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ESTUDIOS / *RESEARCH STUDIES*

Google Sky and cataloguing standards: an example of the divergence between the most queried astronomical information and what cataloguing standards allow us to describe

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Abstract: A survey has been carried out on the astronomical information supplied by Google Sky and the information which can be described using the standards MARC21, ISBD consolidated edition, and RDA. The main goal of the study is to show that some astronomical and astrophysical information is still not taken into account in describing different astronomical resources as well as cartographic material. This information could eventually be incorporated as description fields of the aforementioned cataloguing rules. Such fields would allow us to carry out a much more complete and adequate description of these astronomical resources. We have focused on celestial objects appearing in astronomical images which can be found in astronomical archives and libraries. First a brief survey of astronomical information supplied by Google Sky and its linked databases, SIMBAD and NED is performed. Subsequently, we show how the existing description fields describe celestial cartographic materials, and finally we present a new proposal consisting of the desirable minimum parameters which could be included in bibliographic records.

Keywords: Google Sky; SIMBAD; NED; cataloguing; MARC 21; ISBD consolidated edition; RDA; celestial cartographic material description; astronomical images; astronomical information retrieval.

Google Sky y los estándares de catalogación: un ejemplo de divergencia entre la información astronómica existente y la que se puede describir

Resumen: Se realiza una revisión tanto de la información astronómica que ofrece *Google Sky* como la que permiten describir MARC21, ISBD consolidada y RDA, para demostrar que no se han contemplado hasta el momento determinados parámetros astronómicos y astrofísicos, susceptibles de convertirse en futuros campos de descripción de estos estándares. Dichos campos permitirán realizar descripciones mucho más completas y adecuadas de diferentes recursos astronómicos como material cartográfico. En concreto, se analizan exclusivamente aquellos objetos celestes contenidos en imágenes astrofotográficas que pueden encontrarse en archivos y bibliotecas astronómicas. Para ello, primero se realiza una síntesis de la información astronómica que ofrecen *Google Sky* y las bases de datos a las que enlaza, SIMBAD y NED. Posteriormente se indican los campos de descripción de los que disponen estos estándares para describir material cartográfico celeste y, por último, se realiza una propuesta de los parámetros mínimos deseables relevantes que podrían incluirse en un registro.

Palabras clave: Google Sky; SIMBAD; NED; catalogación; MARC 21; ISBD consolidada; RDA; descripción de cartografía celeste; imágenes astronómicas; recuperación de información astronómica.

1. INTRODUCTION

1.1. Historical evolution of the astronomical resources

Due to the fascination for night sky and celestial phenomena, the human being has been recording events like these since ancient times. Over time, recording such astronomical information has been an essential and helpful task (Accomazzi, 2010). Thus, one of the most remarkable examples of the importance of recording this information is the publication of Kepler's laws, whose discovery was possible thanks to the observations recorded by Tycho Brahe in his famous star catalogue (Lachièze-Rey and Luminet, 2001).

Different documents reflecting the state of the night sky have appeared throughout history. The most famous ones are known as "celestial charts", often collected in "celestial atlases" (Kanas, 2009). A celestial chart may be defined as a two dimensional representation from some region of the night sky (or from the whole sky) showing all the visible objects up to a certain brightness. Together with celestial charts, star catalogues contain specific information about the objects which appear in the charts. Included in this information, it is worth highlighting star positions in a particular coordinate system and the magnitude of brightness of the considered celestial bodies. Celestial charts were the most important astronomical document for centuries. However, the importance of both types of documents changed thanks to the revolution caused by Copernicus' new planetary theory and the birth of new and more accurate observational instruments such as the telescope. Indeed, from then onwards, the scientific value of the data collected during the observations began to be higher than the artistic value of the pictorical depiction of charts. As a result of this, not only were celestial charts often sent to ruling kings as gifts by astronomers, but also the famous scientist Isaac Newton could not wait to see the data that the royal astronomer John Flamsteed had written down in his catalogue about Moon's trajectory in order to verify his theories (Durán, 2012).

Celestial catalogues are books where a set of tables with numerical data is usually shown. In these tables each row stands for an object name and each column contains different data from the celestial objects. For instance, a star catalogue usually shows a number of tables where rows contain the name of different stars and columns contain interesting data from these stars (position, distance, brightness, etc.). As we can see, these columns represent the type of data by which the catalogue's author decided to record each object. In other words, in celestial catalogues columns represent the "metadata" the catalogue's author has associated with this type of object. In short, researchers such as astronomers and astrophysics usually catalogue celestial objects they discover.

The birth of Astrophotography, together with the construction of increasingly more sophisticated telescopes during the nineteenth and twentieth centuries led to the emergence of a new type of astronomical document: astrophotographic images. Unlike celestial charts or star maps these images usually contain only one celestial object (a star, galaxy, star cluster, etc.) or a reduced number of them. Moreover, the appearance of the radiotelescope in the 50's caused a revolution of celestial cartography because, for the first time, images from distant celestial objects at other wavelengths out of the visible spectrum could be seen.

In turn, the beginning of the space race in the late 50's and the advent of computers marked a milestone in the volume of astronomical information that needed to be recorded for later analysis. In fact, space missions and research projects associated with the study of the cosmos generate massive amounts of data which are collected and stored in huge databases and can be accessed from any computer connected to Internet.

Nevertheless, more and more studies are carried out in order to measure the accuracy of existing data on ancient celestial charts, astrophotographic images and celestial catalogues (Verbunt and Van Gent, 2010a, 2010b, 2012; Rivera, 2012; Bhattacharjee, 2009; McNally, 2001). The goal of a campaign like this is to have reliable data from several centuries ago. These data will allow us to study extraordinarily-slow astronomical phenomena and check them against those scientific theories which have emerged over the centuries.

1.2. The astronomical documentation in a globalized and highly specialized world

From the previous section we can see that the development of Library and Information Science has been, and will continue to be intrinsically linked to the technology evolution. As new observational instruments have released new relevant astronomical data, professionals have felt the need to record these data in order to catalogue and classify the observed celestial objects, and with them the entire known universe. Consequently, each new technological and scientific advance involves increasing the specialization level, not only of the generated knowledge but also of the documentation supporting and preserving that knowledge.

