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# INTERNET SERVICES FOR PROFESSIONAL ASTRONOMY

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**Abstract.** A (subjective) overview of Internet resources relevant to professional astronomers is given. Special emphasis is put on databases of astronomical objects and servers providing general information, e.g. on astronomical catalogues, finding charts from sky surveys, bibliographies, directories, browsers through multi-wavelength observational archives, etc. Archives of specific observational data will be discussed in more detail in other chapters of this book, dealing with the corresponding part of the electromagnetic spectrum. About 200 different links are mentioned, and every attempt was made to make this report as up-to-date as possible. As the field is rapidly growing with improved network technology, it will be just a snapshot of the present situation.

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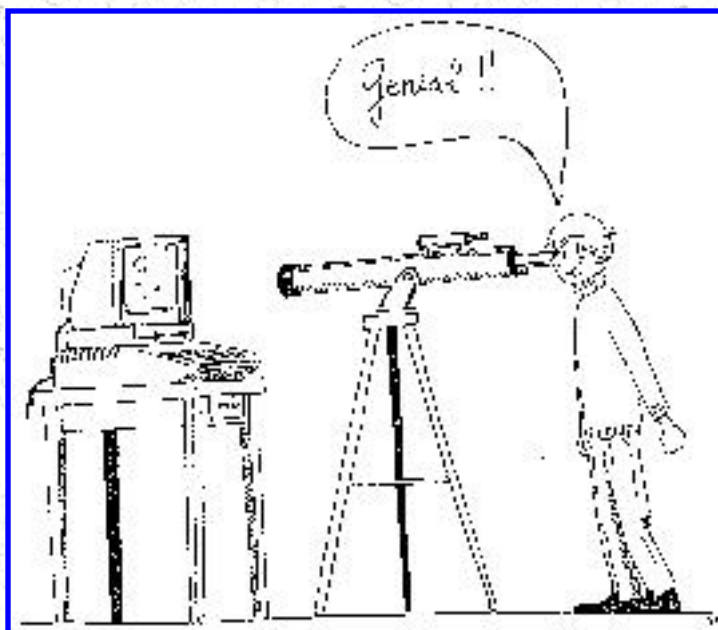
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# 1. INTRODUCTION

During the five or so years since the advent of the World Wide Web (WWW) the number of servers offering information for astronomers has grown as explosively as that of other servers (cf. [\[Adorf \(1995\)\]](#)). Perhaps even more than other media, the Internet is flooding us with an excessive amount of information and it has become a challenge to distinguish signal from noise. This report is yet another attempt to do this.

A web address is usually referred to as "Universal Resource Locator" (URL), and starts with the characters "http://". For better readability I omit these characters here, since one of the most common web browsers (netscape) assumes these by default anyway, unless other strings like "ftp://" are specified. All URL links in this overview are given in bold font. It should be emphasized that, owing to the nature of the WWW, some of these URLs may change without notice. The "File Transfer Protocol" (FTP) will appear as ftp in this text to coincide with the corresponding Unix command.

A useful introduction to the basics of Internet, explaining electronic mail, telnet, ftp, bulletin boards, "Netiquette", Archie, Gopher, Veronica, WAIS can be found e.g. in [\[Grothkopf \(1995\)\]](#) or [\[Thomas \(1997\)\]](#). I shall not repeat these basics here, but rather concentrate on practical tools to obtain astronomical information from the Internet. Many search engines have been developed for browsing WWW servers by keywords, e.g. AltaVista, Lycos, Savvy, Yahoo, WebGlimpse ([www.altavista.digital.com](http://www.altavista.digital.com), [www.lycos.com](http://www.lycos.com), <http://www.cs.colostate.edu/~dreiling/smartform.html>, [www.yahoo.com](http://www.yahoo.com), [donkey.CS.Arizona.EDU/webglimpse](http://donkey.CS.Arizona.EDU/webglimpse), resp.).





**Figure 1.** A typical example of an astronomer in the Internet age. (Drawing courtesy Georges Paturel)

A comprehensive list of URLs for "resource discovery" can be found in [[Adorf \(1995\)](#)], at [searchenginewatch.com](#), or see [www.cnet.com/Content/Features/Dlife/Search/ss06.html](http://www.cnet.com/Content/Features/Dlife/Search/ss06.html) for some useful tips to define your search adequately. For astronomical topics the flood of URLs returned is smaller at AstroWeb ([fits.cv.nrao.edu/www/astronomy.html](http://fits.cv.nrao.edu/www/astronomy.html)) or its mirrors ([cdsweb.u-strasbg.fr/astroweb.html](http://cdsweb.u-strasbg.fr/astroweb.html), [www.stsci.edu/astroweb/astronomy.html](http://www.stsci.edu/astroweb/astronomy.html), [msowww.anu.edu.au/~anton/astroweb](http://msowww.anu.edu.au/~anton/astroweb), [www.vilspa.esa.es/astroweb/astronomy.html](http://www.vilspa.esa.es/astroweb/astronomy.html)).

AstroWeb is a consortium of several astronomers who have been collecting astronomy-relevant links since 1995. However, AstroWeb does not actively skim the web for relevant sites regularly, although it has been done occasionally. It relies mainly on forms sent in by the authors or webmasters of those sites, and currently collects about 2500 links.

Recent reviews related to Internet resources in astronomy were given by Andernach, Hanisch & Murtagh (1994), [[Egret & Heck \(1995\)](#), [Murtagh et al. \(1995\)](#)], Egret & Albrecht (1995), [[Ochsenbein & Hearn \(1997\)](#)], [[Heck \(1997\)](#)], and [[Grothkopf et al. \(1998\)](#)]. Equally useful are the proceedings of the meetings on Astronomical Data Analysis Software and Systems, I-VII, held annually since 1991 and published as ASP Conference Series vols. 25, 52, 61, 77, 101, 125, and 145. For information and electronic proceedings on meetings III-VII, look at:

- [cadwww.dao.nrc.ca/ADASS/adass\\_proc/adass3/adasstoc/adasstoc.html](http://cadwww.dao.nrc.ca/ADASS/adass_proc/adass3/adasstoc/adasstoc.html)
- [www.stsci.edu/stsci/meetings/adassIV/toc.html](http://www.stsci.edu/stsci/meetings/adassIV/toc.html)
- [iraf.noao.edu/ADASS/adass.html](http://iraf.noao.edu/ADASS/adass.html)
- [www.stsci.edu/meetings/adassVI](http://www.stsci.edu/meetings/adassVI)
- [www.stsci.edu/stsci/meetings/adassVII](http://www.stsci.edu/stsci/meetings/adassVII)

I do not discuss services explicitly dedicated to amateurs, although there is no well-defined boundary between professional and amateur astronomy, and the latter can be of vital use to professionals, e.g. in the field of variable stars, comets or special solar system events. Indeed, stellar photometry - a field traditionally dominated by amateur observers - boasts a database of variable star observations ([www.aavso.org/adata/database.stm](http://www.aavso.org/adata/database.stm)) that is the envy of many professionals and a shining example to the professional world of cooperation, organization and service. A further proof of a fruitful interaction between professionals and amateurs is "The Amateur Sky Survey" (TASS) which plans to monitor the sky down to 14-16 mag and study variable stars, asteroids and comets ([www.tass-survey.org](http://www.tass-survey.org); [[Gombert & Droege \(1998\)](#)]).

