, hhmm (2 for the hour, 2 for the minute), represent the time as hour and minute. The last 5 character positions +hhmm give the Time Differential Factor information. The Time Differential Factor (TDF) is preceded by a plus (+) or minus (-) sign, indicating the hours and minutes the local time is ahead of or behind Universal Time (Greenwich Mean Time), respectively. Local times throughout the world vary from Universal Time by as much as -1200 (west of the Greenwich Meridian) and by as much as +1300 hours (east of the Greenwich Meridian). 518—Date/Time and Place of an Event Note (R) Note on the date/time and/or place of creation, capture, recording, filming, execution, or broadcast associated with an event or the finding of a naturally occurring object. Field 033 (Date/Time and Place of an Event) contains the same information in coded form. Date/time and place of an event note information may be encoded as a note in subfield $a or parsed into specific subfields $d—Date of event Date/time of event. May be in a controlled or uncontrolled form. $o—Other event information Other information that is related to the date or place of event.
	ISBD	7.4. Notes on the publication, production, distribution, etc. area 7.4.1. Notes on the publication, production, distribution, etc., [. . .]; and additional dates.
	RDA	7.11.3. Date of Capture Date of capture is a date or range of dates associated with the capture (i.e. recording, filming, etc.) of the content of a resource. Record the place of capture, giving the year, month, day and time, as applicable.

Table 2. New Potential Parameters for Current Description Fields (cont.)

Parameters	Standards	Description fields
Observation place	MARC 21	033—Date/Time and Place of an Event (R) Formatted date/time and/or coded place of creation, capture, recording, filming, execution, or broadcast associated with an event or the finding of a naturally occurring object. This information in textual form is contained in field 518 (Date/Time and Place of an Event Note). $p—Place of event Place of event. May be in a controlled or uncontrolled form. 518—Date/Time and Place of an Event Note (R) Note on the date/time and/or place of creation, capture, recording, filming, execution, or broadcast associated with an event or the finding of a naturally occurring object. Field 033 (Date/Time and Place of an Event) contains the same information in coded form. Date/time and place of an event note information may be encoded as a note in subfield $a or parsed into specific subfields. $p—Place of event (R) Place of event. May be in a controlled or uncontrolled form. Record the place of capture, naming the specific studio, concert hall, etc., if applicable, in addition to the name of the city, etc.
	ISBD	7.10 Other notes 7.10.1 Any other notes that are particular to the specialized material or considered important to users of the catalog may be given.
	RDA	7.11.2. Place of Capture Place of capture is the place associated with the capture (i.e. recording, filming, etc.) of the content of a resource.
Related document	MARC 21	510—Citation/References Note (R) Citations or references to published bibliographic descriptions, reviews, abstracts, or indexes of the content of the described item. 786—Data Source Entry (R) Information pertaining to a data source to which the described item is related. It may contain information about other files, printed sources, or collection procedures. 787—Other Relationship Entry (R) Information concerning the work related to the target item when the relationship does not fit any of those defined in fields 760–785.
	ISBD	7.2.4.6 Other relationships Notes on other relationships between the resource being described and other resources may be given, provided that the nature of the relationship, the titles or the key titles and ISSNs of the other resource or resources specified.
	RDA	7.16. Supplementary content Supplementary content is content (e.g., an index, a bibliography, an appendix) designed to supplement the primary content of a resource.

from equatorial coordinates, that is, positive declinations are immediately associated with the northern hemisphere and vice-versa. However, if the coordinate system differs from the equatorial, positive latitudes do not always correspond to the northern celestial hemisphere. Figure 3 shows an example of a record of the galaxy M31 from the SIMBAD Astronomical Database in which a negative galactic latitude (-21.5733) corresponds to a positive declination (+4116 07.50), meaning that M31 is located in a northern hemisphere. Since some of these new systems of coordinates have developed within the last few decades and their correspondence to the classical celestial hemispheres is not straightforward, including the field hemisphere in the cataloging process could be essential for fast and precise information identification and retrieval.

Further, we believe that the parameter "celestial hemisphere" should have its own field or subfield, and that this parameter can currently be reflected by the existing cataloguing rules. In particular, MARC 21, ISBD, and RDA allow us only to register equatorial coordinates of any extraterrestrial entity, plus record the celestial hemisphere as long as the declination is indicated (see table 2). More specifically, according to MARC 21, catalogers may record "N" (northern) or "S" (southern) to precede coordinates (which is the declination) in the MARC 034 field. This parameter could be included as a "geographic name" in the MARC 651 field, Subject Added Entry—Geographic Name or as a "hierarchical place name" in the MARC 662 field, where the hemisphere may be indicated within $a "Country or larger entity." Another option is to use the subfield $a—Geographic name of the field 751—Added Entry-Geographic Name. In ISBD and RDA, these standards use the sign (+) or (-) followed by the degrees (º) for declination to show the northern or southern celestial hemisphere respectively. In short, determination of the celestial hemisphere depends on the system of coordinates for resources that should be recorded as commented above.

