# A new proposal to improve the description of astronomical resources

## The case of historical star catalogues

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### Abstract

**Purpose** – The purpose of this paper is to show that some important astronomical information is still not taken into account in the documental description of historical star catalogues.

**Design/methodology/approach** – A sample of 28 historical star catalogues (eighteenth, nineteenth and twentieth centuries) from the Royal Institute and Observatory of the Spanish Navy was selected in order to analyse their structure and to identify information patterns.

**Findings** – The analysis shows that there are a number of technical parameters which are not present in the cataloguing standards and which should be taken into account in the bibliographic descriptions of these specialised documents since they are of great interest to astronomers and astrophysicists. On the other hand, star catalogues provide some cartographic information which can be described by these standards but whose corresponding fields are not widely used by cataloguers.

**Originality/value** – A proposal of new technical parameters is given in order to try to improve the bibliographic records of these astronomical resources. Some directions are also given in order to identify the sections of the catalogues where these parameters may be found, making the task of locating them easier.


**Keywords** Astronomical information retrieval, Cartographic resources, Cataloguing quality, Cataloguing standards, Royal institute and observatory of the spanish navy, Star catalogues

**Paper type** Research paper

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## Introduction

Analysis of available data are a powerful tool to obtain information to allow predictions about future events in certain areas and to make new discoveries in others. In particular, most of the main advances in astronomy have been possible due to the use of historical data and the efforts to preserve them by astronomers (Griffin, 2001; López, 2013). One of the last examples was the discovery of the 14th Neptune moon thanks to the analysis of "more than 150 archival Neptune photographs taken by Hubble from 2004 to 2009" (NASA Headquarters, 2013).

From a documentary point of view, the results of astronomical observations have been presented throughout history in different formats, including handwritten records, charts and astrophotographic images, etc. These results have also been stored in different ways, books being the main format for the historical star catalogues (Covington, 2006).

### *Definition of a star catalogue*

Different definitions have been given in the literature for a star catalogue. A first definition can be found in the specialised dictionary of the Real Academia de Ciencias Exactas, Físicas y Naturales (1990, p. 123) where "star catalogue" is defined as a list of stars with their coordinates, apparent magnitudes, spectral types, proper motions and radial velocities. These data refer to a specific instant of time known as the epoch of the catalogue which is often the beginning of a Besselian year. The catalogue can also refer to a specific type of star (doubles, variables, etc.). In turn, a similar definition can be found in Enciclopaedia Britannica (2013) which defines star catalogue as: "list of stars, usually according to position and magnitude (brightness) and, in some cases, other properties (e.g. spectral type) as well".

Finally, a more documentary definition was given by Evans (2010) who stated that "the star catalogue, as a genre, is the formal presentation of the results of observations of celestial objects published in book form, as distinguished from specifically mathematical treatises on celestial movement, from star tables used for chronological or astrological purposes, or from observing reports written in a narrative style".

### *Importance of star catalogues throughout history*

From the earliest stages of civilisation, human beings have felt it necessary to record the positions of celestial objects and this practice is currently known as "astrometry" which is defined as "the branch of astronomy concerned with the accurate measurement of the positions and motions of celestial objects" (Perryman, 2012).

According to López (2013), the history of astrometric catalogues can be divided into three different periods: "visual (with or without instrument), photographic and charge-coupled device (CCD) (earth- or space-based instruments)". As their names suggest, the determination of every period is directly related to the available technology, both to carry out the observations and to record them. From the very beginning, the human naked eye became the first detector because of the absence of technical devices to observe the night sky. At that time, the documentation of the positions and brightness of the stars had to be performed by hand. However, this rudimentary procedure did not prevent the discovery of previously unknown movements of the Earth when sets of data from different catalogues and centuries were compared (Perryman, 2012).

Over time, and due to the birth of new and more modern observation and registration instruments (telescope, CCD cameras, etc.) (Stephenson *et al.*, 2000; Kanas, 2009; Bennett, 1992; Brooks, 1991), the first and basic handwritten records gave way to the publication of voluminous books containing astrometric information of thousands of stars. López (2013) refers to these catalogues as “astrometric catalogs” since these books may provide information about different kind of celestial objects (asteroids, comets, galaxies, etc.) and not only stars. Therefore, a star catalogue is a type of astrometric catalogue but not all the latter are necessarily star catalogues. Irrespective, the comparative analysis of new and old data have always been a source of new findings. For instance, E. Halley discovered the now well-known “proper motion” of the stars (Perryman, 2009) when he compared their positions in contemporary observations (eighteenth century) with those that the Greek Hipparchus and others had made in second century AD.

Later, with the advent of the internet, modern computers and new high-quality Earth- and space-based instruments, astrometric information began to be stored in databases (see for instance CDS, 2014) and, therefore, books were no longer used for this purpose. For example, the data obtained from the Hipparcos satellite launched in 1989 were stored electronically and are the most comprehensive and accurate ever achieved and therefore help us to plan successful new space missions, amongst other uses (Perryman, 2009; ESA, 2007).

A new space mission, named “GAIA”, which will succeed Hipparcos, is already planned, and its satellite was launched in late 2013. This will generate 50GB of data per day during its five-year mission (ESA, 2013) and a comprehensive catalogue of this project, containing thousands of millions of stars, will probably be published in 2021.

Thus, as commented above, the importance of these historical catalogues lies in the scientific information they provide and this is extremely helpful for both astronomers and astrophysicists in their daily work. Indeed, as we will see in Section 3, the main tables of star catalogues “played a fundamental role in the transmission of scientific knowledge” (Chabás, 2012). Indeed, some precision studies of data from historical star catalogues have been published in the last few years (Verbunt and Van Gent, 2010a, b, 2012).