A cautionary note: by its very nature of describing "sites" on the "web", this work is much like a tourist guide with all its imperfections; hotels or restaurants may have closed or changed their chefs, new roads

may have been opened, and beaches may have deteriorated or improved. As similar things happen constantly with web pages or URLs, take this work as a suggestion only. You will be the one to adapt it to your own needs, and maintain it as your own reference.

Although I ``visited" virtually all links quoted in the present report, be prepared to find obsolete, incomplete or no information at all at some URLs. However, after having convinced yourself of missing, obsolete, or incorrect information offered at a given site, do not hesitate to contact the ``webmaster" or manager of that site and make constructive suggestions for improvement (rather than merely complain). This is even more important if you find a real error in database services used by a wide community. Vice versa, in your own efforts to provide your web pages, try to avoid links to other documents which do not exist or merely claim to be ``under construction", just imagine the time an interested user with a slow connection may waste in calling such a link.

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## 2. DATA CENTRES

The two largest, general purpose data centres for astronomy world-wide are the ``Astronomical Data Center" (ADC; [adc.gsfc.nasa.gov/adc.html](http://adc.gsfc.nasa.gov/adc.html)) of NASA's Astrophysics Data Facility (ADF), and the ``Centre de Données astronomiques de Strasbourg" (CDS; [cdsweb.u-strasbg.fr](http://cdsweb.u-strasbg.fr)). They were the first institutions to systematically collect machine-readable versions of astronomical catalogues but have now widened their scope considerably. Several of their services are so diverse that they will be mentioned in different sections of this paper. At other, medium-sized, regional data centres (e.g. in Moscow, Tokyo, Beijing, Pune, etc.) some of the services of the two major centres are mirrored to reduce the network load on ADC and CDS.

The increasing number of space missions has led to the creation of mission-oriented data centres like:

- IPAC ([www.ipac.caltech.edu](http://www.ipac.caltech.edu))
- STScI ([www.stsci.edu](http://www.stsci.edu))
- ST-ECF ([ecf.hq.eso.org](http://ecf.hq.eso.org))
- MPE ([www.rosat.mpe-garching.mpg.de](http://www.rosat.mpe-garching.mpg.de))
- ESTEC ([astro.estec.esa.nl](http://astro.estec.esa.nl))
- VILSPA ([www.vilspa.esa.es](http://www.vilspa.esa.es))
- CADCA ([cadwww.dao.nrc.ca](http://cadwww.dao.nrc.ca))

and many others. Several major ground-based observatories have evolved data centres offering access to their archives of past observations. Examples are the European Southern Observatory ([archive.eso.org](http://archive.eso.org)), the Royal Greenwich Observatory Isaac Newton Group of Telescopes on La Palma ([archive.ast.cam.ac.uk/ingarch](http://archive.ast.cam.ac.uk/ingarch)), the National Radio Astronomy Observatory (NRAO) Very Large Array ([www.aoc.nrao.edu/vla/html/VLAhome.shtml](http://www.aoc.nrao.edu/vla/html/VLAhome.shtml)), the Westerbork Synthesis Radio Telescope (WSRT; [www.nfra.nl/scissor](http://www.nfra.nl/scissor)), etc.

Many bulky data sets, like e.g. the IRAS data products, the Hubble Space Telescope (HST) Guide Star Catalogue (GSC), etc., have been widely distributed on CD-ROMs. For a comprehensive, though not complete, list of CD-ROMs in astronomy see the ``Mediatheque" maintained at CDS ([cdsweb.u-strasbg.fr/mediatheque](http://cdsweb.u-strasbg.fr/mediatheque)) and D. Golombek's contribution to these proceedings.

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### 3. ASTRONOMICAL CATALOGUES

We consider here "astronomical catalogues" as static, final compilations of data for a given set of cosmic objects. According to [\[Jaschek \(1989\)\]](#) they can be further subclassified into (1) observational catalogues, (2) compilation catalogues, and (3) critical compilation catalogues and bibliographic compilation catalogues. In class (1) we also include tables of observational data commonly published in research papers.

The CDS maintains the most complete set of astronomical catalogues in a publicly accessible archive at [cdsweb.u-strasbg.fr/Cats.html](http://cdsweb.u-strasbg.fr/Cats.html). Currently ~ 2700 catalogues and published data tables are stored, of which ~ 2200 are available for downloading via **ftp**, and a subset of ~ 1760 of them are searchable through the **VizieR** browser (see below). Catalogues can be located by author name or keyword. Since 1993 tables published in *Astronomy & Astrophysics* and its Supplement Series are stored and documented in a standard way at CDS. As the authors are only recommended, but not obliged, to deposit their tables at CDS, there is a small incompleteness even for recently published tabular material. CDS is also making serious efforts in completing its archive by converting older or missing published tables into electronic form using a scanner and "Optical Character Recognition" (OCR) software. However, catalogues prepared in such a way (as stated in the accompanying documentation file) should be treated with some caution, since OCR is never really free of errors and careful proof-reading is necessary to confirm its conformity with the original.

Access to most catalogues is offered via anonymous **ftp** to [cdsarc.u-strasbg.fr](http://cdsarc.u-strasbg.fr) in the subdirectory `/pub/cats`. This directory is further subdivided into nine sections of catalogues (from stellar to high-energy data), and the "J" directory for smaller tables from journals. These subdirectories are directly named after their published location, e.g., `/pub/cats/J/A+AS/90/327` has tabular data published in *A&AS* Vol. 90, p. 327.

There are other useful commands on the CDS node `simbad` which are also available without a "proper" SIMBAD account ([Section 4.1](#)). You can telnet to [simbad.u-strasbg.fr](http://simbad.u-strasbg.fr), login as **info**, give `<CR>` as password. This account allows one to query the "Dictionary of Nomenclature of Celestial Objects" and provides comments on the inclusion (or not) in SIMBAD of objects with a certain acronym. Other useful commands are e.g. **findcat**, allowing one to locate electronic catalogues by author or keyword, **findacro** to resolve acronyms of object designations ([Section 9](#)), **findgsc** to search the Guide Star Catalogue (GSC 1.1), and **findpmm** to search in the USNO-A1.0 catalogue of ~ 5  $10^8$  objects ([Section 5.2](#)). The commands **simbib** and **simref** are useful to interrogate the SIMBAD bibliography remotely (by author's names or words in paper titles) or resolve the 19-digit "refcodes" ([Section 6](#)). The syntax of all commands can be checked by typing command `-help`. Users with frequent need for these utilities may install these commands on their own machine, by retrieving the file **cdsarc.u-**



[strasbg.fr/pub/cats/cdsclient.tar.Z](http://strasbg.fr/pub/cats/cdsclient.tar.Z) (~ 40 kb). This allows them to access the above information instantaneously from the command line.