In this sense, Astronomy and Astrophysics are two very specialized sciences as they are boosted by the ongoing process of globalization in which we are immersed. For this reason the documents generated by these two sciences are also very specialized, as are the searches accomplished by professionals in specialized databases. However, why is a more specialized description of the astronomical resources not carried out in our archives and libraries? The response to this question involves recalling the essence of cataloguing. We should remember that our astronomical resources are described so that users can retrieve them, because the final goal of documental description is information retrieval (IR). In the words of Ricky Erway (referring to special collections) "We need to find better ways to describe our collections so that users will find them" (Erway, 2012).

Naturally, librarians and other information professionals should play a leading role in this process of searching better documental descriptions. In this regard, A. Heck states that "it is clear that we have entered a new age where librarians have a new attitude towards IR and where scientists also have a new attitude towards their librarians" (Heck, 1993). Nevertheless, in order to fulfil such an important role, we should adopt a more active and dynamic attitude, which involves dealing with astronomical information and its typology, learning to manage it and being connoisseurs of the information sources and channels. Thus, we will set ourselves up as real and necessary intermediaries between researchers and the documentation they handle daily, as well as establish the data necessary for a better description of the resources. This will allow for successful information retrieval (Kumar, 2010; Lagerstrom and Grothkopf, 2010; Grothkopf, 2011).

1.3. Cataloguing standards and the problems of astronomical libraries

As we are currently witnessing changes in the cataloguing standards (Sainz, 2012), professionals are concentrating on the creation of standards which are adapted to the semantic web technology. However, they are not focusing on carrying out a more detailed description of the contents of the resources, that is, descriptions which allow us to indicate the desired minimum data from each type of resource.

In this respect, our contribution focuses on the data representation level at which the cataloguing rules are within the classification for bibliographic control proposed by Picco and Ortiz (2012). In particular, we are talking about a contribution based on improving the description of the contents of celestial images from space projects and missions. According to the authors, as we know, MARC 21 is a storage standard ("computer application collecting systematically descriptions and representations of bibliographic universe"), whereas consolidated ISBD and RDA are description standards ("instructions or specific rules allowing us to represent symbolically the bibliographic universe"). Despite this distinction and although the Library of Congress has recently announced (November 2012) that MARC 21 will be replaced with BIBFRAME (Library of Congress, 2012a; Picco and Ortiz, 2012; Estivill-Rius, 2011), in practice it can be observed that MARC 21 allows us to describe a greater number of elements of an astronomical resource (section 4), when compared with other standards such as consolidated ISBD and RDA (we will see that the difference is not very significant, but it nevertheless exists). Despite this, MARC 21 is constantly updated and a big effort has been made to make it compatible with semantic web. Indeed, the Library of Congress has undertaken some initiatives over the last few years such as *MARCXML*, *MARC in FRBR*, *RDA in MARC*, *MARC Code Lists as Linked Data* (Library of Congress, 2012b).

In turn, ISBD has also recently been updated. The last update was the publication of the consolidated ISBD in June 2011(ISBD, 2011) where the data on cartographic material in this new edition is presented in the area 3.1. IFLA, as the institution in charge of this standard, has also created the *ISBD/XML Study Group* which is currently working with Linked Data technology with the goal of adapting ISBD to semantic web. Thus they have recently published (September 2012) the ISBD namespaces in *Resource Description Framework* (RDF) (IFLA, 2012).

With respect to the new cataloguing code as a substitute for AACR2, RDA (Resource, Description & Access) was published in July 2010 after about ten years of work. This standard is based on FRBR (published in 1998) and FRAD models (published in 2009) as well as the *Statement of International Cataloguing Principles* (published en 2009) as a substitute for *Principles of Paris* (1961). In spite of the fact that RDA adapts better to technology and can be easily computerised, at the beginning it did not receive a very warm welcome by the librarian's community, hence why the suitability of its implementation was tested in the USA. One of the results of this test showed that "errors increase as a consequence of the complexity of the catalogued material and that these errors do not depend so much on the code used" (Estivill-Rius, 2011). This is one of reasons why there are so few authors who have studied how RDA interacts specifically with cartographic material, and with more general cataloguing standards. Among them we must highlight Paige G. Andrew and Mary Larsgaard who plan to publish sometime (2013) a book titled *RDA and Cartographic Resources*, edited by *American Library Association* (ALA). It is also worth noting an interesting lecture on changes introduced by RDA with respect to other standards such as AACR2 and MARC21. This lecture was given by Andrew in 2011 and was organized by ALCTS (The Association for Library Collections and Technical Services) (Andrew, 2011).

For Andrew, RDA's greatest contribution is focusing on relationships, drawn from the "WEMI" model (*Works*, *Expressions*, *Manifestations*, and *Items*) and, if possible, including coordinates in records for maps and other cartographic materials. In the words of Andrew "the power of the WEMI model will not be realized or become truly apparent until we break away from the MARC content standard and come up with a new data-driven standard" (this idea is shared by Escolano, 2011). Mary Larsgaard agrees with Andrew with respect to the WEMI model, though she does think that RDA does not allow us to accomplish a more detailed description of cartographic materials. From her point of view, "what RDA does is to take most of the rules from AACR2 to rearrange them and often reword them".

On the one hand, despite the fact that RDA focuses on description and access to resources, it does not allow us to carry out a detailed description of them (not even astronomical resources). However, on the other hand, RDA enhances access, allowing us to create rich relationships and associations with different records, by using the entity-relationship model of FRBR (Picco-Gómez, 2007). There are some interesting papers about FRBR's application to cartographic material which deserve a mention: McEathron, 2002; Larsgaard, 2007; Kalf, 2008 and Morse, 2012.