### *The need for specialised descriptions*

In the Library and Information Science literature, there is little information on cataloguing and classification in relation to special libraries (Gardner, 2012) including astronomical. Thus, authors such as Griffin (2001) suggest that the information existing in astronomical collections from libraries and archives should be “converted into science”. This idea can also be found in Escolano Rodríguez (2011), indicating that, currently, the interest of cataloguing is no longer the “document” but the “data”. According to her, cataloguing has two goals: to identify and access the document (which has always been the main objective of cataloguing); and to navigate between closely related information. Our work is directed towards a third target which we can call specialised descriptions. It involves improving the quality of bibliographic records so that users can find the desired information in a more efficient way. In our opinion, the cataloguing of astronomical resources should be updated in two senses: first, it should be adjusted to the technological environment in which we live to properly manage and exchange existing information; second, it should be adapted to the specialised society in which we live.

The first has generated great interest over the last few years but the second, very little. On the one hand, some bibliographic agencies involved in the creation of cataloguing standards have brought together several specialised standards about different resources into a single code, as is the case of the ISBD. On the other hand, different agencies have also used a single code to describe the bibliographic universe (the case of RDA) (Picco and Ortiz Repiso, 2012). The development of the second idea is more difficult to achieve since it requires first, to identify the typologies of existing specialised documents and, later, to study them in order to find the desirable minimum fields which allow us to describe them. This obviously involves a greater research effort to improve bibliographic records.

These considerations are related to the quality of library cataloguing, which has been discussed in the literature for the last four decades. In our opinion, what is clear is that a lack of quality in bibliographic descriptions results in poor information retrieval. An example of this is the adoption of minimal level cataloguing (MLC) in 1979. Indeed, the information excluded from MLC records hindered access to them and the missing information was eventually added by some cataloguers (see Schultz-Jones *et al.*, 2012 and references therein). Therefore, as it is pointed out by Grothkopf (2012), "the idea of making information resources easily accessible has traditionally been more important for us than the application of strict library rules".

Since the information available in a typical OPAC record is usually limited (Large and Beheshti, 1997), quality may sometimes imply quantity as far as the number of description fields concerns but it may also mean the use of existing fields which are seldom used. According to Heck (2002), "as of today, sorting out good-quality and validated information, as well as the detailed maintenance of information resources, cannot be secured automatically. The work must be done 'by hand' and must be carried out by knowledgeable scientists or documentalists. Searching, critically analyzing, authentifying and validating information is a painstaking and meticulous job that should not be underestimated".

In short, the key to good information retrieval lies in the capability of describing the object content as reliably as possible. Hence we need specialised, specific or technical metadata of the branch we are dealing with. In this paper we will show how the description of a star catalogue as a monograph may not be enough to satisfy the needs of astronomers. To this end, recording some technical data provided by the catalogues will be paramount.

### *Stars catalogues' collection from Royal Institute and Observatory of the Spanish Navy*

The Royal Institute and Observatory of the Spanish Navy (ROA in what follows) is a scientific institution of the Spanish Navy concerned with the study of Astronomy and Geoscience since its foundation in the mid eighteenth century. It was founded as a research centre in Cádiz in 1753 where, from the very beginning, the interaction between education, practice and research was one of its main objectives. This rapidly contributed to the increasing importance of its library which was considered a tool as useful as any other scientific instrument.

During the last third of the eighteenth and nineteenth centuries, contacts with European astronomers and scientists as well as the exchange of publications with other scientific institutions resulted in a significant growth of the library of the observatory. Remarkably, many contemporary scientific publications were collected during the nineteenth century and most of them belonged to collections of periodical publications such as the Mémoires […] Royal Academy of Sciences of Paris, the Astronomical observations […] of the Royal Observatory of Greenwich and the annual volumes of astronomical ephemerides published in Great Britain and France (The nautical almanac, Connaissance des temps). Works of the most prominent contemporary scientists were also gathered, namely: Newton, Boyle, Hooke, Riccioli, Galileo, Huygens, Fermat, Bernouilli. Also noteworthy are the results of research projects undertaken by other European astronomical observatories which ranged from astronomical observations to the development of star catalogues created by their astronomers.

The Library of the ROA currently possesses more than 1,300 old scientific works before 1801, four of them incunabula. These features make it one of the most important Spanish libraries with more than 30,000 volumes related to Astrometry, Celestial Mechanics, Geodesy, Geophysics and time and frequency Metrology. The library was built in the Defense Library Network, where all library centres of the Spanish Ministry of Defense were merged in order to preserve and disseminate the bibliographic heritage as well as improving and increasing the quality of the library services (Government of Spain, 2011).

A large collection of star catalogues can also be found in the ROA library. In particular, a representative sample of them published during the last three centuries has been selected to carry out our work. The older ones by Flamsteed (1725), Wollaston (1789), Herschel (1798), or Bode (1801) marked the beginning of modern Astrometry, whose influence extended to the nineteenth century, as can be seen in the catalogues by Airy (1838) or The Royal Greenwich Observatory (1843). The first star catalogues compiled by southern observatories appeared soon after (see Stone (1881) or Gill (1898)). Moreover, the first astrophotographic catalogues were compiled in early 1900s. Among them, we highlight those belonging to the international astronomical project *Carte du Ciel*: Oxford (1906), San Fernando (1921), Hydebarad (1946), Royal Edinburgh Observatory (1949). Finally, our sample includes a number of more specialised catalogues that were created and published during the second half of the twentieth century.

## Objectives and methodology

The analysis of these resources has two main goals. First, to search for new description fields for star catalogues and, second, to show the importance of certain fields of the cataloguing rules which are currently not being widely used in bibliographic descriptions. The first objective arises from the existence of parameters of great interest in astronomy and astrophysics which are not considered in the cataloguing standards and are likely to become future description fields for star catalogues (Alonso-Lifante and Chaín-Navarro, 2013). The second aim is proposed because of the evidence that some fields considered in the description standards are not being frequently used although the corresponding information may be easily found in the documents. This work also gives an idea of the progress of the information provided by historical star catalogues during the last 300 years.