NASA-ADC and CDS maintain mirror copies of their catalogue collections (see the URL [adc.gsfc.nasa.gov/adc/adc\\_archive\\_access.html](http://adc.gsfc.nasa.gov/adc/adc_archive_access.html)). A major fraction of the CDS and NASA-ADC catalogue collection is also available at the Japanese ``Astronomical Data Analysis Center" (ADAC; [adac.mtk.nao.ac.jp](http://adac.mtk.nao.ac.jp)), at the Indian ``Inter-University Centre for Astronomy & Astrophysics" (IUCAA; [www.iucaa.ernet.in/adc.shtml](http://www.iucaa.ernet.in/adc.shtml), click on ``Facilities"), and at the Beijing Astronomical Data Center ([www.bao.ac.cn/](http://www.bao.ac.cn/)) in China.

NASA-ADC has issued a series of four CD-ROMs with collections of the ``most popular" (i.e. most frequently requested) catalogues in their **ftp** archive. Some CDs (see [adc.gsfc.nasa.gov/adc/adc\\_other\\_media.html](http://adc.gsfc.nasa.gov/adc/adc_other_media.html)) come with a simple software to browse the catalogues. However, the CD-ROM versions of these catalogues are static, and errors found in them (see errata at <ftp://adc.gsfc.nasa.gov/pub/adc/errors>), are corrected only in the **ftp** archive.

Many tables or catalogues published in journals of the American Astronomical Society (AAS), like the Astrophysical Journal (ApJ), its Supplement (ApJS), the Astronomical Journal (AJ), and also the Publications of the Astronomical Society of the Pacific (PASP), have no longer appeared in print since 1994. Instead, the articles often present a few sample lines or pages only, and the reader is referred to the AAS CD-ROM to retrieve the full data. As these CD-ROMs are published only twice a year, in parallel with the journal subscription, this would imply that the reader has to wait up to six months or more to be able to see the data. At the time of writing neither the printed papers nor the electronic ApJ and AJ mention that the CD-ROM data are also available via anonymous **ftp** (at <ftp://ftp.aas.org/cdrom>) before or at the time of the publication on paper. The **ftp** service appears much more practical than the physical CD-ROMs for active researchers (i.e. probably the majority of readers), and perhaps for this reason AAS has decided that CD-ROMs will not be issued beyond Vol. 9 (Dec. 1997; see also [www.journals.uchicago.edu/AAS/cdrom](http://www.journals.uchicago.edu/AAS/cdrom)). It would be desirable if readers of electronic AAS journals were able to access the newly published tabular data in their entirety and more directly in the future. With the trend to publish tabular data only in electronic form, there is also hope that authors may be released from the task of marking up large tables in TEX or L<sup>A</sup>TEX, since the main use of these tables will be their integration in larger databases, processing with TEX-incompatible programming languages, or browsing on the user's computer screen, where TEX formatting symbols would only be disturbing (cf. also [Section 11](#)).

Most of the AAS CD-ROM data are also ingested in the catalogue archives of CDS and ADC. However, many other catalogues, not necessarily available from these two centres, can be found within various other services, e.g. in CATS, DIRA2, EINLINE, HEASARC, STARCAT (see [Section 4.2](#)), or the LANL/SISSA server ([Section 6.2](#)), etc.. In particular, the present author has spent much effort to collect (or recover via OCR) many datasets (now almost 800) published as tables in journals (see <ftp://astro.ugto.mx/pub/outgoing/heinz/cats.and>). About half of these were kindly provided upon request



by the the authors of the tables. The others were prepared either via scanning and OCR by the present author, applying careful proof-reading, or they were found on the LANL/SISSA preprint server and converted from TEX (or even PostScript) to ASCII format by the present author. There is no master database that would indicate on which of these servers a certain catalogue is available.

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## 4. RETRIEVING INFORMATION ON OBJECTS

We may distinguish several facets to the task of retrieving information on a given astronomical object. To find out what has been published on that object, a good start is made by consulting the various object databases ([Section 4.1](#)) and looking at the bibliographical references returned by them. Some basic data on the object will also be offered, but to retrieve further published measurements a detailed search in appropriate catalogue collections will be necessary ([Section 4.2](#)). Eventually one may be interested in retrieving and working with raw or reduced data on that object such as spectra, images, time series, etc., which may only be found in archives of ground- or space-based observatories ([Section 4.3](#)).

Only objects outside the solar system will be discussed in this section. Good sites for information on solar system objects are NASA's ``Planetary Data System" (PDS) at JPL ([\[Planetary and Space Science \(1996\)\]](#); [pds.jpl.nasa.gov](http://pds.jpl.nasa.gov) and [ssd.jpl.nasa.gov](http://ssd.jpl.nasa.gov)), the ``Lunar and Planetary Institute" (LPI; [cass.jsc.nasa.gov/lpi.html](http://cass.jsc.nasa.gov/lpi.html)), the ``Solar Physics" and ``Planetary Sciences" links at the NSSDC ([nssdc.gsfc.nasa.gov/solar](http://nssdc.gsfc.nasa.gov/solar) and [.../planetary](http://.../planetary)), and the ``Minor Planet Center" ([cfa-www.harvard.edu/cfa/ps/mpc.html](http://cfa-www.harvard.edu/cfa/ps/mpc.html)). The ``Students for the Exploration and Development of Space" homepage also offers useful links on solar system information ([seds.lpl.arizona.edu](http://seds.lpl.arizona.edu)).



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## 4.1. Object Databases

Object databases are understood here as those which gather both bibliographical references and measured quantities on Galactic and/or extragalactic objects. There are three prime ones: [SIMBAD](#), [NED](#) and [LEDA](#); the latter two are limited to extragalactic objects only. A comparison of their extragalactic content has been given by [[Andernach \(1995\)](#)]. All three involve an astronomical "object-name resolver", which accepts and returns identifiers; it also permits retrieval of all objects within a stated radius around coordinates in various different systems or equinoxes. For large lists of objects the databases can also support batch jobs, which are prepared according to specific formats and submitted via email. The results can either be mailed back or be retrieved by the user via anonymous **ftp**. While [SIMBAD](#) and [NED](#) allow some limited choice of output format, [LEDA](#) is the only one that delivers the result in well-aligned tables with one object per line.

[SIMBAD](#) (Set of Identifications, Measurements, and Bibliography for Astronomical Data) is a database of astronomical objects outside the solar system, produced and maintained by CDS. Presently [SIMBAD](#) contains 1.54 million objects under 4.4 million identifying names, cross-indexed to over 2200 catalogues. It provides links to 95,700 different bibliographical references, collected for stars systematically since 1950. Presently over 90 journals are perused for [SIMBAD](#), which is the most complete database for Galactic objects (stars, HII regions, planetary nebulae, etc.), but since 1983 it has included galaxies and other extragalactic objects as well. [SIMBAD](#) is not quite self-explanatory; its user's guide can be retrieved from <ftp://cdsarc.u-strasbg.fr/pub/simbad/guide13.ps.gz>, or may be consulted interactively at [simbad.u-strasbg.fr/guide/guide.html](http://simbad.u-strasbg.fr/guide/guide.html).

