

# STRASBOURG ASTRONOMICAL DATA CENTRE (CDS)

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## ABSTRACT

*The Centre de Données astronomiques de Strasbourg (CDS), created in 1972, has been a pioneer in the dissemination of digital scientific data. Ensuring sustainability for several decades has been a major issue because science and technology evolve continuously and the data flow increases endlessly. The paper briefly describes CDS activities, major services, and its R&D strategy to take advantage of new technologies. The next frontiers for CDS are the new Web 2.0/3.0 paradigm and, at a more general level, global interoperability of astronomical on-line resources in the Virtual Observatory framework.*

**Keywords:** Data Centre, Astronomy, Web 2.0/3.0, Interoperability, Virtual Observatory

## 1 INTRODUCTION

The *Centre de Données astronomiques de Strasbourg* (CDS, <http://cdsweb.u-strasbg.fr/>, Genova, Egret, Bienaymé, Bonnarel, Dubois, Fernique, et al., 2000) was a very early player in the dissemination of digital scientific data: it was created in 1972 by the French astronomy agency, INAG (National Institute for Astronomy and Geophysics), which is now CNRS/INSU (National Institute for Universe Sciences), in agreement with the University Louis Pasteur, now University of Strasbourg. Its mandate showed a far-seeing vision because it included, in those early times, the collection of “useful” data on astronomical objects in electronic form, their improvement by critical evaluation and combination, the distribution of the results to the international community, and also conducting research using the data. The whole idea of electronic data collection, curation, dissemination, and scientific re-use, which is the guideline of current policies about scientific data, has thus been present from the very beginning at CDS. The data centre had originally been created as the Centre de Données Stellaires (Stellar Data Centre), with the initial aim of gathering stellar data for studying the galactic structure, but it was given its current name, keeping the already well known acronym, in 1983 when its domain of action was extended to all astronomical objects (outside the solar system).

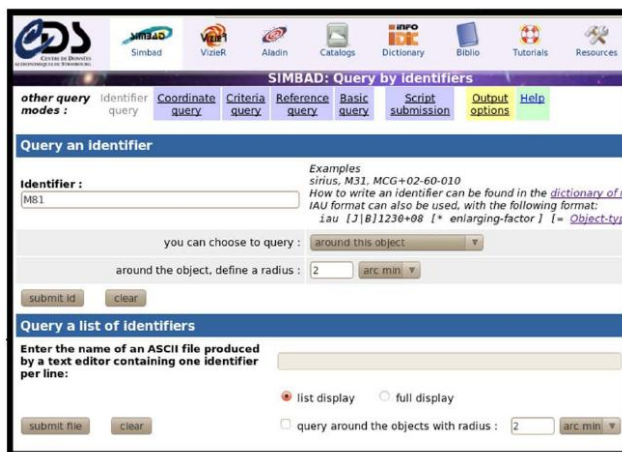
CDS's main role is to support the international community in its research tasks, not just to collect and curate information. Its core task is to provide highly used value-added services (Section 2). The main keywords of its activities are quality, scientific and technical relevance, collaboration with other actors of the field, and networking of expertise and resources. Its strategy, including its R&D strategy (Section 3), is *user* and *science driven*, not technology driven. Over the years, the CDS has built a unique expertise on scientific data, data dissemination, and exchange standards. It plays a major role in the astronomical Virtual Observatory, which aims at providing seamless access to the wealth of astronomical on-line resources.

## 2 CDS SERVICES

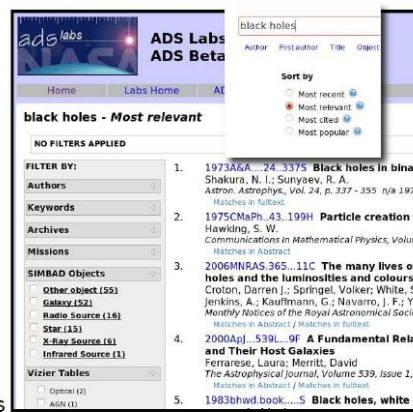
CDS has developed highly successful added-value services: SIMBAD, which summarizes information about astronomical objects – it reached 5 million objects in 2011; VizieR, the reference service for astronomical catalogues and tables published in academic journals; and Aladin, an image visualizer, conceived to access images and catalogues stored locally or remotely. These services are used daily by the international astronomical community, and their usage is constantly increasing (500,000 queries/day on average in 2010).