Two different terms have been used in the previous paragraph to avoid confusion. The term "parameter" will be used in general in order to make reference to those features or measurable factors which we proposed to be incorporated into the bibliographic records, while the term "field" will be reserved for those elements which are already contained in the cataloguing standards. Since a number of these parameters have still not been considered as fields by these standards, this discrimination will allow us to hightlight the existence of an astronomical term (parameter) that does not always correspond to a documental term (field).

To achieve this, we analyzed a sample of star catalogues of the eighteenth, nineteenth and twentieeth centuries from the ROA. This consisted of identifying information patterns in the organisation of the catalogues with the aim of finding the most frequently supplied scientific data. The Union Catalogue of Defense Library Network (commonly known as Bibliodef) (Government of Spain, 2011) was consulted in order to obtain as many catalogues as possible. We prepared a priori the following list of terms through which the searches were made in the OPAC: catalogue, stellar catalogue, star catalogue and astrophotographic catalogue. Some initial searches based on these exact terms allowed us to identify the subjects assigned to the retrieved records. These were mainly two: "stellar catalogue", which led us to a small set of records, and "catalogues, stars, astronomy" which allowed us to retrieve a large number of records.

Once these searches were performed, three lists of records were made, each one containing catalogues from eighteenth, nineteenth, and twentieth century respectively. Catalogues concerning comets, asteroids, galaxies, etc. were excluded, hence a sample of 28 star catalogues (see references section) covering, as reliably as possible, the aforementioned historical periods were considered (Table I). However, all decades could not be covered due to the lack of documents in the archive.

After selecting the sample, a preliminary study of the contents of those catalogues was carried out. Specifically, we accomplished a first survey by considering only the information provided by the "main tables" (see Section 3.2) of data of the catalogues. This analysis consisted of identifying the names of the columns at the top of these tables. Thus, some parameters were found and, later, a catalogue-by-catalogue revision was performed in order to identify the frequency of occurrence of each parameter in the whole sample. The remaining sections of the catalogues (title page, index, introduction, other type of tables, etc.) were studied by following this stepwise procedure.

## Structure and general arrangement of the historical star catalogues

In general, the star catalogues included in our sample are formed by the following parts: Title page, Index, Errata, Preface, Introduction, the star catalogue itself, other sections dedicated, for instance, to the comparison of data with other previous catalogues, appendix, etc. However, as Evans (2010) states, "many individual star catalogues do not represent the same information in the same way". Indeed, both the arrangement of these parts and the contents changed depending on the century (Table II).

In particular, note that in our sample there is usually a dedication (usually addressed to the contemporary kings) immediately after the title page in the catalogues from eighteenth century (Flamsteed, 1725; Wollaston, 1789). In general, there is no section explicitly entitled "Introduction" in this century but rather some short sections such as "Ad lectorem and/or Preface" which provide a context for the work, including a brief biographic note of the author (Flamsteed, 1725). The first introductions appeared in the late eighteenth century with names as "introductory remarks". Moreover, these catalogues used to show observations or comments about previous catalogues before introducing the catalogue itself and they also used to add errata at the end of the work.

An index or table of contents started to be included at the beginning of the catalogues (just after the title page) in the nineteenth century (Baily, 1845; Yarnall and Frisby, 1889; Gill, 1898). Note that this is very important from a cataloguing point of view since the index is an essential tool to know the content of the catalogue, thus providing cataloguers with the possibility of writing better descriptions. Another important feature in this century was the development of the introductions together with explicit explanations of the data collected in the main tables of the catalogue. It is very important to note that

**Table I.** Number of catalogues selected according to the period

| Century | Documents selected | Decades analyzed |
|---|---|---|
| Eighteenth | 3 | 20, 80 and 90 |
| Nineteenth | 10 | 10, 20, 30, 40, 80 and 90 |
| Twentieth | 15 | 10, 20, 30, 40, 50, 60, 70 and 80 |
| Total | 28 | |

| Eighteenth century | Nineteenth century | Twentieth century |
|---|---|---|
| Title page | Title page | Title page |
| Dedication | Index/table of contents | Index/table of contents |
| Preface | Errata | Introduction |
| Notes about previous catalogs | Preface | On instruments (construction, adjustments, etc.) |
| Catalogue | Introduction | Measurement of photographs |
| Errata | On instruments | Determination of photographic magnitudes |
| | References to other catalogues | Determination of standard coordinates |
| | On the reductions and corrections of the coordinates | On errors of astrometric observations |
| | Proper motions, precessions and secular variations | Comparison with other catalogues |
| | Explanation of the separate columns of the Catalogue | Etc. |
| | Etc. | Tables related to corrections and reductions |
| | Catalogue | Explanation of the separate columns of the Catalogue |
| | Appendix | Catalogue |
| | | Notes |
| | | Appendix |
| | | Errata |

**Table II.** General structure of the star catalogues according to the century

the columns of these tables are actually the metadata by which the authors decide to catalog each star.

Although other sections on the methodology in the observations, instruments, coordinate corrections, etc., were already developed in the nineteenth century, these subjects were studied in greater depth in the introductions of the catalogues of the twentieth century, giving additional and better organised information.

*The title page*

Like in the majority of documents, title pages are an essential part of the star catalogues since they provide basic information about the content of each catalogue. This may be classified into two groups: common and technical information. We refer to common as those data that can be found in any document, such as the title, author, publication year or printing data, among others. However, since these data are already present in the cataloguing rules, in this paper we will focus on technical information which are the specific data found in a star catalogue.