Access to [SIMBAD](#) requires a password, and applications may be sent by email to [question@simbad.u-strasbg.fr](mailto:question@simbad.u-strasbg.fr). By special agreement, access is free for astronomers affiliated to institutions in Europe, USA and Japan, while users from other countries are charged for access. The **telnet** address of [SIMBAD](#) is [simbad.u-strasbg.fr](telnet://simbad.u-strasbg.fr) and its web address in Europe is [simbad.u-strasbg.fr/Simbad](http://simbad.u-strasbg.fr/Simbad). It has a mirror site in USA, at [simbad.harvard.edu](http://simbad.harvard.edu).

The "NASA/IPAC Extragalactic Database" ([NED](#), [[Helou et al. \(1995\)](#)]) currently contains positions, basic data, and over 1,275,000 names for 767,000 extragalactic objects, nearly 880,000 bibliographic references to 33,000 published papers, and 37,000 notes from catalogues and other publications, as well as over 1,200,000 photometric measurements, and 500,000 position measurements. [NED](#) includes 15,500 abstracts of articles of extragalactic interest that have appeared in A&A, AJ, ApJ, MNRAS, and PASP since 1988, and from several other journals in more recent years. Although [NED](#) is far more complete in extragalactic objects than is [SIMBAD](#), it is definitely worthwhile consulting [SIMBAD](#) to cover the extragalactic literature for the five years in its archives before [NED](#) commenced in 1988. Samples of

objects may be extracted from [NED](#) through filters set by parameters like position in the sky, redshift, object type, and many others. [NED](#) has started to provide digital images, including finding charts from the ``Digitized Sky Survey" (DSS) for some 120,000 of their objects. A unique feature of [NED](#) is that the photometric data for a given object may be displayed in a plot of the ``Spectral Energy Distribution" (SED). [NED](#) is accessible without charge at [nedwww.ipac.caltech.edu](http://nedwww.ipac.caltech.edu) or via telnet to **ned.ipac.caltech.edu** (login as **ned**).

The ``[Lyon-Meudon Extragalactic Database](#)" (LEDA), created in 1983 and maintained at Lyon Observatory, offers free access to the main (up to 66) astrophysical parameters for about 165,000 galaxies in the ``nearby" Universe (i.e. typically  $z < 0.3$ ). All raw data as compiled from literature are available, from which mean homogenized parameters are calculated according to reduction procedures refined every year ([[Paturel et al. \(1997\)](#)]). Finding charts of galaxies, at almost any scale, with or without stars from the GSC, can be created and  $\sim 74,000$  images of part of these galaxies can be obtained in PS format. These images were taken with a video camera from the POSS-I for identification purposes only and are of lower quality than those from the Digitized Sky Survey ([5](#)). However, they have been used successfully by the [LEDA](#) team to improve positions and shape parameters of the catalogued galaxies. [LEDA](#) also incorporates the galaxies (20,000 up to now) which are being detected in the ongoing ``Deep Near-IR Survey of the Southern Sky" (DENIS; [www.strw.leidenuniv.nl/denis](http://www.strw.leidenuniv.nl/denis) or [denisexg.obspm.fr/denis/denis.html](http://denisexg.obspm.fr/denis/denis.html)). A flexible query language allows the user to define and extract galaxy samples by complex criteria. LEDA can be accessed at [www-obs.univ-lyon1.fr/](http://www-obs.univ-lyon1.fr/) or via telnet to **lmc.univ-lyon1.fr** (login as **leda**). The homogenized part of LEDA's data, together with simple interrogation software, is being released on ``PGCROMs"s every four years (1992, 1996, 2000...).

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## 4.2. Pseudo-Databases: Searchable Collections of Catalogues

It should be kept in mind that object databases like SIMBAD, NED and LEDA, generally do not include the full information contained in the CDS/ADC collections of catalogues and tables. This is especially true for older tables which may have become available in electronic form only recently. The catalogues and tables frequently contain data columns not (yet) included in the object databases. Thus the table collections should be considered as a valuable complement to the databases. Different sites support different levels of search of those collections.

Probably the largest number of individual catalogues (~ 1560) that can be browsed from one site is that offered by **VizieR** at CDS ([vizier.u-strasbg.fr](http://vizier.u-strasbg.fr)). You may select the catalogues by type of object, wavelength range, name of space mission, etc. An advantage of **VizieR** is that the result comes with hyperlinks (if available) to SIMBAD or other relevant databases, allowing more detailed inquiries on the retrieved objects. A drawback is that a search on many of them at the same time requires selecting them individually by clicking on a button. An interface allowing searches through many or all of them is under construction.

The DIRA2 service ("Distributed Information Retrieval from Astronomical files") at [www.ira.bo.cnr.it/dira/gb](http://www.ira.bo.cnr.it/dira/gb) is maintained by the ASTRONET Database Working Group in Bologna, Italy. It provides access to data from astronomical catalogues (see the manual at [www.pd.astro.it/prova/prova.html](http://www.pd.astro.it/prova/prova.html)). The DIRA2 database contains about 270 original catalogues of Galactic and extragalactic data written in a DIRA-specific ASCII format. The output of the searches are ASCII or FITS files that can be used in other application programs. DIRA2 allows one to plot objects in an area of sky taken from various catalogues onto the screen with various symbols of the user's choice. Sorting as well as selecting and cross-identification of objects from different catalogues is possible, but there is no easy way to search through many catalogues at a time. The software is publicly available for various platforms.

The "CATalogs supporting System" (CATS; [cats.sao.ru](http://cats.sao.ru)) has been developed at the Special Astrophysical Observatory (SAO) in Russia. Apart from dozens of the larger general astronomical catalogues it offers the largest collection of radio source catalogues searchable with a single command (see chapter on Radio Astronomy by H. Andernach in these proceedings). A search through the entire catalogue collection "in one shot" is straightforward.

A set of about 100 catalogues, dominated by X-ray source catalogues and mission logs, can be browsed at the "High Energy Astrophysics Science Archive Research Center" (HEASARC) at [heasarc.gsfc.nasa.gov/W3Browse](http://heasarc.gsfc.nasa.gov/W3Browse). The same collection is available at the "Leicester Database and Archive Service" (LEDAS; [ledas-www.star.le.ac.uk](http://ledas-www.star.le.ac.uk)).

A similar service, offered via telnet and without a web interface, is the ``Einstein On-line Service" (EOLS, or EINLINE) at the Harvard-Smithsonian Center for Astrophysics (CfA). It was designed to manage X-ray data from the EINSTEIN satellite, but it also served in 1993/94 as a testbed for the integration of radio source catalogues. Although EOLS is still operational with altogether 157 searchable catalogues and observing logs, lack of funding since 1995 has prevented any improvement of the software and interface or the integration of new catalogues.