Another important parameter to consider is table of contents. Indeed, in library and information science literature, several studies such as those by Cochrane and Markey, Calhoun et al., and Dinkins and Kirkland have demonstrated that the descriptive quality of a bibliographic record is enhanced when its table of contents is included in the record.[35] In the case of star catalogs, tables of content provide interesting and detailed information for astronomers, namely previous works by other astronomers, instruments involved in observations, corrections applied to measurements, etc. Additionally, tables of contents of star atlases sometimes supply constellation names that users will find inside the atlas together with further information such as hemisphere, coordinates, projection, magnitude, etc.

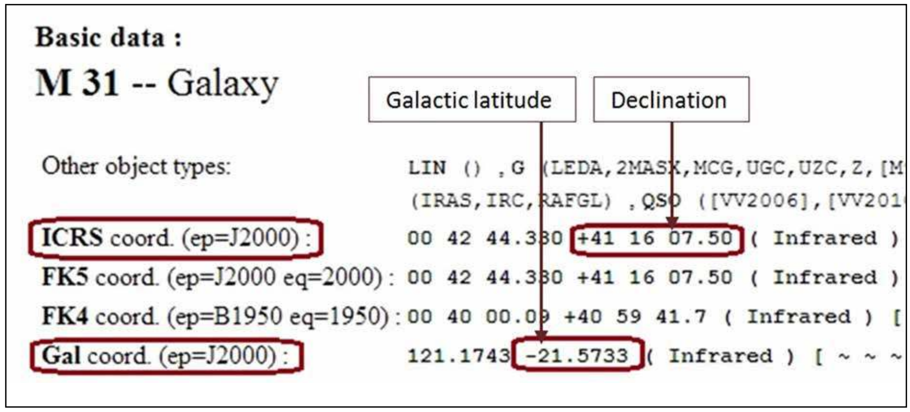

Figure 3. Example of a record of the galaxy M31 from SIMBAD database. Source: SIMBAD Astronomical Database (object name M31; accessed May 18, 2014), http://simbad.u-strasbg.fr/simbad/sim-basic?Ident=m31&submit=SIMBAD+search.

Despite the obvious benefits of recording the "table of contents," this information is often not included in bibliographic records for star atlases and catalogs, as demonstrated by Alonso-Lifante et al.[36] This parameter may be added using specified note fields in MARC 21, ISBD and RDA. ISBD allows catalogers to include the list of a resource's contents (Section 7.7). When using MARC 21 and RDA, catalogers can indicate the presence of a table of contents (MARC 21 field 505 or RDA 7.16) (see table 2).

The "magnitude" of a star is an astronomical parameter that measures a star's brightness for different purposes. According to Evans, "The stellar magnitude scale is one of the oldest scientific standards of measurement still in use, dating back to observations by Hipparchus in 130 BC and the publication of a stellar magnitude reference table in Ptolemy's Almagest almost three hundred years later."[37] Therefore this parameter is of great relevance for astronomers and astrophysicists since, among other applications, some important physical quantities can be derived from it. Concerning "magnitude," none of the three standards provide guidance on where and how to record this information. MARC 21 does not consider this parameter, hence magnitude can only be recorded in the MARC 500 general note field. In turn, ISBD and RDA mention the magnitude in note fields (ISBD 7.3.1.1 RDA 7.27).

The next parameter is "observation period," the period during which the astronomical observations were carried out. This parameter is always relevant for astronomers because these dates enable them to know the state of the sky at the time of those observations. As shown in table 2, this parameter could be included in "$a Formatted date/time" of the MARC 21 033 field or in "$a Date of event" of MARC 21 518 field ("$o Other event information" of MARC 21 518 field could also be used). Using ISBD, this parameter could be included in the note section 7.4.1 where "additional dates" are recorded. RDA allows catalogers to describe the "observation period" in "Date of Capture" (RDA 7.11.3).

The "observation period" is often provided with the "observation place," which is typically an astronomical observatory. Both parameters are essential to know the spatiotemporal window of observations. Considering MARC 21 (see table 2), this parameter could be recorded in the MARC fields 033 Date/Time and Place of an Event or 518 Date/Time and Place of an Event Note, since both indicate the "place of an event," in this case an astronomical observation. RDA 7.11.3 is aimed at recording a "place of capture," which is, in this case, the observatory where observations were made. We note that the ISBD is not equipped to record this information in the sense that there is no specific section for it, and this parameter would need to be recorded using the general note section 7.10.

The last parameter to be considered is "related document." It is common in astronomy to specify that contemporary star catalogs were compiled from previous ones, or that contemporary star atlases were designed using content from previous catalogs. Moreover, both types of documents (previous atlas or catalogs) sometimes include citations to scientific works published separately from the main catalog or atlas, which could provide useful information for astronomers. These citations could therefore be included in the

Table 3. List of General Note Fields of Each Cataloguing Standard

Standards	Description fields
MARC 21	500—General Note (R) General information for which a specialized 5XX note field has not been defined.
ISBD consolidated	7.10 Other notes 7.10.1 Any other notes that are particular to the specialized material or considered important to users of the catalogue may be given.
RDA	7.27. Other details of cartographic content Other details of cartographic content include mathematical data and other features of the cartographic content of a resource not recorded in statements of scale, projection, and coordinates.

records either as a traditional bibliographic reference or as a link to the corresponding resource. ISBD and RDA (see table 2) allow catalogers to record "supplementary content" (RDA) or "related resources" if the relationship between the resources is provided (ISBD). In MARC 21, this information could be included in the 510 Citation/References Note field or in both 786 Data Source Entry and 787 Other Relationship Entry.