In connection with the aforementioned U.S. test, celestial images are a type of resource that can be found in astronomical libraries. Unfortunately cataloguing them is not an easy task. These astronomical libraries have to catalogue their collections without using traditional cataloguing standards because of the difficulty in cataloguing them, together with the limited possibilities of enriching records with the astronomical information available, not to mention the lack of human and technical resources. A couple of important examples may be cited at European level. On the one hand, the library of *Royal Astronomical Society* (RAS) (RAS, 2012) makes the astronomical images available via the Internet, through the Science Photo Library site. These images are catalogued with a title, date, identification code, brief description of the image and a group of keywords (*Science Photo Library*, 2012). On the other hand, the library of the *Astronomical Institute* of the University of Cambridge possesses a digital images repository called *DSpace* where, if an object's name is searched in the repository, the system brings up a table where each row displays an image of the object and each column represents a type of data by which the image was catalogued. The books can be catalogued using MARC21. Moreover, the library staff itself is in charge of scanning and cataloguing images for *DSpace*. In short, due to the lack of options to perform a useful description using the standards available, these important libraries are creating repositories where interfaces are based on the incorporation of the metadata available (Schaffner, 2009).

1.4. The contribution of *Google Sky* and the specialized databases

In recent years society has witnessed a major revolution in the field of geoinformation. In a short period of time people have gone from using simple street maps to being guided. They have seen the birth of global positioning systems (GPS - *Global Positioning System*), as well as the use of free software which allows us to navigate virtually almost anywhere in the world through any computer connected to Internet. Indeed, programs like *Google Earth* are a true innovation for the field of navigation, which is growing at an ever increasing rate. In fact, among other applications, this program offers the opportunity not only to navigate by land (*Earth*) (2012a) but also by the night sky (*Sky*) (2012b).

Bearing in mind the free software available (Mc Cool, 2009), we have decided to support our research by *Google Sky*, firstly because, as the astronomical application of the company *Google* (third most valuable brand in the world according to the study *BrandZTM Top 100 Most Valuable global Brands 2012*) it is one of the most popular programs, and secondly, because it links two important astronomical databases all over the world: SIMBAD (*Set of Identifications Measurements and Bibliography for astronomical data*) (SIMBAD, 2012a) and NED (*NASA / IPAC Extragalactic Database*) (NED, 2012a).

As we will see in section 3, SIMBAD is a database managed by the *Centre de Données astronomiques de Strasbourg* (CDS) which receives FITS images (*Flexible Image Transport System*) (a storage system containing selected metadata) and data from research projects and space missions (ProEspacio, 2011). Once the data have been analyzed, selected metadata are added to the image. Some of this metadata come from FITS records, once any incorrect data have been removed. Moreover, it should be taken into account that there may be information from different projects which are observing the same regions in the sky; hence why the process of obtaining relevant metadata needs to be conducted with care. In the same way, NED collaborates with several astronomical research projects from which it receives information in exchange. Like SIMBAD, when images are recorded in the database, metadata coming from FITS, together with data released in articles and specialized websites are extracted before being stored.

In short, the enormous volume of information generated by observatories and research projects (measured in Terabytes per month (Hernández et al, 2009)), not only justifies the existence of these large databases, but it implies the need to manage this information by using all of the techniques available. This will enhance the value of the information. It is at this point that professionals of documentation play an important role. To cite an example, the staff working in these databases are already applying data-mining and web-mining techniques (Wenger and Oberto, 2010), due to the increasing interoperability between NED and different astronomical archives and other services. These techniques (Mazzarella, 2001) are part of the new applications performed by NED in the

Virtual Observatories. This is what is happening now, but the role that information managers will play in the future of mega-databases should not be overlooked.

2. OBJECTIVES AND METHODOLOGICAL ASPECTS

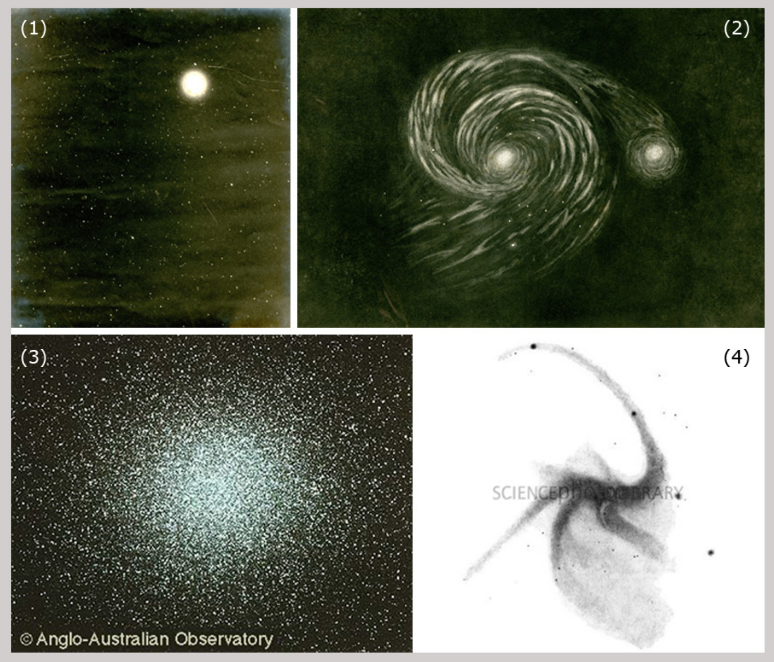
The main goal is to show that there are areas of great interest in Astronomy and Astrophysics which are not listed in the cataloguing standards and are likely to become future description fields of astronomical resources. To do this, not only do we need to analyze *Google Sky* and the two linked databases: SIMBAD and NED; but we also need to analyze the two important cataloguing standards: consolidated ISBD and RDA and also the coding format MARC21.

Nevertheless, due to the different types of documents in Astronomy (see section 1.1) we are forced to delimit which of them will be analyzed in this paper. NED and SIMBAD databases have independently elaborated different classifications of celestial objects in their websites (SIMBAD, 2012b; NED 2012b). Since both lists are very long, describing the whole set of objects would be an impossible task to carry out in this article. For this reason we will focus on those objects which are part of the SIMBAD and NED classifications and are at the same time available as astrophotographic images in astronomical archives and libraries. As NED excludes all of the objects inside our galaxy and SIMBAD does not consider the Solar System objects; then planets, satellites, asteroids and comets are not included in the list of objects in these databases or in our study. From the rest of celestial objects included in both databases, we have chosen a selection of objects proposed by Michael A. Covington in his book *Celestial objects for modern telescopes* (*Objetos celestes para telescopios modernos*) (Covington, 2006), which is recommended by the *International Astronomical Union* (IAU). Thus, in general, only stars, galaxies, clusters and nebulae are studied in this article (Figure 1). Consequently, the cataloguing of celestial charts is not part of the aim of this study because these charts usually contain a wide range of objects. The cataloguing of these objects will be addressed in a forthcoming paper.