Table III shows a selection of the most important technical information to be recorded from a star catalogue together with its frequency distribution, that is, how many times these parameters appear in the title page of each document. Note that parameters such as coordinates or epoch/equinox are already part of the cataloguing rules but they belong to the section of mathematical data of cartographic resources. The ISBD consolidated edition states that "to describe a resource that exhibits characteristics of different types of materials (e.g. an electronic continuing resource, a digital map that is serially issued), a cataloguer should combine stipulations for the different types of materials that are necessary to describe all aspects of the resource, including its content, its carrier and its mode of issuance" (ISBD, 2011). However, other parameters are often shown in the title pages of the star catalogues which are not considered by these standards, namely: observation place, observation instrument, observation period and related documents or catalogues. It is important to state that, although the frequency of occurrence of some of these parameters is rather low in the title pages, their importance for both astronomers and astrophysicists deserves consideration.

Concerning these technical parameters, the observation place (generally an astronomical observatory) is important since it accounts for the hemisphere where the observations took place and the place where measurements were carried out. The importance of knowing the observation place lies in the fact that astronomers may easily identify which stars are contained in the catalogue and which are not.

From the most technical point of view, the type of instrument used to make the observations and measurements is a key parameter which allows scientists not only to know the extent of the observations but also to determine the accuracy of the data provided by the star catalogue. In this sense, the observation period also gives the astronomers the necessary information to know the positions of the stars at that time.

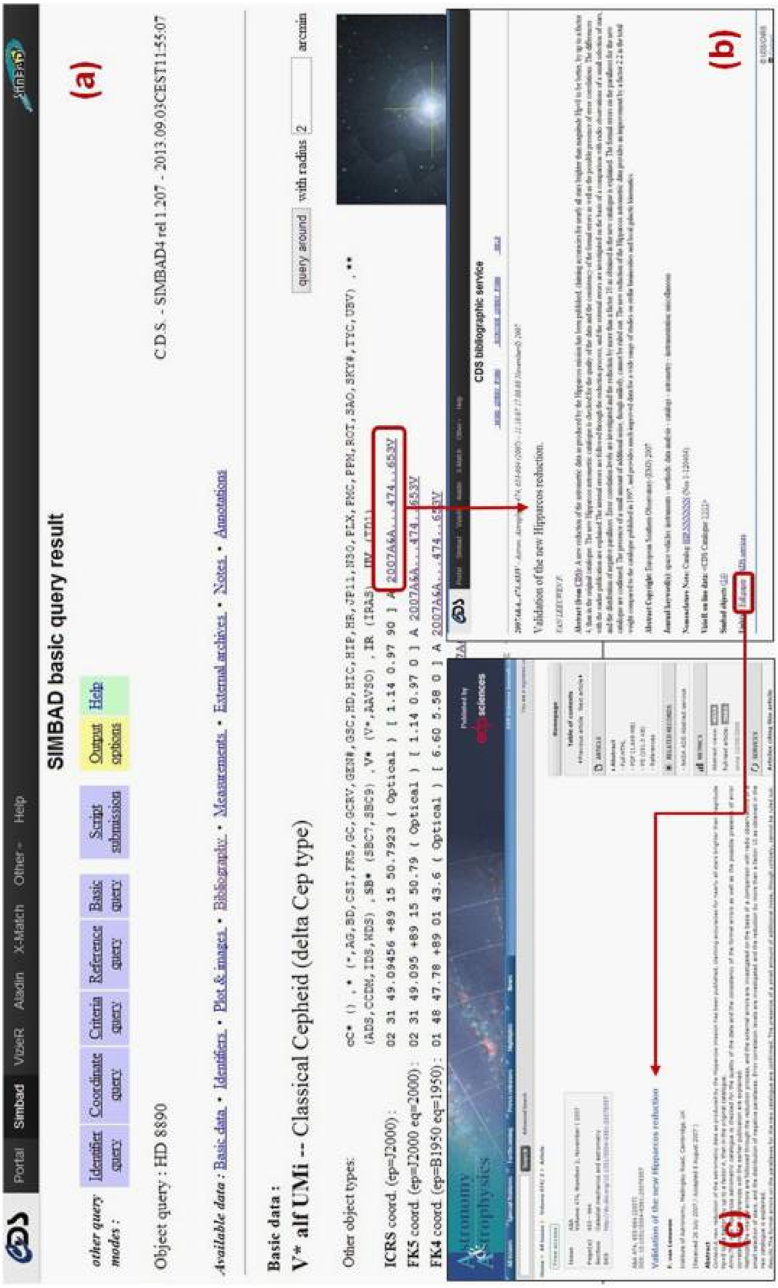
Another type of information that seldom appears in the title pages (its occurrence is higher in the introductions) but whose importance has been increasing in the last few decades is what we have called "related document or catalogue". In general, there are two types of document closely related to the star catalogues. On the one hand, it is well known that some star catalogues have been compiled from the observations coming from other catalogues (Airy, 1838; Smart, 1928; Pourteau, 1933) but, on the other hand, a number of scientific papers have also been published during the course of some catalogues (Turner, 1906; Dyson, 1921; Jackson, 1953; Jackson and Stoy, 1955). These papers used to contain some information about certain observations which were not published in the catalogue itself, among other knowledge. Furthermore, new articles, measuring the accuracy of old star catalogues, have been published in order to ensure the reliability of the data of such catalogues when comparing the information with that provided by the modern catalogues from new space missions. In our opinion, the existence of such documents should be written down in the records as proposed by the best known astronomical databases. These provide a link called "bibcode" which leads users to all scientific articles related to the information they are searching for (Figure 1) (for further details see also Schmitz *et al.*, 1995; Meakins and Grothkopf, 2012).