New Parameters to Record in Note Fields

As noted at the beginning of this section, there is a final set of parameters that cannot be recorded using the existing cataloging standards because of their specialized nature. This is why these parameters can be recorded only in the general note fields given in table 3.

The parameter "instruments" concerns those tools used to make observations and to take the corresponding measurements, such as telescopes, micrometers, etc. Only when the tools are known can their precision be calculated, thus assuring the precision of the data taken by these instruments. This information is absolutely crucial for new research and developments when comparing old data with new data from recent space missions. Therefore recording the type of instruments used during the observations will allow users to filter those catalogs whose data was taken by certain instruments whose performance provides the desired precision. Since these instruments have been present throughout the history of cartography, it is difficult to understand why cataloguing standards have not yet incorporated them. On the contrary, catalogers may record them only in general note fields as shown in table 3.

The following parameter is of paramount importance when providing an accurate description of a star catalog. The most important information provided by a star catalog is given in its "main table" (see again figure 2).[38] A star catalog contains many tables with several purposes, ranging from corrections of measurements to providing useful information about the set of stars covered by the observations. This last piece of information is usually provided in tables where each row corresponds to a star and the columns convey different data about those stars. These data are, in fact, the most important information that could be recorded about the resource. Since these columns are commonly headed by a short name, which is frequently explained elsewhere in the catalog, in our view, although there is no specific field for this information, it should at least be recorded in a general note field.

Other important parameters considered in the description of astronomical resources are "type of coordinates" and "type of magnitude." The former is related to coordinates as explained above. Many catalogs and atlases provide star coordinates that are based on reference frames that differ from the classical equatorial, but when this happens, catalogers cannot indicate them. Since such information is crucial for astronomers, it should be recorded, at least in a note to give consistency to the information recorded. With respect to the type of magnitude, it is important to note that several types of magnitudes exist in astronomy and the specific type offered by each resource should also be recorded.[39]

It is worth mentioning the importance of recording the captions corresponding to tables, apart from the main table of a star catalog, giving extra information about corrections, errors, instruments, etc. These captions indicate the existence of very important information about data contained in the resources. The presence of information about interesting celestial objects such as supernovas or comets is often overlooked. This results in the loss of valuable information that is not retrieved by astronomers through their specialized queries. It is notable that many newer celestial charts and maps have been captured out of the visible range of electromagnetic spectrum, and the wavelength (or frequency) of such captures is also important information. "Perspective," which is related to the shape of constellations, is another important aspect to record. From a geocentric perspective, constellation images are considered to be left-to-right reversed with respect to the opposite perspective commonly known as external. Finally, when a resource offers limited information, recording whether it has constellation images is not petty, since the presence of such images provides useful historical information, including their star nomenclature.

Table 4. Examples of How to Record the Cartographic Parameters

Parameters	Standards	Examples
Coordinates	Example	A star chart whose declination goes to 0º to 20º and whose right ascension ranges from 0h 56' to 2h and 4.' This is a real star chart from "Atlas des Nördlichen Gestirnten Himmels für den anfang des jahres 1855" by Dr. E. Schönfeld and Dr. A. Krueger published in 1863.
	MARC 21	0340 #abjN0200000$kN0000000$m005600$n020400 255 ##$d(RA 0h 56 min to 2h 4 min/Decl. 0º to 20º)
	ISBD	(RA 0h 56 min to 2h 4 min/Decl. 0º to 20º)
	RDA	Right ascension 0 hr. 56 min. to 2 hr. 4 min./Declination 0º to 20º
Type of coordinates	Example	A star catalogue titled "Catalogue of galaxies and clusters of galaxies" by F. Zwicky, E. Herzog and P. Wild, which shows a table with galactic coordinates.
	MARC 21	500 ##$aType of coordinates: Galactic
	ISBD	.- Type of coordinates: Galactic
	RDA	Type of coordinates: Galactic
Projection	Example	A star chart from "Nouvel Atlas Céleste" by Richard A. Proctor, published in 1886, which is made in stereographic projection.
	MARC 21	008/22–23 af 255 ##$bStereographic proj.
	ISBD	; proj. stéréographique
	RDA	Projection Stéréographique
Scale	Example	A star chart from "Charts of the constellations from the North Pole to between 35 and 40 degrees of south declination" by A. Cottam, published in 1889, which shows the scale in the Preface by this sentence: "The scale is one-third of an inch to a degree of a great circle." The calculation: 1 inch =2.54 cm (2.54/3)*10 =8.466666 mm 8.466666/10 =0.846 cm
	MARC 21	0341#$hScale 8.46 mm per 1º 255 ##$aScale 8.46 mm per 1º
	ISBD	.-Scale 8.46 mm per 1º
	RDA	1º per 0.846 cm
Perspective	Example	A star chart from "Uranographia" by J.E. Bode, published in 1801, where the perspective can be deduced. In this case, the perspective is geocentric.
	MARC 21	500 ##$aPerspective: Geocentric
	ISBD	.- Perspective: Geocentric
	RDA	Perspective: Geocentric

Proposal to Record Identified Astronomical Parameters using Current Cataloging Standards: MARC21, ISBD and RDA

The previous sections address the fields that could be used to record our suggested set of parameters. This section proposes how to record them. Examples of these parameters have been taken from historical star atlases and catalogs, as shown in three tables according to the new following classification: cartographic parameters (table 4), astronomical parameters (table 5) and other important parameters (table 6). These tables have three columns where the first column indicates the name of each parameter; the second column shows, for each parameter, groups with four rows labelled "Example," "MARC 21," "ISBD," and "RDA," whose corresponding content is provided in the third column. The row "Example" contains a piece of information from an astronomical resource used as an example to illustrate the existence of that parameter. In turn, the rows of the third column corresponding to the three cataloging standards show how we advocate that each parameter should be recorded using MARC 21, ISBD, and RDA.