SIMBAD (see Figure 1) is the reference database for identification and bibliography of astronomical objects, providing a homogenized view across astronomy sub-disciplines (Wenger, Ochsenbein, Egret, Dubois, Bonnarel, Borde, et al., 2000). SIMBAD data is selected from articles published in academic journals and astronomical

catalogues. The first version of SIMBAD was developed at the beginning of the seventies, and the current version of the software, the fourth major update since 1972, has been operational since 2006. This last update to date has taken the CDS from a home-made, object oriented database to the open source platform PostgreSQL (Wenger & Oberto, 2007). Another interesting trend has been the inclusion of “less controlled” information in addition to measurements, bibliography, and data: notes from the CDS team (2002) and, more recently (2010), the possibility for users to post annotations, the first CDS Web2.0 implementation. The database content is built by a team of highly qualified librarians working closely with CDS scientists. In December 2011 SIMBAD contained 5,400,000 objects, 15,200,000 object identifiers, and 250,000 bibliographic references (respectively 3,000,000, 8,300,000 and 140,000 in 2003). To cope with the rapidly increasing flux of data, methods have been developed for semi-automated entry of information from article texts (Lesteven, Bonnin, Derriere, Dubois, Genova, Oberto, et al., 2010) and tables, but the results are validated by a specialist to keep a high level of quality.



Simbad interface



ADS Labs  
SIMBAD object types from a list of references



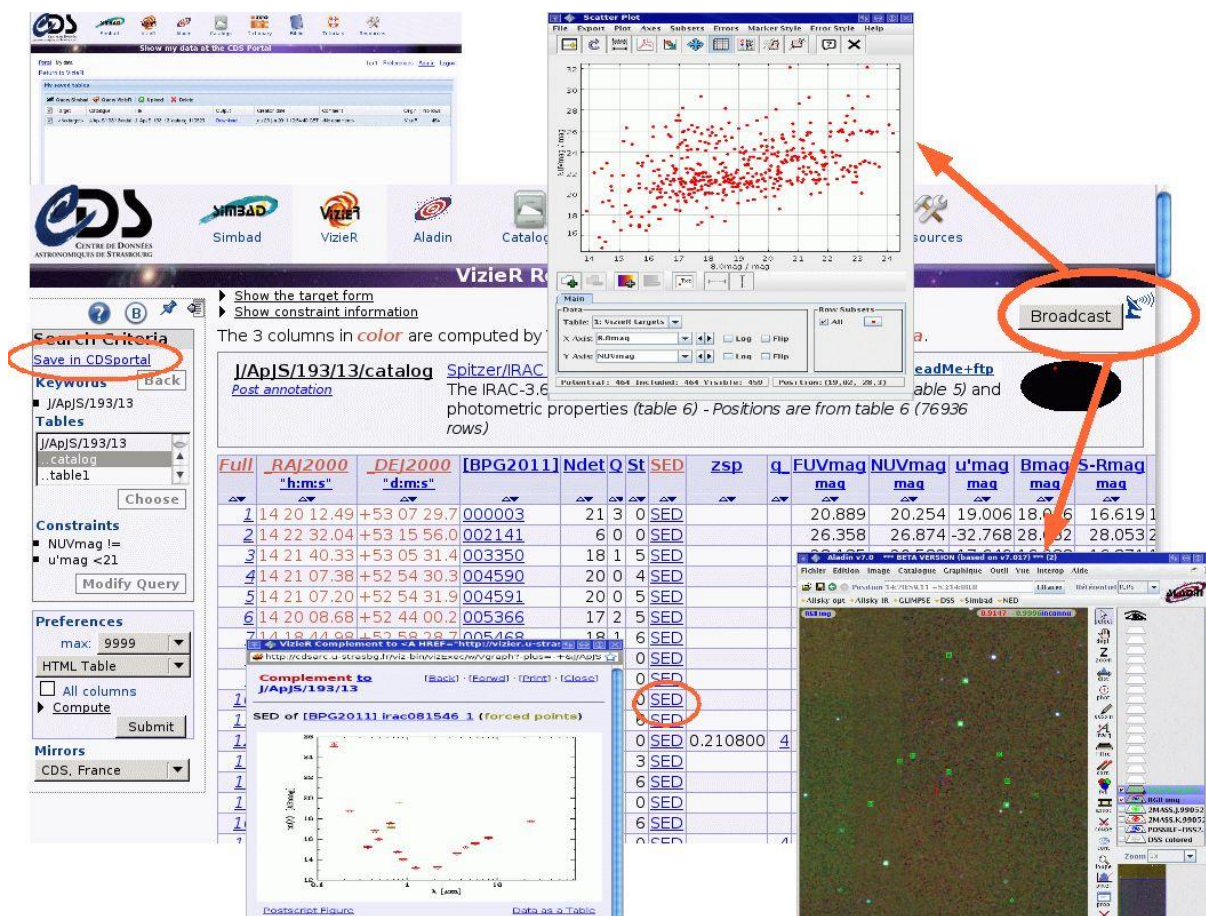
in ESA ISOC Science Data Archive



in STScI MAST Archive

**Figure 1.** SIMBAD user interface (top left) and usage of SIMBAD in other services, providing object types to ADS and “name resolving” to coordinates to various telescope observation archives