Moreover, a brief survey of MARC21, consolidated ISBD and RDA standards is first accomplished to determine the astronomical information which they allow us to describe. We will proceed to compare and contrast the cartographic descriptive elements which these standards contain.

Therefore, our contribution focuses on analyzing the most common parameters used by researchers in SIMBAD and NED databases, as well as those offered by *Google Sky*, which could assist in describing an astronomical image which contains only one celestial object (or a reduced set of them). Once analyzed, we indicate which of them are presented in the current standards under consideration in this article, and which of them should be incorporated.

Figure 1. Examples of celestial objects considered in this article: (1) star, (2) nebula, (3) cluster and (4) galaxy. Source: DSpace (institutional repository of Astronomical Institute of the University of Cambridge), Science Photo Library (Royal Astronomical Society image) and Anglo-Australian Observatory.



Finally, we must note that the parameters proposed in this paper are valid when describing all celestial objects, except for some of them such as stars and/or galaxies. The reason is that these parameters are obtained through the study of the spectrum of light from these objects.

Thus, the content of this work is organized as follows. In Section 3 we present the astronomical information which allows us to describe *Google Sky* and its linked databases SIMBAD and NED, as well as showing how the searches are carried out by using them and the basic astronomical parameters offered. Information allowing us to describe MARC 21, consolidated ISBD and RDA standards is analyzed in Section 4 and we indicate those elements specifically created to describe astronomical resources. From this information, and from finding out what we can describe by means of these standards and the parameters offered by the databases, in Section 5 we propose new parameters to be incorporated in the cataloguing standards.

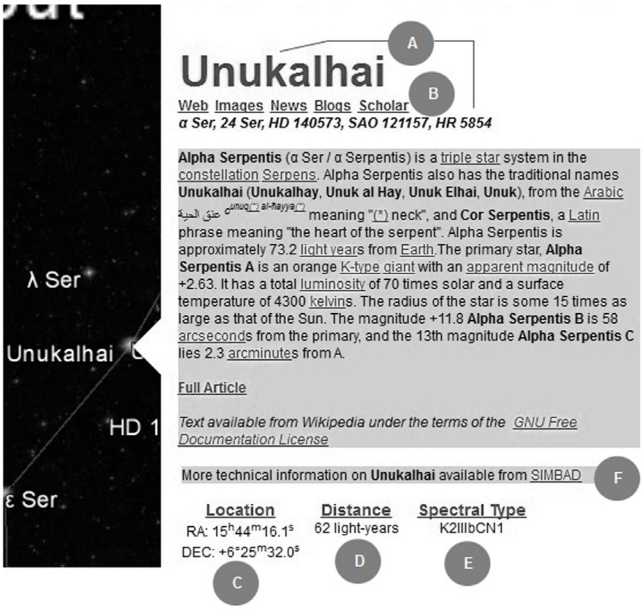
3. ASTRONOMICAL INFORMATION PROVIDED BY *GOOGLE SKY*

Sky is an integrated tool in *Google Earth* which allows us to explore the universe through stellar images, as well as navigate by following their motions in time and space (*Google Earth*, 2012b). *Google Sky* was launched in 2005 and was co-created by two workers from the *Space Telescope Science Institute* (STScI, the home of Hubble), Carol Christian and Alberto Conti (IOP Science, 2008). The last version of *Google Earth* currently available is 6.2. There are two options available: *Google Earth*, free version, and *Google Earth Pro*, paid version (*Google Earth*, 2012a). *Google Sky* aims to create a framework giving users access to images, catalogues and metadata from the sky. It also provides images from the visible spectral range, infrared, X and ultraviolet rays, as well as overlaying the images taken at different wavelengths.

Clicking on any of the celestial objects, *Google Sky* provides the following astronomical information (Figure 2):

- *Celestial object name/s (A)*. It provides the name of the celestial object in their different versions according to the nomenclature used by different catalogues.
- *Google extra information (B)*. The software provides five links to different *Google* services where it is possible to find more information about each celestial object.
- *Location (C)*. Equatorial celestial coordinates (right ascension and declination) of the selected celestial object.
- *Distance (D)*. Distance between Earth and selected object in light years.
- *Spectral type (E)*. Also known as Harvard spectral classification. It is the most used stellar classification in astronomy where the different types are sorted according to the temperature of the star.
- *Technical information (F)*. *Google Sky* gives us access to details about the selected object by clicking the links to the SIMBAD and NED databases (see sections 3.1 and 3.2).

Figure 2. Distribution of information on celestial objects provided by Google Sky Source: own elaboration. Image taken from Google Sky.



Unukalhai

Web Images News Blogs Scholar

α Ser, 24 Ser, HD 140573, SAO 121157, HR 5854

Alpha Serpentis (α Ser / α Serpentis) is a triple star system in the constellation Serpens. Alpha Serpentis also has the traditional names **Unukalhai** (**Unukalhay**, **Unuk al Hay**, **Unuk Elhai**, **Unuk**), from the Arabic عنق الحية cunuq(*) al-hayya(*) meaning "(*) neck", and **Cor Serpentis**, a Latin phrase meaning "the heart of the serpent". Alpha Serpentis is approximately 73.2 light years from Earth.The primary star, **Alpha Serpentis A** is an orange K-type giant with an apparent magnitude of +2.63. It has a total luminosity of 70 times solar and a surface temperature of 4300 kelvins. The radius of the star is some 15 times as large as that of the Sun. The magnitude +11.8 **Alpha Serpentis B** is 58 arcseconds from the primary, and the 13th magnitude **Alpha Serpentis C** lies 2.3 arcminutes from A.