Regarding cartographic parameters, the most important parameter to be highlighted is "type of coordinates." Note in table 4 that the coordinate system is essential to mention. The numerical value of the coordinates is useless unless

Table 5. Examples of How to Record the Astronomical Parameters

Parameters	Standards	Examples
Epoch	Example	A star chart from "Charts of the constellations from the North Pole to between 35 and 40 degrees of south declination" by A. Cottam, published in 1889, which shows the epoch within the own star chart. The epoch is 1890.
	MARC 21	0341 #$p1890 255 ##$e1890
	ISBD	; epoch 1890
	RDA	Epoch: 1890
Equinox	Example	A star chart from "Celestial charts for the equinox 1860.0 made at the Lichfield Observatory of Hamilton College" by C. H. F. Peters, published en 1882, which shows the equinox within the own star chart. The equinox is 1860.0.
	MARC 21	0341 #$p1860.0 255 ##$eEq. 1860.0
	ISBD	; equinox 1860.0
	RDA	Equinox: 1860.0
Magnitude	Example	A star chart from "Cordoba Durchmusterung" by J. M. Thome, published in 1893, which shows the scale of magnitudes. In this case the scale ranges from 1 to 10.
	MARC 21	500 ##$aRange of magnitudes: from 1 to 10
	ISBD	.-Limiting magnitude 10.
	RDA	Range of magnitudes: from 1 to 10
Type of magnitude	Example	A star catalogue titled "Catalogue of double stars from observations made at the Royal Observatory, Greenwich with the 28-inch refractor during the years 1893–1919" by F. W. Dyson, published in 1921, contains in its main table two specific columns namely: apparent magnitude and absolute magnitude.
	MARC 21	500 ##$aType of magnitude: apparent and absolute.
	ISBD	.- Type of magnitude: apparent and absolute.
	RDA	Type of magnitude: apparent and absolute.
Celestial Hemisphere	Example	A star chart from "Charts of the constellations from the North Pole to between 35 and 40 degrees of south declination" by A. Cottam, published in 1889, whose celestial hemisphere can be deduced from the title page information (north pole). In this case, it is the Northern Hemisphere.
	MARC 21	0340 #abjN0200000$kN0000000 662 ##$aCelestial hemisphere: Northern 651 # $aCelestial hemisphere: Northern
	ISBD	.- Celestial hemisphere: Northern (RA 0h 56 min to 2h 4 min/Decl. +0º to +20º)
	RDA	Celestial hemisphere: Northern Right ascension 0 hr. 56 min. to 2 hr. 4 min./Declination +0º to +20º
Observation period	Example	A star catalogue titled "A catalogue of 606 principal fixed stars in the Southern Hemisphere" by M. J. Johnson, published in 1835, whose observation period ranges from November 1829 to April 1833 which it shows on the title page.
	MARC 21	03320$a182911183304 518 ##$d1829 November to 1833 April
	ISBD	.-Observation period ranges from November 1829 to April 1833
	RDA	1829 November to 1833 April
Observation place	Example	A star catalogue titled "A catalogue of 606 principal fixed stars in the Southern Hemisphere" by M. J. Johnson, published in 1835, whose observations made at The Observatory, St. Helena which it shows on the title page.
	MARC 21	033 ##$pSt. Helena Observatory, United Kingdom 518 ##$p St. Helena Observatory, United Kingdom
	ISBD	.- St. Helena Observatory, United Kingdom
	RDA	St. Helena Observatory, United Kingdom

Table 5. Examples of How to Record the Astronomical Parameters (cont.)