To illustrate the previous comments, Figure 2 shows an example of Gill's title page (Gill, 1898) where one can see the aforementioned two types of information: common (black colour) and technical (red colour). Figure 3 shows a bibliographic record where a great deal of the title page's information is collected in the field "Title" (245 MARC tag). In our opinion, even though the majority of information from

**Table III.** Technical information shown in the title pages of the star catalogues of the eighteenth, nineteenth and twentieth centuries

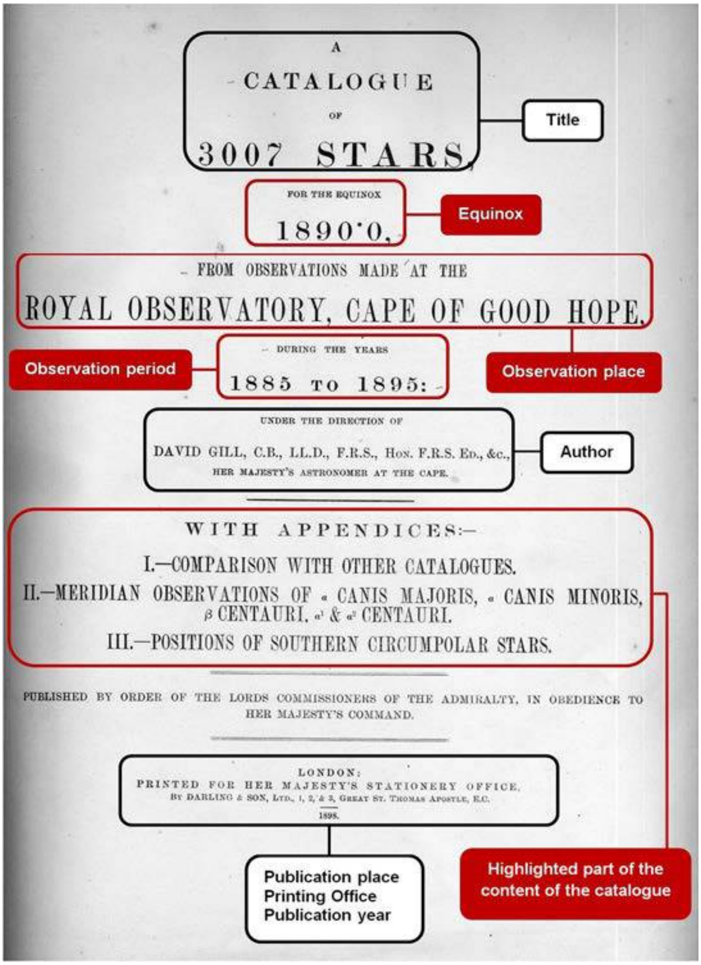
| Parameters | Frequency distribution | % with respect to total numbers of catalogues |
|---|---|---|
| Coordinates | 7/28 | 25 |
| Epoch/Equinox | 12/28 | 42.85 |
| Observation place | 15/28 | 53.57 |
| Observation and measurement instrument | 3/28 | 10.71 |
| Observation period | 10/28 | 35.71 |
| Related document or catalogue | 1/28 | 3.57 |

**Notes:** Coordinates and epoch/equinox are already recordable data by the cataloguing rules. Observation place is a parameter frequently provided (53.57 per cent of the catalogues analyzed)



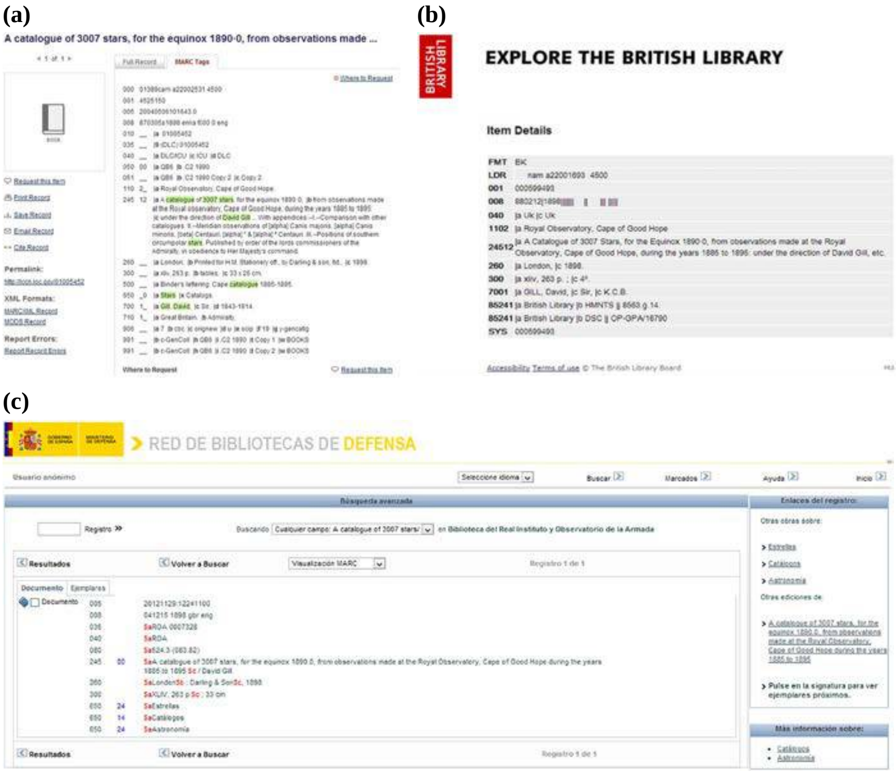

**Notes:** (a) Record of a star found in SIMBAD database where the bibcode is highlighted; (b) a snapshot where is shown a summary about the information of the reference to which the bibcode link leads, (c) web-site of the journal where the reference is found

**Figure 1.**
Example of how the Set of Identifications Measurements and Bibliography for Astronomical Data (SIMBAD) Bibliographic Reference Coding (Bibcode) works




**Notes**: Black boxes represent common information and the red technical information. The cataloguing standards allow us to record some parameters of the title page as a part of the field "title". For instance: the observation period could be recorded in $f or $g in the field 245 of MARC 21 or in the field 518 if this parameter is shown but not in the title page. Nevertheless, these fields are called: date/time and place of an event note (518 $a), inclusive dates (245 $f) and bulk dates (245 $g), which suggest that several types of dates could be included. The point is that none of these fields are explicitly denominated "observation period" hence this circumstance could prevent a specialized information retrieval performed by the parameter "observation period".
**Source**: Image kindly provided by ROA's staff (Gill, 1898)