NASA's ``Astrophysics Data System" (ADS) offers a ``Catalog Service" at [adscat.harvard.edu/catalog\\_service.html](http://adscat.harvard.edu/catalog_service.html). With the exception of the Minnesota Plate Scanning project (APS, cf. [Section 5.1](#)), all available 130 catalogues are stored at the Smithsonian Astrophysical Observatory (SAO). For a complete list, request ``catalogues by name" from the catalogue service. Not all available catalogues can be searched simultaneously. The service has not been updated for several years and will eventually be merged with **VizieR** at CDS.

A growing number of catalogues is available in *datOZ* (see [146.83.9.18/datoz\\_t.html](http://146.83.9.18/datoz_t.html)) at the University of Chile as described in [[Ortiz \(1998\)](#)]. It offers visualization and cross-correlation tools. The STARCAT interface at ESO ([arch-http.hq.eso.org/starcats.html](http://arch-http.hq.eso.org/starcats.html)) with only 65 astronomical catalogues is still available, but has become obsolete. ASTROCAT at CADC ([cadwww.dao.nrc.ca/astrocat](http://cadwww.dao.nrc.ca/astrocat)) offers about 14 catalogues.

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### 4.3. Archives of Observational Data

As these will be discussed in more detail in the various chapters of this book dedicated to Internet resources in different parts of the electromagnetic spectrum, I list only a few URLs from which the user may start to dig for data of his/her interest.

Abstracts of sections of the book by [\[Egret & Albrecht \(1995\)\]](#) are available on-line at [cdsweb.u-strasbg.fr/data-online.html](http://cdsweb.u-strasbg.fr/data-online.html) and provide links to several archives. The AstroWeb consortium offers a list of currently 129 records for "Data and Archive Centers" at [www.cv.nrao.edu/fits/www/yp\\_center.html](http://www.cv.nrao.edu/fits/www/yp_center.html). STScI ([archive.stsci.edu](http://archive.stsci.edu)) has been designated by NASA as a multi-mission archive centre, focussing on optical and UV mission data sets. It now plays a role analogous to HEASARC for high-energy data (see below) and IPAC ([www.ipac.caltech.edu](http://www.ipac.caltech.edu)) for infra-red data. The latter are associated in the "Astrophysics Data Centers Coordinating Council" (ADCCC; [hea-www.harvard.edu/adccc](http://hea-www.harvard.edu/adccc)). The Canadian Astronomy Data Center (CADC; [cadcwww.dao.nrc.ca](http://cadcwww.dao.nrc.ca)) includes archives of the CFHT, JCMT and UKIRT telescopes on Hawaii. The ESO and ST-ECF Science Archive Facility at [archive.eso.org](http://archive.eso.org) offers access to data obtained with the "New Technology Telescope" (NTT), and to the catalogue of spectroscopic plates obtained at ESO telescopes before 1984. The "Hubble Data Archive" at [archive.stsci.edu](http://archive.stsci.edu) includes the HST archive, the International Ultraviolet Explorer (IUE) archive and the VLA FIRST survey. The La Palma database at [archive.ast.cam.ac.uk/ingarch](http://archive.ast.cam.ac.uk/ingarch) contains most observations obtained with the Isaac Newton group of telescopes of RGO. At the National Optical Astronomy Observatory (NOAO; [www.noao.edu/archives.html](http://www.noao.edu/archives.html)) most data from CTIO and KPNO telescopes are now being saved, and are available by special permission from the Director. Data from several high-energy satellite missions may be retrieved from HEASARC ([heasarc.gsfc.nasa.gov](http://heasarc.gsfc.nasa.gov)), and from LEDAS ([Section 4.2](#)). For results of the Space Astrometry Mission HIPPARCOS see [astro.estec.esa.nl/Hipparcos/hipparcos.html](http://astro.estec.esa.nl/Hipparcos/hipparcos.html) or [cdsweb.u-strasbg.fr](http://cdsweb.u-strasbg.fr).

Images from many surveys of the whole or most of the sky can be retrieved from the SkyView facility ([skyview.gsfc.nasa.gov](http://skyview.gsfc.nasa.gov)) at Goddard Space Flight Center (GSFC). Documentation of these surveys is available at [skyview.gsfc.nasa.gov/cgi-bin/survey.pl](http://skyview.gsfc.nasa.gov/cgi-bin/survey.pl). Overlays of these surveys with either contours from another survey or objects from a large set of object catalogues may be requested interactively.

Until late 1997 there was no tool which unified the access to the multitude of existing observatory archives. A serious approach to this goal has been made within the "AstroBrowse" project ([sol.stsci.edu/~hanisch/astrobrowse\\_links.html](http://sol.stsci.edu/~hanisch/astrobrowse_links.html)). This resulted in the "Starcast" facility [faxafloi.stsci.edu:4547/starcast](http://faxafloi.stsci.edu:4547/starcast) allowing one to find (and retrieve) relevant data (photometric, imaging, spectral or time series) on a given object or for a given region of sky, in any range of the electromagnetic spectrum from ground- or space-based observatories. The HEASARC "AstroBrowser"

([legacy.gsfc.nasa.gov/ab](http://legacy.gsfc.nasa.gov/ab)) provides an even wider scope, including astronomical catalogues and **VizieR** at the same time. The ``Multimission Archive at STScI" (MAST; [archive.stsci.edu/mast.html](http://archive.stsci.edu/mast.html)) currently combines the archive of HST, IUE, Copernicus, EUVE, UIT, plus that of the FIRST radio survey and the DSS images. Its interface with astronomical catalogues allows one to query e.g. which high-redshift QSOs have been observed with HST, or which Seyfert galaxies with IUE.

An ``Astronomy Digital Image Library" (ADIL) is available from the National Center for Supercomputing Applications (NCSA) at [imaginglib.ncsa.uiuc.edu/imaginglib](http://imaginglib.ncsa.uiuc.edu/imaginglib).