Parameters	Standards	Examples
Constellation name	Example	A star chart from "Charts of the constellations from the North Pole to between 35 and 40 degrees of south declination" by A. Cottam, published in 1889, whose constellations names are shown within the own star chart.
	MARC 21	662 ##$hCygnus$hCepheus$hCamelopardus$hLyra$hHercules $hBootes$hUrsa Major
	ISBD	.-Constellation names: Cygnus, Cepheus, Camelopardus, Lyra, Hercules, Bootes and Ursa Major.
	RDA	Constellation names: Cygnus, Cepheus, Camelopardus, Lyra, Hercules, Bootes and Ursa Major.
Instruments	Example	A star catalog titled "A catalog of 606 principal fixed stars in the Southern Hemisphere" by M. J. Johnson, published in 1835, which shows within the introduction the instruments used.
	MARC 21	500##$aInstruments: the transit instrument and the mural circle
	ISBD	.- Instruments: the transit instrument and the mural circle
	RDA	Instruments: the transit instrument and the mural circle
Astronomic naming conventions	Example	A star chart from "Atlas Coelestis" by J. Flamsteed, published in 1729, contains Bayer's nomenclature.
	MARC 21	500 ##$aAstronomic naming convention: Bayer's letters.
	ISBD	.- Star nomenclature: Bayer's letters.
	RDA	Star nomenclature: Bayer's letters.
Wavelength	Example	A star chart from "Catalog of stars in the Nothern Milky Way having H-Alpha in emission. Part 2 (charts)" by L. Kohoutek and R. Wehmeyer, published in 1997, which shows the wavelength on the title page.
	MARC 21	500##$aWavelength: H-Alpha in emission
	ISBD	.- Wavelength: H-Alpha in emission
	RDA	Wavelength: H-Alpha in emission
Celestial objects of special interest	Example	A star chart from "Celestial charts for the equinox 1860.0 made at the Lichfield Observatory of Hamilton College" by C. H. F. Peters, published en 1882, which shows some stars with their associated name, number and nomenclature along with the date in what was discovered.
	MARC 21	500##$aInteresting objects: Electra (130) discovered 1873 Feb. 17 and Una (160) discovered 1876. Febr. 20.
	ISBD	.-Interesting objects: Electra (130) discovered 1873 Feb. 17 and Una (160) discovered 1876. Febr. 20.
	RDA	Interesting objects: Electra (130) discovered 1873 Feb. 17 and Una (160) discovered 1876. Febr. 20.
Constellation images	Example	A star chart from "Uranographia sive astrorum description viginti tabulis ceneis incise ex recentissimis et absolutissimis astronomorum observationibus" by J.E. Bode, published in 1801, which shows constellation images.
	MARC 21	500##$aConstellation images: Yes.
	ISBD	.- Constellation images: Yes.
	RDA	Constellation images: Yes.

users know which system is used. Note also how we give the calculation process from the statement of the scale to get the corresponding numerical value.

With respect to astronomical parameters, we want to emphasize the parameters "magnitude" and "type of magnitude" in table 5. Concerning the magnitude, we record in the MARC 21 field 500 the range of magnitudes, that is, the magnitude of the brightest star (1) and the magnitude of the faintest star (10). We also provide two examples for ISBD and RDA. Concerning the type of magnitude, it is relevant to convey that two types of magnitudes are given in the catalog. The parameters "wavelength" and "instruments" are very important to consider when describing a celestial cartographic resource.

The authors pay special attention in table 6 to the parameter "Names of the astronomical parameters included in the main table." For astronomers and astrophysicists, the names of the columns of a star catalog represent those technical data that they will find in each catalog. This is therefore the most important information from this resource to be recorded by catalogers.

Finally, table 7 shows an example of a complete MARC 21 record of the Gill's star catalog according to the proposal outlined in this paper.[40] Fields in black correspond to LC's original record. Note, for instance, that the equinox, although given in the catalog's title, has not been included in neither the MARC 034 nor 255. Note also that most of the parameters must be accommodated in general note

Table 6. Examples of how to Record Other Important Parameters

Parameters	Standards	Examples
Table of Contents	Example	A star atlas titled "Star Atlas of Reference Stars and Nonstellar Objects" by Smithsonian Astrophysical Observatory published in 1969, which contains an index.
	MARC 21	500 ##$a Table of contents: Foreword, Joseph Ashbrook.—1. General—2. Sources Other than the SAO Star Catalog—3. Projection System—4. Indices—5. Magnitudes—6. Interpolation Reseaux—7. Scale Factors 8. Star Names—9. Acknowledgments—10. Bibliography—Table 1—Table 2—Table 3—Figure 1—Figure 2a—Figure 2b. 504 ##$a Includes index
	ISBD	.-Contents: Foreword, Joseph Ashbrook.—1. General—2. Sources Other than the SAO Star Catalog—3. Projection System—4. Indices—5. Magnitudes—6. Interpolation Reseaux—7. Scale Factors 8. Star Names—9. Acknowledgments—10. Bibliography—Table 1—Table 2—Table 3—Figure 1—Figure 2a—Figure 2b.
	RDA	Include table of contents.
Related document	Example	A star catalogue titled "Allgemeine beschreibung und nachwersung der gestinne nebst verzeichniss" by J. E. Bode, published in 1801, shows on the title page a related document: "Uranographie" (Bode's star atlas).
	MARC 21	5100 #$a Uranographie
	ISBD	.- Related document: Uranographie (Bode's star atlas).
	RDA	Related document: Uranographie (Bode's star atlas).
Names of the astronomical parameters included in the main table	Example	Main table from a star catalogue titled "A catalogue of 3007 stars, for the equinox 1890.0, from observations made at the Royal Observatory, Cape of Good Hope during the years 1885 to 1895" by D. Gill, D., published in 1898.
	MARC 21	500 ##$a The columns represent: the rotation number (col. 1), Bradley or Lacaille (col. 2), Piazzi. 1800 (col. 3), B.A.C. 1850 (col. 4), C.G.A. 1875 (col. 5), star name (col. 6), magnitude (col. 7), mean date 1800+ (col. 8), number of observations in Right Ascension (col. 9), mean R.A. 1890.0 (col. 10), annual precession 1890.0 (col. 11), secular variation 1890.0 (col. 12), annual proper motion $\mu\alpha$. (col. 13); and corrections for $\mu\alpha$ to 1890.0 (col. 14).
	ISBD	.- The columns represent: the rotation number (col. 1), Bradley or Lacaille (col. 2), Piazzi. 1800 (col. 3), B.A.C. 1850 (col. 4), C.G.A. 1875 (col. 5), star name (col. 6), magnitude (col. 7), mean date 1800+ (col. 8), number of observations in Right Ascension (col. 9), mean R.A. 1890.0 (col. 10), annual precession 1890.0 (col. 11), secular variation 1890.0 (col. 12), annual proper motion $\mu\alpha$. (col. 13); and corrections for $\mu\alpha$ to 1890.0 (col. 14).
	RDA	The columns represent: the rotation number (col. 1), Bradley or Lacaille (col. 2), Piazzi. 1800 (col. 3), B.A.C. 1850 (col. 4), C.G.A. 1875 (col. 5), star name (col. 6), magnitude (col. 7), mean date 1800+ (col. 8), number of observations in Right Ascension (col. 9), mean R.A. 1890.0 (col. 10), annual precession 1890.0 (col. 11), secular variation 1890.0 (col. 12), annual proper motion $\mu\alpha$. (col. 13); and corrections for $\mu\alpha$ to 1890.0 (col. 14).
Captions of other tables giving extra-information about corrections, instruments, etc.	Example	A star catalogue "Catalogue of double stars from observations made at the Royal Observatory, Greenwich with the 28-inch refractor during the years 1893–1919" by F. W. Dyson, published 1921, which shows several tables that give extra information.
	MARC 21	500 ##$a Hypothetical Parallaxes of Double Stars. (Stars whose Orbits have been completely determined)
	ISBD	.- Hypothetical Parallaxes of Double Stars. (Stars whose Orbits have been completely determined)
	RDA	Hypothetical Parallaxes of Double Stars. (Stars whose Orbits have been completely determined)