**Figure 2.**
Common and technical information present in the title page of Gill's star catalog (Gill, 1898)




**Notes:** (a) Record made by the Library of Congress; (b) the same record as made by the British Library; (c) the same record as made by the ROA library. We may see how the cataloguers tend to combine both common and technical information in the field "title"

**Figure 3.** Three records of Gill's catalogue whose title page is shown in Figure 2

the title page can be recorded as part of the title, we feel that technical information should also be shown in specific fields which will allow users to filter the information in a more effective way. Unfortunately, this task has not yet been widely accomplished. In fact, catalogues from our sample showing the coordinates and/or the epoch in their title pages have been consulted in the OPAC of both the British Library and the Library of Congress. In the case of the former, this information has been recorded as a part of the title (245 MARC tag) but is not included in the field 255-Cartographic Mathematical Data. The case of the Library of Congress is similar but the recorded titles do not always show all data from the title page and therefore important information is sometimes missed since neither is it included in the field 255.

*The main table of a star catalogue*

The most important information offered by a star catalogue, even more than the data provided by the title page, is the information (metadata) supplied by its main tables, i.e., the catalogue itself, which should not be confused with other tables giving additional information about instruments, corrections, errors, etc. The information given in these main tables is usually numerical and it contains a number of columns, each one representing a parameter about a set of celestial objects which has been studied, stars in our case, whose names or astronomical denominations are found in the rows (Figure 4).

Due to the importance of the information provided by these tables, we think that recording the name of the metadata corresponding to each column is absolutely essential for good information retrieval. Fortunately, cataloguers count on some help when facing such a complex task. For example, in our analysis, more than 90 per cent of catalogues give explanations about the content of columns before showing the data itself (see Section 5).

The information provided by star catalogues has been evolving according to the technological improvements and general understanding of the universe. Therefore, tables of data have been adding new parameters throughout history complementing

(a)

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. $\mu_\alpha$. | Corr. for $\mu_\alpha$ 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 | ... | ... |

(b)

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. $\mu_\delta$. | Corr. for $\mu_\delta$ 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 |

**Notes:** (a) Piece of the table located on the left-hand page. The columns represent: the rotation number (col.1), information about four previous star catalogues (col. 2 to 5), star name (col. 6), magnitude (col. 7), mean date of observation in R.A. (col. 8), number of observations in right ascension –R.A.- (col. 9), mean R.A. 1890.0 (col. 10), annual precession 1890.0 (col. 11), secular variation 1890.0 (col. 12), annual proper motion (col. 13); and corrections of proper motion to the R.A. (col. 14), (b) piece of the table located on the right-hand page. The columns represent: 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), and information about other four catalogues (col. 24 to 27)

**Source:** Image kindly provided by ROA's staff

**Figure 4.**
Example of the main table of a star catalogue (Gill, 1898).

existing ones. Indeed, coordinates were one of the first parameters recorded from a star by ancient astronomers together with its brightness (Evans, 2010). Centuries later, milestones such as the birth of the telescope or spectroscopy allow the measurement of new quantities which have been appearing as new parameters in star catalogues.

In this sense, Table IV shows the most common astronomical parameters collected in the main tables of our sample. This table has three columns: parameters, frequency of occurrence of these parameters in the sample and percentage with respect to the total number of catalogues. In our analysis, ten parameters have been identified (see the first column), coordinates and magnitude being the most frequent. There are some parameters whose frequency is lower but it does not mean they are less important for astronomers and astrophysicists. On the contrary, some of these have been added to the catalogues for the last century (for instance, the time of exposure) and others, like the parallax, although discovered earlier, were not immediately incorporated into the catalogues.

Figure 5 shows the total quantity of the above astronomical parameters which has been found in each catalogue of our sample. It gives an idea of the number of important parameters collected in each catalogue which should be taken into account in the corresponding records. Some of them can be recorded in the existing fields (coordinates, epoch/equinox, magnitude, etc.), but new fields should be designed for the others. For further details about the relevance of these parameters, see Perryman (2012).

| Parameters | Frequency distribution | % with respect to the total number of catalogues |
|---|---|---|
| Coordinates | 28/28 | 100 |
| Epoch | 18/28 | 64.28 |
| Magnitude | 28/28 | 100 |
| Proper motion | 12/28 | 42.86 |
| Precession | 14/28 | 50 |
| Observations | 15/28 | 53.57 |
| Spectral type | 7/28 | 25 |
| Parallax | 4/28 | 14.28 |
| Data related to photographic plates | 1/28 | 3.57 |
| Times of exposure | 2/28 | 7.14 |

**Table IV.** The most common astronomical parameters collected in the main tables of the star catalogues analyzed from the eighteenth nineteenth and twentieth centuries

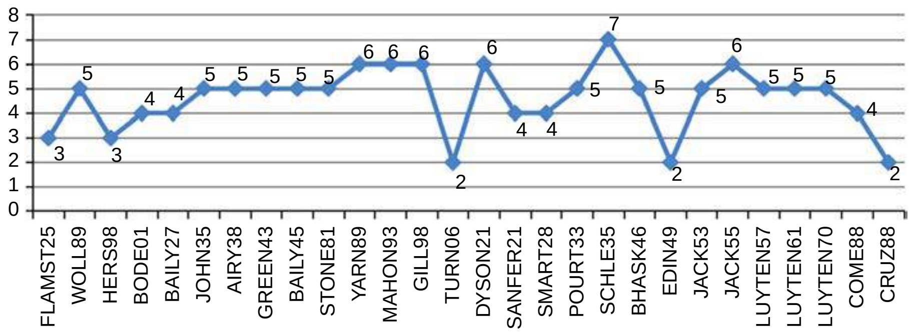



**Figure 5.** Astronomical parameters which have been found in each catalogue of our sample

It is important to state that most of the parameters shown in Table IV have also evolved over time, hence, the way in which each parameter may be displayed is not unique. For instance, magnitudes can be classified into different groups depending on the device used as a detector, eg. visual, photographic, photometric, etc. Coordinates may be given with respect to the celestial equator or the ecliptic (among other reference frames) and different types of parallax can be found: hypothetical, spectroscopic, trigonometric, dynamic, etc. In short, the existence of this wide typology shows the increasing needs of astronomers, hence all this information should be considered in the cataloguing process.