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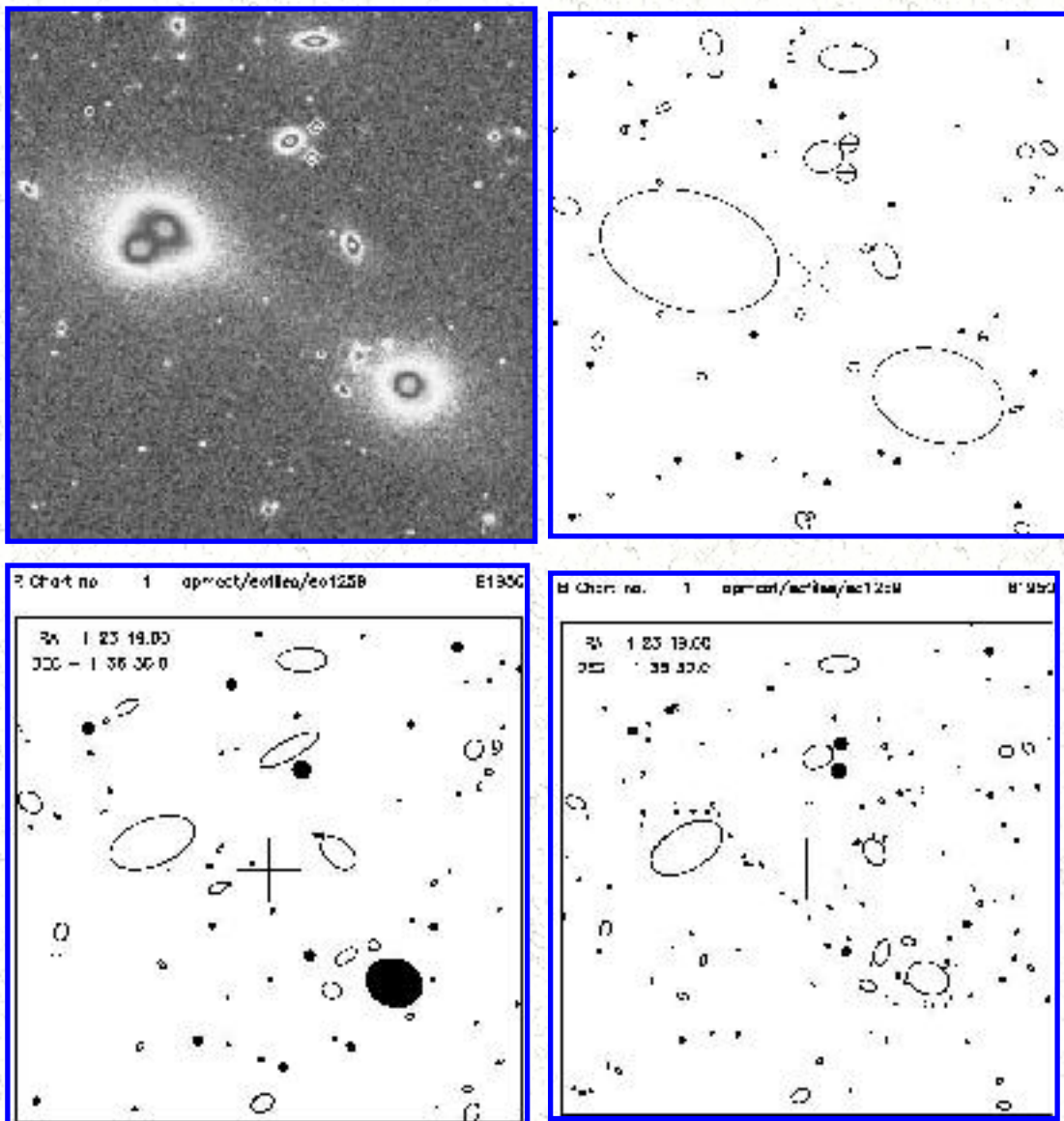
## 5. DIGITAL OPTICAL SKY SURVEYS, FINDING CHARTS, & PLATE CATALOGUES

The first Palomar Observatory Sky Survey (POSS-I) was taken on glass plates in red (E) and blue (O) colour from 1950 to 1958. While glass copies are less commonly available, the printed version of POSS-I provided the first reference atlas of the whole sky north of  $-30^\circ$  declination down to  $\sim 20$ mag. Together with its southern extensions, provided 20-30 years later by ESO in B, and by the UK Schmidt Telescope (UKST) in B<sub>J</sub>, it was the basic tool for optical identification of non-optical objects. However, reliable optical identification required a positional accuracy on the order of a few arcsec. A common, but not too reliable, tool for this were transparent overlays with star positions taken from the SAO star catalogue. Major limitations are the low density of stars at high Galactic latitudes and differences in the scale and projection between the transparency and the Palomar print or plate. For higher accuracy than a few arcsec the use of a plate measuring machine was required for triangulation of fainter stars closer to the object in question, but such machines were only available at a few observatories.

Curiously, it was mainly the necessity, around 1983, to prepare the HST Guide Star Catalog (GSC; [www-gsss.stsci.edu/gsc/gsc.html](http://www-gsss.stsci.edu/gsc/gsc.html)), which led to a whole new Palomar Sky survey (the ``quick-V") with shorter exposures in the V band, which was then fully digitized at STScI with 1.7" pixel size to extract guide stars for the HST. Later the deeper red plates of POSS-I were also scanned at the same resolution to provide an image database of the whole northern sky. For the first time almost the whole sky was available with absolute accuracy of  $\sim 1''$ , but owing to the sheer volume the pixel data were accessible only to local users at STScI during the first years. By the time that they had been prepared for release on 102 CD-ROMs and sold by the Astronomical Society of the Pacific (ASP), the Internet and the WWW had advanced to a point where small extractions of these pixel data could be accessed remotely. Other observatories also employed plate-scanning machines to scan POSS, ESO and UKST surveys at even finer pixel sizes, and some catalogues were prepared that contained several  $10^8$  objects detected on these plates. Such catalogues usually include a classification of the object into stars, galaxies or ``junk" (objects which fit into neither class and may be artefacts). However, such classifications have a limited reliability. They should not be taken for granted, and it is wise to check the object by visual inspection on the plates (or prints or films), or at least on the digitized image. It is important to distinguish between these different media: the glass plates may show objects of up to  $\sim 1$ mag fainter than are visible on the paper prints. Thus the pixel data, being digitized from the glass plates, may show fainter objects than those visible on the prints. Moreover, they offer absolute positional accuracy of better than  $1''$ . On the other hand, the pixel size of the standard DSS (1.7") represents an overriding limitation in deciding on the morphology of faint (i.e. small) objects. Eventually we have the ``finding charts" which are merely sketches of all the objects extracted from the image, plotted to scale, but with artificial symbols representing the object's magnitude, shape, orientation, etc. (usually crosses or full ellipses for stars, and open ellipses for non-stellar objects). They should not be taken as a true image of the sky, but rather as an indication of the presence of an optical object at a given position, or as an accurate orientation indicator

for observers (see [Fig. 2](#) for an example).

In what follows I present a quick guide to the various data products which can be freely accessed now. The Royal Observatory Edinburgh (ROE) offers comprehensive information on the status of ongoing optical sky surveys at [www.roe.ac.uk/ukstu/ukst.html](http://www.roe.ac.uk/ukstu/ukst.html) (go to the "Survey Progress" link). Other places to watch for such information are "Spectrum" (the RGO/ROE Newsletter), the ESO Messenger ([www.eso.org/gen-fac/pubs/messenger](http://www.eso.org/gen-fac/pubs/messenger)), the STScI Newsletter ([www.stsci.edu/ftp/stsci/newsletters/newsletters.html](http://www.stsci.edu/ftp/stsci/newsletters/newsletters.html)), the Anglo-Australian Observatory (AAO) Newsletter ([www.aao.gov.au/htdocs/library/news.html](http://www.aao.gov.au/htdocs/library/news.html)) and the Newsletter of the "Working Group on Sky Surveys" (formerly "WG on Wide Field Imaging") of IAU Commission 9 (chaired by Noah Brosch, email [noah@stsci.edu](mailto:noah@stsci.edu), a URL at <http://pixela.stsci.edu/iauwg/welcome.html> is in preparation). See also the chapter by D. Golombek for a summary of plate digitizations available at the STScI.