fields, and that is not the best solution but currently the only option.

Conclusion

Despite the general nature of MARC 21, ISBD, and RDA, we can conclude that the new proposal for description parameters may be accommodated within their fields and elements with some limitations. Nevertheless, catalogers who wish to enrich the content of bibliographic descriptions of their historical astronomical resources can do so by following the guidelines discussed in this paper. It is also important to state that, since some parameters can be included only in note fields, and these may not be indexed by libraries' and archives' information retrieval systems, it would be necessary to create new descriptive fields or subfields to achieve optimal information retrieval. With respect to the remaining parameters, their suggested inclusion in existing fields would require updating and modification in some cases to include essential information for astronomers and astrophysicists.

Table 7. Example of a Complete MARC 21 Record of Gill's Celestial Catalog (1898) Following the Given Proposal

000	01389cam a220025314500	
001	4525150	
005	20040506101643.0	
008	870305s1898 enka f0000 eng	
034	0#	$pEq. 1890•0
035	__	ǀ9 (DLC)01005452
906	__	ǀa 7 ǀb cbc ǀc orignew ǀd u ǀe ocip ǀf 19 ǀg y-gencatlg
010	__	ǀa 01005452
040	__	ǀa DLC/ICU ǀc ICU ǀd DLC
050	00	ǀa QB6 ǀb .C21890
051	__	ǀa QB6 ǀb .C21890 Copy 2 ǀc Copy 2.
110	2_	ǀa Royal Observatory, Cape of Good Hope.
245	12	ǀa A catalogue of 3007 stars, for the equinox 1890·0, ǀb from observations made at the Royal observatory, Cape of Good Hope, during the years 1885 to 1895: ǀc under the direction of David Gill . . . With appendices:—I.—Comparison with other catalogues. II.—Meridian observations of [alpha] Canis majoris, [alpha] Canis minoris, [beta] Centauri, [alpha] ¹ & [alpha] ² Centauri. III.—Positions of southern circumpolar stars. Published by order of the lords commissioners of the Admiralty, in obedience to Her Majesty's command.
255	##	$eEq. 1890•0
260	__	ǀa London, ǀb Printed for H.M. Stationery off., by Darling & son, ltd., ǀc 1898.
300	__	ǀa xliv, 263 p. ǀb tables. ǀc 33 x 26 cm.
500	__	ǀa Binder's lettering: Cape catalogue 1885–1895.
500	##	$aRange of magnitudes: from 0 to 9.
500	##	$aType of magnitude: apparent.
500	##	$aSentences on magnitude: For Stars North of Declination—30º the magnitudes (unmarked) are taken from the Harvard Photometry, and South of that Declination from the Southern Meridian Photometry. Magnitudes marked ° are taken form the C.G.A. or C.Z., those marked † from B.D., and those marked ǂ from other authorities which are quoted in the notes at the foot of the right-hand page. Where doubt exists whether the "mass" or a component of a Double Star was observed, an asterisk is inserted of the magnitude. The particulars respecting Variable Stars are from Chandler's Catalogue (Astron. Journal, No. 379), unless otherwise stated.
500	##	$aInstruments: Cape Transit-Circle
500	##	$aAstronomical naming convention: For Stars contained in Auwers' Bradley the nomenclature of that work has been retained, only substituting Argûs or Puppis for Navis. For Stars not in Auwers' Bradley the nomenclature of the Fundamental lists (Ast. Nach. 2890 and Monthly Notices R.A.S., Vol. XLVII., p. 455) was adopted. For all other Stars between the South Pole and Declination—23º, the nomenclature of the Argentine General Catalogue was employed, and for Stars North of Declination—23º that of the British Association Catalogue. The only exceptions to these rules are a very few close Circumpolar Stars which are designated by letters long in use at the Cape.
500	##	$aWavelength: visible spectrum
500	##	$aInteresting objects: 7m•0,11m •53"•044º 1891•70 Brighter star observed.
500	##	$aThe columns of the main table of the catalogue: the rotation number (col. 1), Bradley or Lacaille (col. 2), Piazzi. 1800 (col. 3), B.A.C. 1850 (col. 4), C.G.A. 1875 (col. 5), star name (col. 6), magnitude (col. 7), mean date 1800+ (col. 8), number of observations in Right Ascension (col. 9), mean R.A. 1890.0 (col. 10), annual precession 1890.0 (col. 11), secular variation 1890.0 (col. 12), annual proper motion μα. (col. 13); corrections for μα to 1890.0 (col. 14); the rotation number (col. 15); mean date of observation in declination (col. 16); number of observations in declination (col. 17); mean declination 1890.0 (col. 18); seconds of final declination (col. 19); annual precession 1890.0 (col. 20); secular variation 1890.0 (col. 21); annual proper motion (col. 22); corrections of proper motion to the declination (col. 23); Fallows and Henderson (col. 24); Johnson (col. 25); Cape Catalogues 1840,1850,1860,1880,1885 (col. 26); and Melbourne, 1870 and 1880 (col. 27).
500	##	$aCaptions of other tables: Table I. Right Ascensions of the Clock-Stars; Table II. Observations of Circumpolar Stars for Latitude; Table III. Corrections to N.P.D. for variation of latitude, 1885–1895 (Communicated by Dr. Albrecht); Table IV. Corrections to the colums «Mean Dec. 1890•0», on account of error of latitude and refraction; Table V. Comparison of direct and reflex observations.
500	##	$aRange of coordinates not given
500	##	$aType of coordinates: Right ascension and Declination (equatorial coordinates).