Full Article

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More technical information on **Unukalhai** available from SIMBAD

Location	Distance	Spectral Type
RA: $15^h44^m16.1^s$ DEC: $+6°25^m32.0^s$	62 light-years	K2IIIbCN1

As discussed previously, the information presented so far is not the only information that can be found in *Google Sky*, since it stores more information about each celestial object which can be accessed by clicking on links that lead to the specialized astronomical databases SIMBAD and NED.

3.1. SIMBAD database

SIMBAD is a database created by the Astronomical Data Centre in Strasbourg (*Centre de Données astronomiques de Strasbourg* -CDS-). The CDS "defines, develops, and maintains services to help astronomers find the information that they need from the very rapidly increasing wealth of astronomical information, and in particular of on-line information" (Wenger et al., 2000).

The fact that SIMBAD is one of the best databases in the world of Astronomy and Astrophysics is no trivial matter. In the 80's it started to be used as a reference for bibliographic research into Astronomy and Astrophysics (Debois, 1989), as R. Shobbrook and F. Genova claimed in the 90s: "SIMBAD and its host, the Strasbourg Observatory, needs no introduction. It is probably the best known database in the field of astronomy and has been around as an online service since 1981" (Shobbrook and Genova, 1995). This is evidenced by the significant increase in requests per day that the database has experienced in recent years (Wenger and Oberto, 2010). SIMBAD is currently an important resource within online astronomical services and the so-called Virtual Observatories (VO) (Wenger, 2007).

This database contains information about stars, galaxies, non stellar objects (planetariums nebulas, cluster, etc.) and additional objects observed in several wavelengths (radio, infrared, X ray). "The only astronomical objects specifically excluded from SIMBAD are the Sun and Solar System bodies" (Wenger et al., 2000).

3.1.1. SIMBAD search types

The SIMBAD user interface contains seven sections: *Queries*, *Documentation*, *Information*, *Content*, *Statistics*, *Acknowledgement* and *Basic Search*, from which we are interested only in the first one (*Queries*), since it allows us to carry out different searches to request information from the database (SIMBAD, 2012a):

- · Basic search. It allows us to search by any field or parameter. Users can type both object names and their own coordinates.
- · Search by identifier. It allows us to search by a particular identifier (nomenclature of object) or a list of them within an ASCII text file with an identifier per line.
- · Search by coordinates. It is possible to search an object or a list of them directly by their coordinates.
- · Search by criteria. It is a more advanced system that allows us to search objects by distinct criteria, from coordinates to speeds, including combinations of all of them through specific search expressions where the infrastructure is provided by the database.
- · Search by reference query. It allows us to search by bibliographic references (authors, titles, years, etc.).
- · Search by display all user annotations. It is a service by which it is possible to retrieve information that users can write in the database by means of posts.
- · Search by scripts. It is a search method for advanced users by which they can make requests through command lines and combine different types of search.

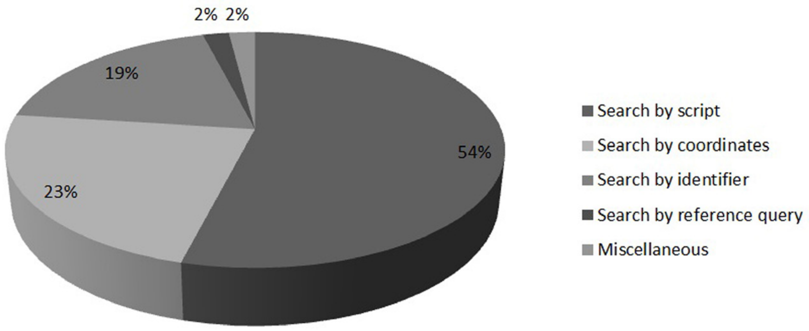
3.1.2. Most popular search types by SIMBAD users

As stated before in Section 2, this work aims to show that certain astronomical information exists which current cataloguing standards do not take into account. If this hypothesis is correct, it automatically raises the question: what is this information? In other words, what are the minimum data required to make the recording of this type of material more useful to researchers?

Naturally, the answer to this question should be given by the researchers themselves. Nevertheless, as it would be too costly to survey a large number of them, we must ask database administrators in order to find out what the most common types of searches performed by users in their requests to the database are. This gives us untraceable and therefore objective information about the needs of researchers.

Figure 3 shows the percentage of the most performed searches in SIMBAD between the months of October 2011 and August 2012. As we can see, the search by script is used most often (54%), which is not surprising since, as we have mentioned, users of these databases are often as specialized as their own working material. Unfortunately, we do not have statistics on the commands most commonly used within the search by scripts. However, if we go to the help section of SIMBAD's search by script (SIMBAD, 2012c) information can be requested regarding the parameters it sets each celestial object, as shown in the "search by criteria". Another 23% of searches are performed by coordinates, 19% by identifiers, 2% by bibliographic references and the remaining 2% which we have called "Miscellaneous" includes search by image, authors, examples, etc.

Figure 3. Most frequently used search types in SIMBAD. Resource: Data kindly provided by Marc Wenger, engineer of SIMBAD staff.



3.1.3. Basic astronomical parameters provided by SIMBAD

According to the information provided by the *Description section of the queriable fields* (SIMBAD, 2012d) and of that offered in the records of searches performed in the database that have been retrieved, we present a selection of minimum fields or parameters that must show celestial objects according to the criteria of "basic data" from SIMBAD.

These are the basic astronomical parameters offered by SIMBAD: *coordinates; redshifts; stellar distances; filters; fluxes; magnitude; proper motion; parallaxes; angular size; spectral type; morphological type; and radial velocity.*

3.2. NED database

The second largest database that *Google Sky* links to is known as *NASA / IPAC Extragalactic Database* (NED), and it is managed by the *National Aeronautics and Space Administration* (NASA) together with the *Infrared Processing and Analysis Center* (IPAC). It has been in operation since June 1990 and provides an enormous amount of astronomical and astrophysical data covering multi-wavelength. Moreover being immersed in a continuous process of expansion and revision makes it one of the best worldwide databases in this discipline (Corwin, 1995).