*Other important astronomical data supplementing a star catalogue*

As shown in Table II, star catalogues usually offer more information than that provided in their main tables. Indeed, there are other tables often placed in the prefaces or introductions which add complementary information concerning the instruments used for the observations, some types of corrections and comments about certain errors, among other considerations. This information is also very important to a better insight into the data provided by the catalogue. Thus, some details on these issues will be given in this short section.

The first issue concerns what is commonly known as "coordinates corrections". Indeed, the observed coordinates of the stars have to be corrected due mainly to two different phenomena, namely, astronomical refraction and light aberration. Astronomical refraction is related to the deviation of light when it passes through the atmosphere whilst light aberration refers to the motion of the observer (orbital motion of the Earth, for instance) while light is travelling towards us. Both phenomena should be taken into account to give the exact location of the stars, along with others such as proper motions and the slower motions of the Earth, nutation and precession (Abad *et al.*, 2002).

The second issue is related to the instruments used to carry out the observations. As is well known, these instruments do not work perfectly hence the possible errors introduced by them should also be considered. Furthermore, while measurements were still not taken by means of a machine procedure, the observers had to give them a value. This may cause errors which are also reported in some catalogues (Turner, 1906).

Due to the non-minor difficulties which some non-specialist cataloguers may encounter when dealing with such specialised information, the task of recording these documents without help may be very difficult. However, this information is often arranged in tables and it is even more important to include a short caption with each table (Figure 6). In fact, captions together with these tables were found in 16 of the 28 catalogues of our sample (take into account that not all the catalogues have these tables and some of them have tables with no captions). Recording these captions would allow astronomers gain access to some catalogues with information of interest to them. The idea of recording both titles of the chapters and other information from any document can also be found in Breeding (2010).

## Results. Proposal of parameters for descriptions of star catalogues of the eighteenth, nineteenth and twentieth centuries

In relation to the above, new parameters may be added to the cataloguing rules in order to get better descriptions for this type of astronomical resource. Some of these are already available in these standards but so far they have been seldom used probably due to the specialised nature of these resources and lack of time for staff to become familiar with them.

Table V contains a list with our proposal of parameters which should be taken into account for both future descriptions of these documents and for cataloguers to improve existing records. It is important to state that this list does not aim to be a discussion about the convenience of using one or another cataloguing standard, but rather to illustrate which of our parameters can be found as fields in these standards and which do not. Thus, this discussion requires further analysis, work which is in progress and will be given in a forthcoming paper. The first column indicates whether the parameters are already shown in the cataloguing standards (some further details are given in Tables I and II of Alonso-Lifante and Chaín-Navarro, 2013) or whether they represent our proposal of new ones. The second column is the list of proposed parameters and the third shows a preliminary approach of the information which should be recorded for each parameter.

It is important to state that, despite RDA being a recent standard which allows us to describe resources by strengthening the relationships among them, in order to be part of semantic web, it makes little contribution to the overall content which may be described using previous standards such as ISBD and MARC 21. Therefore, there is still some way to go as regards content descriptions. In particular, cataloguing standards should adapt to the current information needs by providing new description fields so that cataloguers can provide better descriptions that will lead to better information retrieval.

## Places where the proposed parameters can often be found in historical star catalogues

In order to improve bibliographic records, it is not only important to find new parameters to be recorded but also to indicate where these parameters may be found in the catalogues. Thus, as shown in Table III, coordinates, epoch and the observation place and period are often given in the title pages (see Section 3.1), although this information may also be found as part of the parameters given in the section corresponding to the catalogue itself. On the contrary, information related to the measurement and observation instruments is given in the introduction, generally in subsections dedicated to these technical matters.

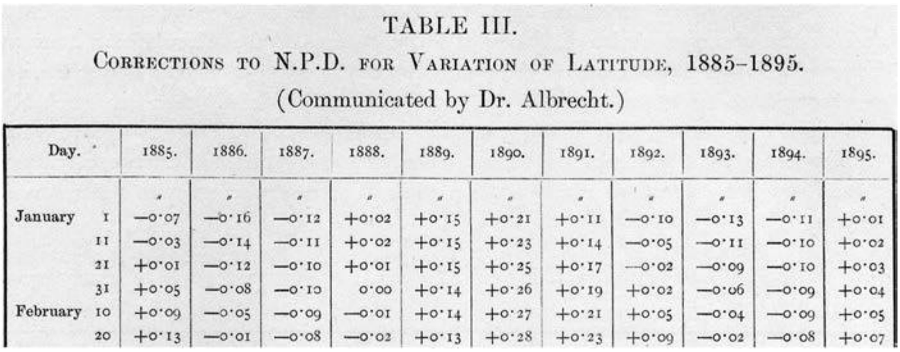


TABLE III.

CORRECTIONS TO N.P.D. FOR VARIATION OF LATITUDE, 1885–1895.