Table 7. Example of a Complete MARC 21 Record of Gill's Celestial Catalog (1898) Following the Given Proposal (cont.)

505	0#	$aIndex: Errata—General Plan of Catalogue—Explanations of the Separate Columns of the Printed Catalogue—RIGHT ASCENSIONS—Fundamental Clock-Stars—Formation of the Right Ascensions—Personal Equation—Use of the Reversing Prism—Relative Weights of Upper and Lower Transits—DECLINATIONS—Division-Errors—Error of the micrometer-Screws—Basis of the Annual Catalogues—Horizontal Flexure—Discussion of the Latitude from observations of Circumpolar Stars—Discussion of the Latitude without corrections for errors of Bessel's Refractions or Variation of Latitude—Discussion of the Latitude with corrections to Bessel's Refractions and daily corrections for change of Latitude—Formation of the Definitive Declinations—Comparison of Direct and Reflex observations—COMPARISON WITH OTHER CATALOGUES—Catalogues used—Mean results in order of Right Ascension—Mean Results in order of Declination—Systematic Corrections—Magnitude-personality—Observers, &c.—Catalogue of 3007 stars—APPENDIX I.—Comparison with other catalogues—APPENDIX II.—Meridian Observations of α Canis Majoris, α Canis Minoris, β, α1 and α2 Centauri—APPENDIX III.—Mean R.A. and Dec. of 24 Southern Circumpolar Stars—Introduction—Observations reduced to 1900•0—Mean Places 1875–1920.
510	1#	$aGreenwich Five-Year Catalogue, 1890: Auwers' Fundamental Catalogue (B.J.)$c Appendix I
510	1#	$aCape Catalogue of 12,441 Stars for 1880•0$c Appendix I
510	1#	$aMelbourne Catalogue of 1,211 Stars for 1880•0$c Appendix I
510	1#	$aGreenwich Catalogue of 4,059 Stars for 1880•0$c Appendix I
510	1#	$aCape Catalogue of 1,713 Stars for 1885•0$c Appendix I
510	1#	$aRadcliffe Catalogue of 6,424 Stars for 1890•0$c Appendix I
518	##	$pObservation Place: Royal Observatory, Cape of Good Hope.
518	##	$dObservation Period: 1885 to 1895.
650	_0	ǀa Stars ǀx Catalogs.
651	#4	$aCelestial hemisphere: Southern
700	1_	ǀa Gill, David, ǀc Sir, ǀd 1843–1914.
710	1_	ǀa Great Britain. ǀb Admiralty.
991	__	ǀb c-GenColl ǀh QB6 ǀi .C21890 ǀt Copy 1 ǀw BOOKS
991	__	ǀb c-GenColl ǀh QB6 ǀi .C21890 ǀt Copy 2 ǀw BOOKS

Table 8. Recommendations to Standards Developers Regarding the Proposed Addition of Elements to Accommodate Attributes of Celestial Cartography Material

Parameters	Standards	Recommendations
Coordinates / Type of coordinates	MARC 21	—Create a new subfield entitled Statement of type of coordinates in 255. —Make clearer that $d—Statement of zone (Used for celestial charts) is used to register the classical celestial equatorial coordinates (Right Ascension and Declination).
	ISBD	Include this element in section 3.1.3.
	RDA	Include this element in a new section 7.4.5.
Projection	MARC 21	-
	ISBD	-
	RDA	-
Scale	MARC 21	Provide catalogers with some technical instruction and some examples about the inclusion of this datum in 034 according to ISBD principles.
	ISBD	-
	RDA	Provide catalogers with some technical instruction about the inclusion of this datum in element 7.25.1.5.
Perspective	MARC 21	Create a new subfield entitled Perspective in 034 and 255.
	ISBD	Include a sentence and some examples in section 3.1.2.2
	RDA	Include a sentence and some examples in section 7.26.