**Figure 2.** Digitized Sky Survey (DSS) images versus finding charts from object catalogues, for an 8' x 8' region in the core of the galaxy cluster Abell 194. Upper left: DSS image of POSS-I red plate from **SkyView**; upper right: COSMOS finding chart from B<sub>J</sub> plate (open ellipses are galaxies, star-like objects are crossed); lower panels: APM charts from POSS-I, red (R) and blue (B) plate (filled symbols are star-like, open ones are galaxy-like, and the central cross is 1 arcmin wide). Note the different classification of objects in APM and COSMOS and in the R and B scans of APM. Several multiple objects, clearly separated on the DSS, are blended into single, often elongated objects in the APM or COSMOS catalogues.

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## 5.1. Digitized Sky Survey Images

Digitizations of the POSS E plates in the northern sky and UKST B<sub>J</sub> plates in the southern sky are available from **SkyView** at URL [skyview.gsfc.nasa.gov](http://skyview.gsfc.nasa.gov). For the vast majority of astronomical institutions without a CD-ROM juke box, this web service allows much easier access to the DSS than working locally with the set of 102 CD-ROMs of the ASP. Batch requests for large lists of DSS extractions can be formulated from the command line using server URLs based on **perl** scripts (see [skyview.gsfc.nasa.gov/batchpage.html](http://skyview.gsfc.nasa.gov/batchpage.html) or [www.ast.cam.ac.uk/~rgm/first/collab/first\\_batch.html](http://www.ast.cam.ac.uk/~rgm/first/collab/first_batch.html)). Several other sites offer the standard DSS through their servers, e.g. the CADC at [cadwww.dao.nrc.ca/dss/dss.html](http://cadwww.dao.nrc.ca/dss/dss.html), ESO at [archive.eso.org/dss/dss](http://archive.eso.org/dss/dss), or **Skyeye** at Bologna ([www.ira.bo.cnr.it/skyeye/gb](http://www.ira.bo.cnr.it/skyeye/gb)), the University of Leicester in UK ([ledas-www.star.le.ac.uk/DSSimage](http://ledas-www.star.le.ac.uk/DSSimage)), and NAO in Japan at [dss.mtk.nao.ac.jp](http://dss.mtk.nao.ac.jp). Each of these offer a slightly different "look and feel", e.g. CADC offers absolute coordinates labels around the charts (but only in J2000), SkyEye offers simultaneous extraction of objects from DIRA2 catalogues ([Section 4.2](#)) and an easy batch request for charts via email, etc. A comparison of performance and speed between these DSS servers can be found at [star-www.rl.ac.uk/~acc/archives/archives.html](http://star-www.rl.ac.uk/~acc/archives/archives.html) (see [[Charles & Shayler \(1998\)](#)]).

Meanwhile almost all of the "second-epoch survey" (SES) plates have been taken: the northern POSS-II ([ecf.hq.eso.org/iraf/ftp/iraf/conf/web/adass\\_proc/adass\\_95/laskerb/laskerb.html](http://ecf.hq.eso.org/iraf/ftp/iraf/conf/web/adass_proc/adass_95/laskerb/laskerb.html)) at Palomar, and the southern UKST SES-R survey at AAO ([www.roe.ac.uk/ukstu/ukst.html](http://www.roe.ac.uk/ukstu/ukst.html)). Most of these have been digitized. Early in 1998 the STScI server ([archive.stsci.edu/dss/dss\\_form.html](http://archive.stsci.edu/dss/dss_form.html)) was the only one offering the second-epoch surveys (POSS-II or UKST R), if available, and otherwise POSSI or UKST B<sub>J</sub> surveys.

A digitization of the POSS-I E- and O-survey plates was also performed with the Automated Plate Scanner (APS) at the Astronomy Department of the University of Minnesota. Only those plates (E and O) with  $|b| > 20^\circ$  have been scanned. The APS uses a flying laser spot to record the transmission of each plate only above ~ 65% of the background transmittance as determined in an initial low-resolution scan. This compromise was needed to achieve the small pixel size of 0.3" for the final images which contain only signal above background, i.e. their background is black. They can be retrieved in FITS format from [aps.umn.edu/homepage.aps.html](http://aps.umn.edu/homepage.aps.html).

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## 5.2. Object Catalogues and Finding Charts from DSS

The HST Guide Star Catalog (GSC) was the first all-sky catalogue of optical objects extracted from plate digitizations. For declinations north of  $+3^\circ$  the Palomar "Quick-V" (epoch 1982) plates of 20min exposure were used. For the south the 50-75min exposures of the SERC  $B_J$  survey (epoch  $\sim 1975$ ) and its equatorial extension (epoch  $\sim 1982$ ) were used (see [www-gsss.stsci.edu/gsc/gsc12/description.html](http://www-gsss.stsci.edu/gsc/gsc12/description.html)). The GSC contains  $\sim 19 \cdot 10^6$  objects in the range 6-15 mag. Most of them are stars, but an estimated  $5 \cdot 10^6$  galaxies are present as well. The positional accuracy has been improved to better than 0.4" in version 1.2. Note, however, that this catalogue is not magnitude-limited, but that the selection of stars has been carried out so as to provide a homogeneous density of guide stars over the sky.

The *Automated Plate Measuring Machine* (APM) is located at the Institute of Astronomy, Cambridge, UK and has been used to prepare object catalogues from Sky Survey plates at high Galactic latitudes ( $|b| > 20^\circ$ ), see e.g. [Lewis & Irwin (1996)]. Both colours of the POSS-I survey plates were scanned and the objects cross-identified, so that colour information is available for a matched object catalogue of well over 100 million objects down to  $m = 21.5$  in blue (O) and  $m = 20$  in red (E). For the southern sky the glass plates of the UKST  $B_J$  and later the UKST SES-R survey have been scanned, with limiting magnitudes of 22.5 in  $B_J$  and 21 in R. All plates were scanned at 0.5" scan interval and a scanning resolution of 1". The pixel data of the scans are not available, and no copies of the entire catalogue are distributed. Both the northern hemisphere catalogue ( $\delta > -3^\circ$ ), and the southern hemisphere catalogue based on UKST  $B_J$  and SES-R plates ( $\sim 50\%$  complete) are available for routine interrogation at [www.ast.cam.ac.uk/~apmcat](http://www.ast.cam.ac.uk/~apmcat). The URL [www.aao.gov.au/local/www/apmcatbin/forms](http://www.aao.gov.au/local/www/apmcatbin/forms) offers a standalone client program in C (**apmcat.c**) which allows queries for large sets of finding charts and object lists from the command line. The catalogues can also be accessed from a captive account (**telnet 131.111.68.56**, login as **catalogues** and follow the instructions).