(Communicated by Dr. Albrecht.)

| Day. | | 1885. | 1886. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | " | " | " | " | " | " | " | " | " | " | " |
| January | 1 | −0·07 | −0·16 | −0·12 | +0·02 | +0·15 | +0·21 | +0·11 | −0·10 | −0·13 | −0·11 | +0·01 |
| | 11 | −0·03 | −0·14 | −0·11 | +0·02 | +0·15 | +0·23 | +0·14 | −0·05 | −0·11 | −0·10 | +0·02 |
| | 21 | +0·01 | −0·12 | −0·10 | +0·01 | +0·15 | +0·25 | +0·17 | −0·02 | −0·09 | −0·10 | +0·03 |
| | 31 | +0·05 | −0·08 | −0·10 | 0·00 | +0·14 | +0·26 | +0·19 | +0·02 | −0·06 | −0·09 | +0·04 |
| February | 10 | +0·09 | −0·05 | −0·09 | −0·01 | +0·14 | +0·27 | +0·21 | +0·05 | −0·04 | −0·09 | +0·05 |
| | 20 | +0·13 | −0·01 | −0·08 | −0·02 | +0·13 | +0·28 | +0·23 | +0·09 | −0·02 | −0·08 | +0·07 |

**Source:** Image kindly provided by ROA’s staff

**Figure 6.**
Example of a table from Gill (1898) which does not belong to the catalogue itself

| | Parameters | Information to be recorded |
|---|---|---|
| Parameters already available in the cataloguing standards (ISBD consolidated, RDA and MARC 21) | Coordinates | Area of the sky whose stars are contained in the catalogue. E.g. dec. +24° to +32° |
| | Epoch/Equinox | Date at which observations are referred to. E.g. 1900.0 |
| | Magnitude | Range of magnitude of the stars of the catalogue. E.g. −5 to 8 |
| Proposal of new parameters | Type of coordinates | Name of the reference frame to which coordinates are referred to. E.g. equatorial coordinates, ecliptic coordinates, galactic coordinates, etc. |
| | Type of magnitude | Name of the type of magnitude shown in the catalogue. E.g. visual, photometric, etc. |
| | Observation place | Place where the observations were carried out. E.g. The Royal Observatory of Greenwich |
| | Observation period | Period of time when the observations were carried out. E.g. from 1887 to 1891 |
| | Observation instrument | Instrument used to make the observations. E.g. Telescope |
| | Measurement instrument | Instrument used to measure position of the stars. E.g. micrometre |
| | Related document or catalogue | Bibliographic reference of those documents related to the catalogue. The way in which this information may be recorded is still to be studied. This can be done by using "bibcodes" as shown in Figure 1 |
| | Captions of previous or rear tables giving additional information about corrections, instruments, etc. | The exact statement of every caption. E.g. Corrections to N.P.D. for variation of latitude, 1885-1895 (Communicated by Dr Albrecht) |
| | Meaning of the columns of the main table of catalogue | At least, the name of the each column of the main table of the star catalogue. E.g. magnitude, proper motion, spectral type, etc. |

**Note**: MARC 21 has no specific field to record the parameter "magnitude"

**Table V.**
Proposal of the description parameters for a star catalogue of the eighteenth, nineteenth and twentieth centuries

Captions of other tables giving additional information are usually found in the introduction along with those documents related to the catalogue, as commented in Section 3.1., and this may sometimes be included in the title page. Other technical parameters such as magnitude are almost always shown in the main table of the wcatalogue. However, the introduction sometimes contains some explanations concerning how the magnitude has been dealt with and recorded.

Finally, as commented in Section 3.2, the meaning of the columns of the main table of the catalogue is the most important information from a scientific point of view, hence, the location of this in the catalogue is especially important. In particular, more than 90 per cent of the catalogues in our sample (26/28) explain the content of each column (Figure 7) just before showing the numerical tables, generally in the introduction, although this information can also be found in the preface, in a note section or in an individual sheet immediately before the numerical tables. Catalogues where the columns were not explicitly explained were also found in our study. There were even some cases where it was explicitly pointed out that the arrangement of the catalogue was sufficiently obvious and required no further explanation. This fact reflects the level of specialisation of the readership to which the catalogues are aimed.

## Conclusions

The method by which astronomy amateurs and professionals currently search for information using specialised databases (mainly SIMBAD and NED – NASA/IPAC Extragalactic Database) (CDS, 2013; NASA, 2013) has changed dramatically throughout the decades. Due mainly to technological advances in computer science, astronomical databases have steadily been adding new features allowing us to store new and very specialised parameters. This makes it possible to combine both old and new parameters in our searches. To achieve this in the world of Library and Information Science, it must be understood that a star catalogue is not a simple document such as a monograph but is rather a combination of monographic and cartographic material. Whilst great success has already been achieved by bibliographic agencies in improving cataloguing standards, further efforts must be made to encourage OPACs to provide similar functionality to those offered by astronomical databases. This work has highlighted some deficiencies whereby certain technical data have still not been incorporated into the descriptions of star catalogues and we believe that their inclusion would be helpful for improved and more accesible information retrieval.

EXPLANATION OF THE SEPARATE COLUMNS OF THE CATALOGUE.

*Left-Hand Page.*

"No." is the rotation number. An asterisk (*) attached to this number signifies that the Star is one of the Fundamental Stars for the zones of Schönfeld's *Durchmusterung* (*Ast. Nach.* 2890–91); a dagger (†), that the Star is one of the Fundamental Stars for subsequent meridian observation of the zones of the Cape *Durchmusterung*, between 20° and 80° of South Declination. (Auwers, *Monthly Notices* R.A.S., Vol. XLVII., pp. 455–473, and *Ast. Nach.* 3431–32.) When the Star belongs to both these lists the asterisk only is affixed, and the note "Fundamental Star for Southern Zones" is printed at the bottom of the page.

"Bradley or Lacaille."—This column gives the corresponding number in Auwers' "*Neue Reduction der Bradleyschen Beobachtungen*," or that in the British Association Catalogue of Lacaille's observations—"*Catalogue of* 9766 *Stars in the Southern Hemisphere.*"

When the Star is in one of these Catalogues only, the numeration or the Declination is sufficient to indicate to which of the two Catalogues it belongs; when the Star is in both Catalogues the Bradley number is given with an asterisk attached.

**Source:** Image kindly provided by ROA's staff

**Figure 7.**
A snapshot of the explanation of the columns of Gill's catalogue (Gill, 1898)

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