This is an online research resource designed to support scientists, educators, space missions and observatories, etc., by providing information about objects outside the Milky Way. Their main goal is to maintain all basic data about extragalactic objects updated (galaxies, nebulas, etc.), including references to the literature in Astrophysics (Mazzarella et al., 2001).

3.2.1. NED search types

The user interface of NED database presents five main sections: *Objects*, *Data*, *Literature*, *Tools* and *Info*. For the purpose of this study, the first two are of more interest. The *Objects* section allows us to perform extragalactic object searches in eight different ways:

- Search by name. It allows us to search by object name only. NED is prepared to recognise the different known names of each object.
- Search by near name. It is possible to query the system by searching for a specific object name and all that is found within its radius. The database retrieves the object searched together with all those objects that are found within the specified radius.
- Search by near position. It is a search method similar to the previous one, and uses coordinates instead of a particular celestial object.
- Search by IAU format. It allows us to locate objects by specifying the objects according to the conventions of the International Astronomical Union.
- Search by parameters all-sky. It allows us to search according to the following parameters: redshift or velocity, object type, catalogue name prefix and equatorial and galactic coordinates.
- Search by classifications, types, attributes. In order to find objects by specifiying classification, type or attributes they possess. For instance, it is possible to search by optical morphology or spectral classification.
- Search by refcode. It retrieves objects that are contained within a specific bibliographic reference.

- Search by object notes. It allows us to search for the object notes of several astronomical catalogues and hundreds of articles.

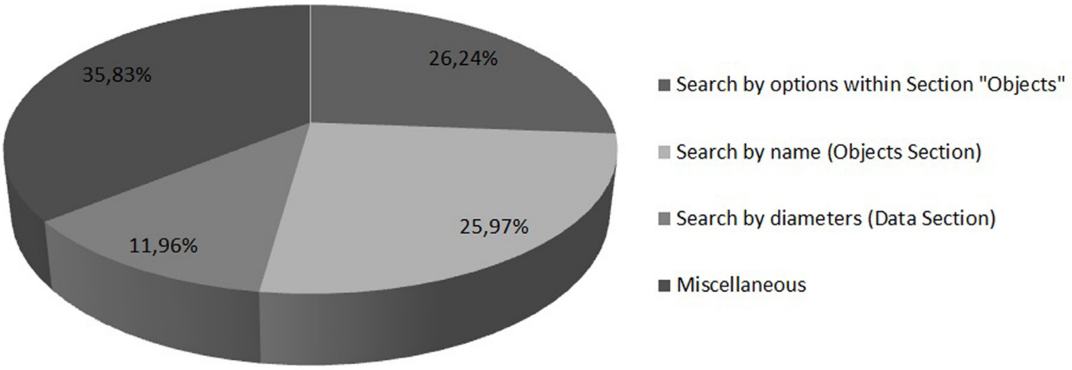
Unlike the previous section, in *Data* it is possible to perform searches by retrieving detailed data of the objects (data which are not always available). We can distinguish between:

- Images search by object name or by region. It allows us to search by object name in the images data base. Search by region enables us to find images or maps of a given part of the sky using the tools provided by the IRSA (*NASA/IPAC InfraRed Science Archive*).
- Search by photometry & SEDs (*Spectral Energy Distributions*). With this option one can search for photometric data for a given object. Additionally, NED provides graphs of spectral energy distribution.
- Search by spectra. This option facilitates the search by NED spectral files and the examination and retrieval of them.
- Search by redshifts. It enables us to search by Redshifts or by radial velocities for a given object.
- Search by redshift-independent distances. To perform searches by object name in an updated list of Redshift-independent distances by NED.
- Classifications search by object name. It enables us to search by classifications, types and other attributes of a given object from several lists and catalogues.
- Search by positions. It allows us to find position data for a given object from several lists and catalogues.
- Search by diameters. It enables to search by diameters, axis ratios or position angles for a given object.

3.2.2. Most popular search types by NED users

Figure 4 shows the most performed searches carried out by users of the database (mainly researchers). Most of them are carried out in the *Objects* Section, i.e. these searches are performed by searching for near name object, IAU format, refcode, object notes, etc., and account for 26.24% of the total number of searches. Nevertheless, search by object name (*by name* belongs to *Objects* Section) represents 25.97% of the total, which is the most popular way to search, hardly surprising given that many NED services require a search by object name as a first step before carrying out a more specific search. The search by diameters is the third most popular search, which is in the *Data Section*, and accounts for 11.96% of the total. The last search shown by Figure 4 is entitled *Miscellaneous* and, although it is the highest percentage, 35.83%, it includes a variety of searches which are performed infrequently (spectral -0.25% - for redshift - 0.04% - for photometric data - 0.35% - by distances - 0.17% -, etc.).

Figure 4. Most frequently used search types in NED. Source: Data kindly provided by Olga Pevunova and Rick Ebert, members of NED staff.



3.2.3. Basic astronomical parameters provided by NED

Taking into account the information provided by *NED's WWW Interface Features* Section (NED, 2012c), and the information given by the records retrieved when a search is performed in the database, we show the set of minimum parameters or fields which are *essential* to describe celestial objects according to NED *basic data* criteria.

These are the basic astronomical parameters offered by NED: coordinates; redshift; angular and physical diameters; spectra; photometry and luminosity; magnitude and filters; object type; morphological type; and radial velocity.