VizieR (see Figure 2) is the reference database for tabular data from astronomical catalogues and tables published in scientific papers – CDS is the data curator of these tables at the international level. Tables are completed by their description, which links their physical and astronomical content (Ochsenbein, Bauer, & Marcout, 2000). Tables are available through a ftp service and are also stored in a relational database system that allows users to browse them to discover and extract information. The master database is a Sybase system, and queries are distributed on a local cluster. Some of the seven mirror copies use PostgreSQL. A specific system allowing very efficient queries by position is implemented for very large catalogues (more than a few ten million objects, the largest ones contain more than  $10^9$  objects). The catalogue and table collection has been built in close collaboration with several of the major astronomy academic journals, beginning with the “on-line only” publication of “long” tables from *Astronomy & Astrophysics* by CDS as early as 1993, as explained in Section 3. VizieR contained 9,500 catalogues in December 2011 compared to 3,800 in 2003. More and more tables now come with “attached data”, such as images, spectra, time series, etc, well in line with the increasing requirement from the funding agencies to make data produced by research available for checking the research process and for re-use.



**Figure 2.** VizieR user interface (centre) with display of data through VO tools, Topcat and Aladin, and an object spectral energy distribution built from the newly implemented photometric metadata

Aladin (see Figure 3) is a reference software dedicated to the integration, visualization, and manipulation of images and catalogues provided by CDS or the user or remotely by astronomical data centres around the world. It is evolving continuously, with functionalities allowing users to manipulate huge images and data cubes, to deal with photometry, to convolve images, to carry out cross-matches, to use the software in scripts, etc. Aladin is used by ESA, the Space Telescope Science Institute, the NASA Extragalactic Database NED, and the Canadian Astronomical Data Centre to provide visualization of their images. Aladin is also the astronomical Virtual Observatory image portal, giving access to all data provided in VO-enabled services and able to interact with the other VO tools thanks to the VO interoperability framework. A major recent evolution is the usage of Healpix sky tessellation (Gorski, Hivon, Banday, Wandelt, Hansen, Reinecke, et al., 2005), which provides a hierarchical view of data with fast zooming capabilities and is used by the Planck and Gaia projects. This allows a new way of using the tool, also adapted to building views of the full or a part of the sky from data obtained by individual projects. These are offered the possibility to build a local Healpix database, which can be opened for usage by all Aladin users, by their collaborators, or kept for themselves (Fernique, Oberto, Boch & Bonnarel, 2009). The CDS reference image database is rapidly growing with the addition of “reference skies” in different wavelengths using this method.