Table 8. Recommendations to Standards Developers Regarding the Proposed Addition of Elements to Accommodate Attributes of Celestial Cartography Material (cont.)

Parameters	Standards	Recommendations
Equinox / Epoch	MARC 21	Use separate subfields for Epoch and Equinox in 034 and 255. For instance, create a new subfield entitled Epoch and maintain $p—Equinox in 034. Create a new subfield entitled Epoch and maintain $e—Statement of equinox in 255.
	ISBD	—Use also separate elements for Epoch and Equinox. For instance, create an element 3.1.3.5 for Epoch. —Indicate that these dates might not be only an integer number, but may include a decimal.
	RDA	Although an example is provided for the Epoch, indicate also that these dates might not be only an integer number, but may include a decimal.
Magnitude and Type of magnitude	MARC 21	Include this parameter as a new subfield in 034 and 255 together with a definition and some examples. The brightest and faintest magnitude of the objects of a resource must be given.
	ISBD	This parameter is already considered, but need to be defined. The concept "limiting magnitude" is set to be 22 and currently must be set to be 30.
	RDA	Idem as with ISBD.
Celestial Hemisphere	MARC 21	Include a sentence indicating the celestial hemisphere and some examples in 662—Subject Added Entry-Hierarchical Place Name (R) ; $a—Country or larger entity (R).
	ISBD	Idem in section 3.1.3.
	RDA	Idem in section 7.3 or 7.4.4.
Observation period	MARC 21	Include a sentence indicating the observation period and some examples in: 033—Date/Time and Place of an Event (R) $a—Formatted date/time 518—Date/Time and Place of an Event Note (R) $d—Date of event
	ISBD	Idem in section 7.4.1.
	RDA	Idem in section 7.11.3.
Observation place	MARC 21	Include a sentence indicating the observation period and some examples in: 033—Date/Time and Place of an Event (R) $p—Place of event 518—Date/Time and Place of an Event Note (R) $p—Place of event
	ISBD	Idem in section 7.4.1.
	RDA	Idem in section 7.11.2.
Constellation name	MARC 21	Include a sentence to add this information and some examples in 662—Subject Added Entry-Hierarchical Place Name (R), $h—Extraterrestrial area.
	ISBD	Idem in section 7.10.
	RDA	Idem in section 7.27
Observation and measurement instruments	MARC 21	Include a sentence and some examples in 500
	ISBD	Idem in section 7.10.
	RDA	Idem in section 7.27.
Astronomical naming convention	MARC 21	Include a sentence and some examples in 500.
	ISBD	Idem in section 7.10.
	RDA	Idem in section 7.27.
Wavelength	MARC 21	Include it in 255—Cartographic Mathematical Data
	ISBD	Include it in 3.1.3 or in 7.3.
	RDA	Include it in section 7.

Table 8. Recommendations to Standards Developers Regarding the Proposed Addition of Elements to Accommodate Attributes of Celestial Cartography Material (cont.)

Parameters	Standards	Recommendations
Celestial objects of special interest	MARC 21	Include this information in 500.
	ISBD	Idem in section 7.10.
	RDA	Idem in section 7.27.
Constellation Images	MARC 21	Include a sentence and some examples in 5XX.
	ISBD	Idem in section 7.5.1.
	RDA	Idem in section 7.27.
Table of Contents	MARC 21	-
	ISBD	-
	RDA	-
Related document	MARC 21	Include some sentence indicating that related documents for the case of celestial cartographic resources are also given when available in 510.
	ISBD	Idem in section 7.2.4.6.
	RDA	Idem in section 7.16
Name of the astronomical parameters included in the main table	MARC 21	Include this information in the subfield $g—Miscellaneous information of 505—Formatted Contents Note.
	ISBD	Idem in section 7.10.
	RDA	Idem in section 7.16.
Captions of other tables giving extra-information	MARC 21	Include this information in the subfield $g—Miscellaneous information of 505—Formatted Contents Note.
	ISBD	Idem in section 7.7.3.
	RDA	Idem in section 7.16.

To ease the work of catalogers, we provide in table 8 a list of proposed fields/subfields/elements and some recommendations to standards developers regarding the addition of subfields to existing fields and elements to accommodate the attributes of celestial cartographic materials. A dash in this table means that a recommendation is not necessary. Note that, in particular, fourteen new parameters are considered: type of coordinates, perspective, type of magnitude, celestial hemisphere, observation period, observation place, constellation names, observation and measurement instruments, astronomical naming convention, wavelength, celestial objects of special interest, constellation images, name of the astronomical parameters included in the main table of a star catalog and captions of other tables giving extra information of the star catalog.

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