4. ASTRONOMICAL INFORMATION THAT MARC 21, CONSOLIDATED ISBD AND RDA ALLOW US TO DESCRIBE

In this section a comparative analysis of the celestial cartographic descriptive elements that MARC 21, consolidated ISBD and RDA contain is performed. To carry out the analysis a table has been created which contains the elements of those standards which allow us to catalogue a celestial image (Table I), and in which we can see their similarities and divergences. Once this information has been acquired, we can create a list with the total number of astronomical parameters that can be described by the three standards, in order to analyze three specific aspects of each of them (Table II):

- · Elements descriptive. In other words, whether or not the standard contains the parameter as descriptive element in the bibliographic record. As we can see in Table 2 almost all three standards enable us to describe the same parameters. In particular, MARC21 Format allows us to describe the *distance from Earth and name of extraterrestrial body* (it can only indicate whether the coordinates entered in field 034 refer to an entity of the Earth or not), and only consolidated ISBD and RDA allow us to describe *magnitude*.
- · Defining elements. This concerns finding out whether the standard defines the parameter. We believe it is very important that the cataloguing standards which define the concepts on data can be described. This helps the cataloguer to understand those concepts and in this way makes the task of describing astronomical resources easier.
- · Elements indicating how these parameters must be recorded. This is, whether the standard explains how the parameter must be recorded in the bibliographic record. In general MARC 21, consolidated ISBD and RDA explain how the information about their elements must be recorded, but there are some surprising exceptions such as *angular scale* and *distance from Earth* in MARC 21 Format, just like *magnitude* in the case of consolidated ISBD and RDA.

Traditionally, the cataloguing and coding standards have created a cartographic mathematical data area where the technical description data have been grouped as follows; "Cartographic Mathematical Data" (MARC 21), "Mathematical Data Area" (ISBD(CM)), "Mathematical data (Cartographic resources)" (consolidated ISBD), while RDA shows all descriptive elements in chapter 7 (*Describing Content*). In these groups they have included descriptive elements relating to the images or astronomical data they contain, such as the angular scale or projection, and other characteristics related to the celestial object itself, such as the object name, coordinates, the magnitude of the object, the distance in light years, the epoch and the equinox. It can be seen therefore that standards have mainly focused on describing purely cartographic data, although an effort has also been made to describe the content of the resource. We believe that they must continue to make an effort in order to improve the technical description of resources and scientific information retrieval.

Finally, we should mention that the *magnitude* element deserves special attention, because it is an essential astronomical parameter for the description of this type of resource; and MARC21 does not allow us to describe it (unless otherwise indicated in a notes field), and consolidated ISBD and RDA neither enable us to define it nor indicate how to record such information. Furthermore, it appears that the standards do not consider it desired minimum data, since the ISBD mentions it in the notes field (7.3.1.1) and RDA in the *Other Details of Cartographic Content* Section (7.27). If it is neither defined nor indicated how this item reflects this information in the description, the cataloguer will probably ignore this element. With the magnitude field it seems that the ISBD wants to refer to the apparent magnitude of a celestial object, but neither says "apparent magnitude", nor correctly specifies the maximum value of this magnitude, since the faintest objects observed by the Hubble Telescope can submit a magnitude of up to 30 (Molla, 2009; Astro.uchile, 2012; Wikipedia, 2012) while ISBD is set to a maximum of 22.

5. RESULTS. PROPOSAL OF THE DESIRED MINIMUM FIELDS TO CATALOGUE IMAGES WITH CELESTIAL OBJECTS

Taking into account the data obtained from the analysis of Google Sky and the SIMBAD and NED databases, the desired minimum parameters for the description of celestial objects are indicated, with particular reference to stars, galaxies, clusters and nebulas, as well as the importance of including them in the cataloguing and coding standards:

Parameter 1. Object name. Although the fact remains that it could be recorded in some fields of current standards (for instance in the *title* field when the celestial image has the own object name like a title), we consider this to be a technical field which should be added to the standards. It does, after all, deal with the star data in the performed searches. In 2006 MARC 21 incorporated the field *Name of extraterrestrial body*. However, this can only be applied when the coordinates of the record refer to a celestial body other than Earth.

Parameter 2. Object type*.* Many searches are performed depending on object type (galaxies, nebulas, stars, etc.). In general the technical names of objects consist of a set of alphanumeric characters. Letters represent the abbreviation of the catalogue to which the object belongs. These abbreviations come with an ordinal number that classifies the object (Arranz, 2004). For instance, the famous Andromeda galaxy is called as "*M31*", where the letter *M* indicates that it is a celestial object from the "*Messier*" catalogue and "*31*" is the number given to the galaxy by the catalogue. The same happens with other names which call this galaxy "*NGC224*".

Parameter 3. Other types of celestial coordinates. Although ISBD allows us to indicate the geographical coordinates of any point on the surface of other celestial bodies other than the Earth (e.g., Moon or Mars), the only celestial coordinates which the current standards enable us to indicate are the right ascension and declination (equatorial coordinates). Nevertheless, in Astronomy, the equatorial coordinates are not the only ones present. In particular, SIMBAD and NED show a further six types of celestial coordinates: ecliptic coordinates, galactic coordinates, supergalactic coordinates, ICRS coordinates, FK4 coordinates and FK5 coordinates.

Parameter 4. Object distance. This is a parameter which was considered by MARC 21 in 2006, but not by the rest of the standards mentioned herein. Nevertheless, MARC defines this distance in light-years, ignoring other types of measurement units more frequently used by astronomers such as *parsec* or *astronomical unit*.

Parameter 5. Morphological type. As its own name indicates, it is related to the shape of the objects observed. Furthermore, this information enables us to classify those objects, although it is mainly used to catalogue galaxies (Astronomia Moderna, 2010).

Parameter 6. Angular and physical diameters (dimensions). Knowing the dimensions of celestial objects allows astronomers to classify them in different groups. For instance, in the case of an ecliptic galaxy it is necessary to know the dimensions of its semi-axis major and minor.

Parameter 7. Redshift. This is an important parameter in Astrophysics since, as well as other information, it allows scientists to find out whether the observed object is approaching or moving away from us, as well as estimate distances to those objects.

Parameter 8. Radial velocity. Parameter related to the redshift which enables us to estimate the star mass and even detect planets around the stars (Centro de Astrofísica da Universidade do Porto, 2012).

Parameter 9. Proper motion. It is a way of measuring the transversal velocity of a celestial object (velocity perpendicular to the radial velocity). It is related to the radial velocity and the redshift and, as well as other information, gives us an idea of the distance to the object under consideration (McKee, 2005; Reid, 2002).