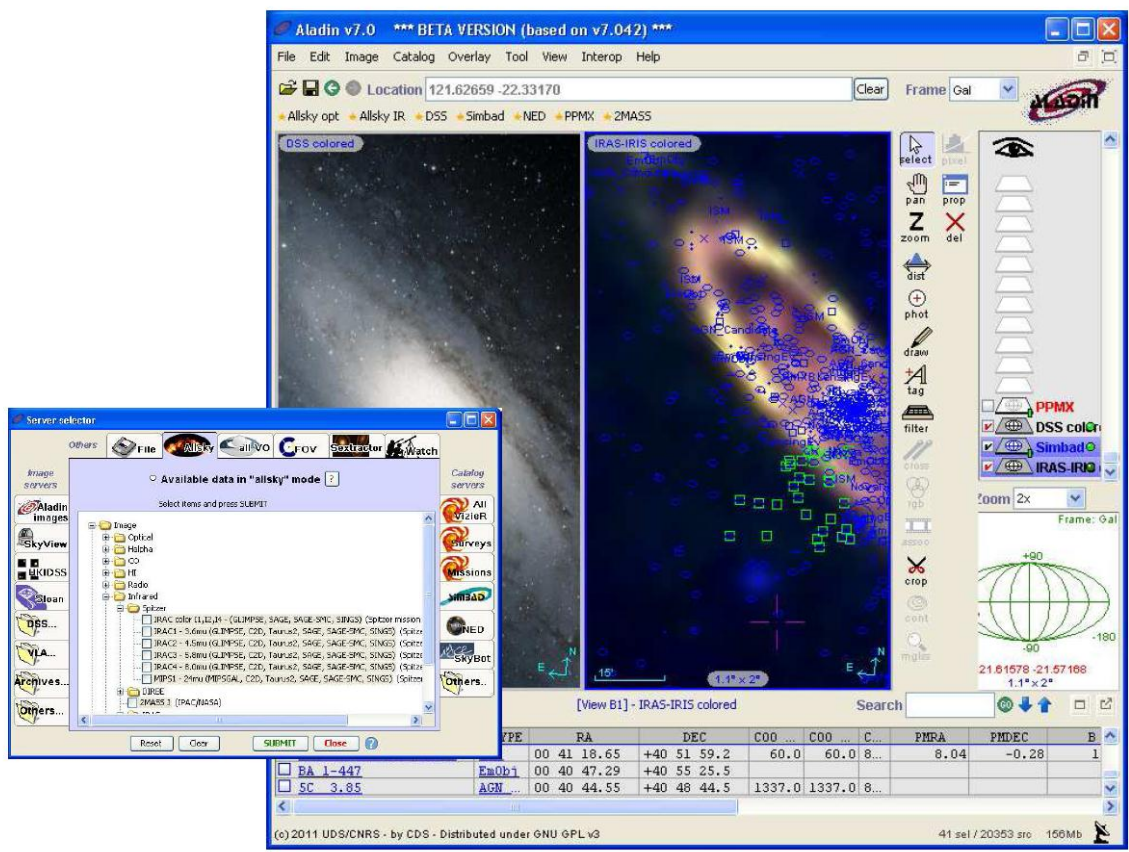


Figure 3. Aladin displaying the list of available All Sky views (left) and images of a galaxy at optical and infrared wavelengths, with objects from SIMBAD and a catalogue displayed on the right view.

### 3 RESEARCH & DEVELOPMENT AT CDS

Ensuring sustainability over a period of ten years when technology is evolving very quickly is not an easy task. It requires, in particular, a continuous and significant effort to be aware of technological and methodological advancements. For example, very soon after the advent of the WWW, CDS was at the forefront of the networking of on-line astronomical resources, in close collaboration with academic journals, the ADS bibliographic service, and observatory archives. As early as 1993, the CDS and *Astronomy & Astrophysics*, which was then a European journal (it now includes several South American countries among its partners), agreed to publish long tables electronically only at CDS, instead of printing them. This was a true change in paradigm because information that before then had been available in print only became usable and searchable data. The system also allows navigation between publication and databases (Ochsenbein, Bertout, Lequeux, & Genova, 2003).

R&D is thus a fundamental activity for medium/long term sustainability, and it has to be maintained in spite of the heavy constraints linked to the core data centre role (inclusion of the ever increasing data flow in the databases, software development and maintenance, operations). At CDS this is an in-house activity, which takes a significant fraction of engineers' and "instrumentalist" researchers' time. R&D actions have to be properly focused: they are driven by the data centre needs and not technology driven, i.e., new technologies are assessed only when there is a serious promise that they could improve CDS services or functioning and not because they are trendy. Relevant technologies have to be implemented early enough to fulfil users' expectations, but one critical requirement is that they be "sustainable enough" for usage for a certain number of years in a technology landscape where buzz and bandwagon effects tend to be dominant and highly praised technologies can disappear within a few years.

One current frontier is the implementation of the so-called Web 2.0 user-centric approach and of the Web 3.0 framework, with the usage of the semantic web, mobility, and universality. This is mandatory because users are expecting to find in their work environment the kind of functionalities they are using in their everyday life. CDS

has already implemented the first steps, with a portal that provides a “mash-up” of its services (Boch & Derriere, 2010) and the possibility for users to post annotations in SIMBAD and VizieR. The implementation of a personal user space opens the way for personalized customization of the user interface and allows one, for example, to store preferences or results. On the other hand, the evolution towards a CDS Web 3.0 will require a deep evolution of the user interface towards a more intuitive human-machine interaction. A first version of the CDS portal for mobile phones is available.

Another frontier for astronomy service providers is global interoperability of on-line resources, the so-called Astronomical Virtual Observatory. The CDS has been a precursor of the VO in many respects. It has also been a major player in the astronomical Virtual Observatory endeavour since the emergence of the project circa 2000. It has been participating actively in the definition of interoperability standards under the auspices of the International Virtual Observatory Alliance and implements the standards in its services, which are important building blocks of the astronomical information system. The CDS services are thus seamlessly available to the VO tools, and Aladin has become the image portal of the Virtual Observatory, able to interact with other tools to manage images, tabular data, spectra or data cubes, to fully explore astronomical data.

## 4 CONCLUSION

Since its creation 1972, CDS has successfully fulfilled its mission to provide support without borders to the astronomical research community and has played an important role in the networking of on-line astronomical resources, with observation archives, academic journals, and other data centres. This has required over the years an agile strategy to deal with the constant evolutions of astronomy, users’ expectations, and technology and with the endless data flow that the data centre has to manage. Among lessons learned is that quality, relevance to user needs, and partnership with other actors are critical to ensure long term sustainability.

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