Parameter 10. Parallax. Alternative measurement used to calculate distances. When these are very big it is used for spectroscopic parallaxes (related to the spectral type and the absolute magnitude), dynamic parallaxes (applying Kepler's laws to binary systems) or cinematic parallaxes (related to the proper motion and the radial velocity are used) (Alfonso-Garzón et al. 2009).

Parameter 11. Brightness magnitudes (Photometry)*.* The Photometry is the branch of Astronomy which is dedicated to measuring the brightness of celestial objects. The measurement of its brightness allows us to classify the observed objects (Alfonso-Garzón et al. 2009). There are different ways of carrying out the Photometry depending on the filters used in the measurements.

Parameter 12. Spectral type. It allows us to classify stars according to the light spectra which is received from them. This allows for a deeper comprehension of the chemical composition of star, temperature, mass, etc. (Alfonso-Garzón et al. 2009).

Parameter 13. Luminosity class. This is a way of classifying stars which complements the previous parameter and takes into account how the gravity of a star's surface and temperature affect spectral lines. This parameter allows us to work out the density of stars and distinguish between different sizes of stars which contain similar spectra according to their temperature (Alfonso-Garzón et al. 2009).

Parameter 14. Wave length of the image. Not all images of celestial objects are taken in the visible spectral range, such as those mentioned in Section 1.1. In fact, many images show how you would see the object in another wavelength (or simultaneously in several wavelengths) providing valuable information not seen by the human eye.

Table I. Similarities and divergences among the elements used to describe astronomical resources which MARC21, consolidated ISBD, and RDA present.

MARC 21 (1999 Edition. Update No. 15, September 2012)	ISBD Consolidated Edition (2011)	RDA (2010)
034 - Coded Cartographic Mathematical Data (R)	**---**	**---**
$h - Angular scale	---	---
$j - Declination - northern limit	---	---
$k - Declination - southern limit	---	---
$m - Right ascension - eastern limit	---	---
$n - Right ascension - western limit	---	---
$p - Equinox Equinox or epoch of a celestial chart.	---	---
$r - Distance from earth	---	---
$z - Name of extraterrestrial body	---	---
255 - Cartographic Mathematical Data (R)	**3.1. Mathematical data (Cartographic resources)**	---
$a - Statement of scale	3.1.1 Statement of scale (mandatory if applicable) 3.1.1.9 The scale for celestial charts is expressed as an angular scale in millimetres per degree.	7.25.1.5 Nonlinear Scale Record a statement of scale for an image, map, etc., with a nonlinear scale (e.g. celestial charts […]).
$b - Statement of projection	3.1.2 Statement of projection	7.26 Projection of Cartographic Content
$c - Statement of coordinates	3.1.3. Statement of coordinates and equinox 3.1.3.2 Maps of other celestial bodies such as the Earth's Moon, may have coordinates recorded as appropriate to the given celestial body's coordinate system.	7.4 Coordinates of Cartographic Content
$d - Statement of zone. Used for celestial charts.	3.1.3.3 Right ascension and declination	7.4.4 Right Ascension and Declination
$e - Statement of equinox Statement of equinox or epoch.	3.1.3. Statement of coordinates and equinox 3.1.3.4 Equinox ([…] the statement of equinox […] statement for the epoch […])	7.5. Equinox 7.6 Epoch
---	7.3. Notes on the material or type of resource for specific area 7.3.1.1 For celestial charts, the first note related to note on magnitude.	7.27 Other Details of Cartographic Content For celestial cartographic content, record the magnitude of the cartographic content.

Table II. Analysis of Astronomical parameters that MARC21, consolidated ISBD and RDA allow us to describe (C), define (F) and indicate how they should be recorded.

Astronomical parameters present in the standards	Aspects analyzed	MARC 21	ISBD Consolidated Edition	RDA
Right ascension and declination (equatorial celestial coordinates)	C	x	x	x
	F		x	x
	R	x	x	x
Distance from Earth	C	x		
	F	x		
	R			
Epoch	C	x	x	x
	F		x	x
	R	x	x	x
Equinox	C	x	x	x
	F		x	x
	R	x	x	x
Angular scale	C	x	x	x
	F			
	R		x	
Magnitude	C		x	x
	F			
	R			
Name of extraterrestrial body	C	x		
	F	x		
	R	x		
Projection	C	x	x	x
	F		x	x
	R	x	x	x

NOTE: **C**: Describe (parameters that allow us to describe the standards); **F**: Define (Parameters that conceptually define the standards); **R**: Record (parameters which show how information should be recorded). **Cell with X**: Yes; **Empty cell**: No.

6. CONCLUSIONS

This study has reflected that there are plenty of astronomical parameters available and accessible on the Internet through astronomical databases such as SIMBAD and NED, and software like *Google Sky*, which are not listed in the current cataloguing and coding standards which have been analyzed. These should be taken into account in order to improve the description of astronomical resources. This is demonstrated by the large number of requests that are performed daily on these databases, using those parameters like elements of consultation. Therefore, these parameters are candidates to become future description fields. In this sense, we think our proposal of astronomical parameters (Section 5) could help to complete the documental description of stars, galaxies, nebulas and clusters which are contained in the images from astronomical archives and libraries.

Although the libraries and associations involved in the creation of these standards have made a great effort to describe, in general terms, the bibliographic universe, we consider it necessary to continue working towards a more specialized description. We ask ourselves, in the same way as Picco and Ortiz-Repiso (2012), "whether the current model of cataloguing which aims to give an answer to the variety of bibliographic universe with a unique code, is adequate". Considering that we live in a highly specialized world where specialized documentation is constantly being generated, we should be able to perform much more specialized searches. Indeed, as Section 3.1.1. shows, now users may be interested not only in retrieving certain information from a celestial object, but, for example, getting all those objects that, having shifted to red between two values, are within a certain distance from the Earth. In short, our goal is to allow users to search the OPAC of documental institutions in a similar way as they do in a specialized database. Therefore, we think that only a more detailed description of astronomical resources will allow a satisfactory scientific information retrieval to be achieved.

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8. NOTES

[1] The database suggests write the acknowledgment including this sentence in the article: *(This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France).*

[2] The database suggests write the acknowledgment including this sentence in the article: *(This research has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration).*

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