COSMOS (COordinates, Sizes, Magnitudes, Orientations, and Shapes) is a plate scanning machine at the Royal Observatory Edinburgh, which was used to scan the whole southern sky ( $\delta < +2.5^\circ$ ) from the IIIa-J and Short Red Surveys, and led to an object catalogue of several hundred million objects ([Drinkwater et al. (1995)]). Public access to the catalogue is provided through the Anglo-Australian Observatory (AAO) at [www.aao.gov.au/htdocs/local/www/apmcatbin/cosmos/index.html](http://www.aao.gov.au/htdocs/local/www/apmcatbin/cosmos/index.html), and through the Naval Research Laboratory (NRL) at [xweb.nrl.navy.mil/www\\_rsearch/RS\\_form.html](http://xweb.nrl.navy.mil/www_rsearch/RS_form.html). The AAO facility requires the user to register and obtain a password. During a **telnet** session the user may either input coordinates on the fly, or have them read from a file previously transferred (via **ftp**) to the public AAO account, and create charts and/or object lists on various different output media. The user has to transfer the output back to the local account via **ftp**. This disadvantage is balanced by the possibility of extracting large amounts of charts for big cross-identification projects. Charts may be requested in stamp-size format resulting in PostScript files containing many charts per page.

The US Naval Observatory (USNO) has scanned the POSS I E- and O-plates (for plate centres with  $\delta \geq -30^\circ$ ) and the ESO-R and SERC-J plates (centred at  $\delta \leq -35^\circ$ ) with the "Precision Measuring Machine" (PMM). A scan separation of 0.9" was used (i.e. finer than that of the STScI scans for DSS), and object fitting on these images resulted in the USNO-A1.0 catalogue of 488,006,860 objects down to the very plate limit (limiting mag O = 21, E = 20, J = 22, F = 21). Objects were accepted only if present to within 2" on both E- and O-plates, which implies an efficient rejection of plate faults, but also risks losing real, faint objects with extreme colours. This catalogue is available both as a set of 10 CD-ROMs and interactively at [psyche.usno.navy.mil/pmm](http://psyche.usno.navy.mil/pmm). Client programs at CDS ([Section 3](#)) and ESO ([archive.eso.org/skycat/servers/usnoa](http://archive.eso.org/skycat/servers/usnoa)) allow extraction of object lists of small parts of the sky very rapidly from the command line. There are plans to produce a USNO-B catalogue, which will combine POSS-I and POSS-II in the north, UKST B<sub>J</sub>, ESO-R, and AAO-R in the south, and will attempt to add proper motions and star/galaxy separation fields to the catalogue.

The images from the APS scans of POSS-I (see above) have been used to prepare a catalogue of  $\sim 10^9$  stellar objects and  $10^6$  galaxies detected on *both* E and O plates. Extractions from this catalogue may be drawn from [aps.umn.edu/homepage.aps.html](http://aps.umn.edu/homepage.aps.html), or from the ADS catalogue service at [adswww.harvard.edu/ads\\_catalogs.html](http://adswww.harvard.edu/ads_catalogs.html).

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### 5.3. Catalogues of Direct Plates

While the object catalogues mentioned above were drawn from homogeneous sky surveys, there are almost 2 million wide-field photographic plates archived at individual observatories around the world (see the Newsletters of the IAU Commission 9 ``Working Group on Sky Surveys"). To allow the location and retrieval of such plates for possible inspection by eye or with scanning machines, the ``Wide-Field Plate Database" (WFPDB) ([www.skyarchive.org](http://www.skyarchive.org)) is being compiled and maintained at the Institute of Astronomy of the Bulgarian Academy of Sciences. As described by [Tsvetkov et al. (1998)], the WFPDB offers metadata for currently ~ 330,000 plates from 57 catalogues (see <http://www.skyarchive.org>) collected from more than 30 observatories. Since August 1997 the WFPDB may be searched as catalogue **VI/90** via the CDS **VizieR** catalogue browser ([vizier.u-strasb.fr/cats/VI.htx](http://vizier.u-strasb.fr/cats/VI.htx)).

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## 5.4. An Orientation Tool for the Galactic Plane

The ``Milky Way Concordance" is a graphical tool to create charts with objects from catalogues covering the Galactic Plane, as described by [[Barnes & Myers \(1997\)](#)], available at the URL [info.aoc.nrao.edu/~pbarnes/concord](http://info.aoc.nrao.edu/~pbarnes/concord). Currently 17 catalogues including HII regions, planetary and reflection nebulae, dark clouds, and supernova remnants are available to create colour-coded finding charts of user-specified regions.



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## 5.5. Future Surveys

The All Sky Automated Survey (ASAS; [sirius.astrouw.edu.pl/~gp/asas/asas.html](http://sirius.astrouw.edu.pl/~gp/asas/asas.html)) is a project of the Warsaw University Astronomical Observatory ([[Pojmanski 1997](#)]). Its final goal is the photometric monitoring of  $\sim 10^7$  stars brighter than 14mag all over the sky from various sites distributed over the world. The first results on variable stars found in  $\sim 100$  square degrees have become available at the above URL.

While current Digitized Sky Surveys are all based on photographic material digitized off-line after observing, the future generation of optical Sky Surveys will be digital from the outset, like the "Sloan Digital Sky Survey" (SDSS; [www-sdss.fnal.gov:8000](http://www-sdss.fnal.gov:8000), [[Margon \(1998\)](#)]). The SDSS will generate deep ( $r' = 23.5\text{mag}$ ) images in five colours ( $u'$ ,  $g'$ ,  $r'$ ,  $i'$ , and  $z'$ ) of  $\pi$  steradians in the Northern Galactic Cap ( $|b| > +30^\circ$ ). The SDSS will be performed in drift-scan mode over a period of five years. A dedicated 2.5m telescope at Apache Point Observatory (NM, USA; [www.apo.nmsu.edu](http://www.apo.nmsu.edu)), equipped with a mosaic of  $5 \times 6$  imaging CCD detectors of  $2048^2$  pixels will allow a uniquely large  $3^\circ$  field of view. Selected from the imaging survey,  $10^6$  galaxies (complete to  $r' \sim 18\text{mag}$ ) and  $10^5$  quasars (to  $r' \sim 19\text{mag}$ ) will be observed spectroscopically. The entire dataset produced during the course of the survey will be tens of terabytes in size. The SDSS Science Archive ([tarkus.pha.jhu.edu/scienceArchive](http://tarkus.pha.jhu.edu/scienceArchive)) will eventually contain several  $10^8$  objects in five colours, with measured attributes, and associated spectral and calibration data. Observations are due to begin in 1998, and the data will be made available to the public after the completion of the survey.

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## 6. BIBLIOGRAPHICAL SERVICES

Long before the Internet age, abstracts of the astronomical literature were published annually in the *Astronomischer Jahresbericht* by the Astronomisches Rechen-Institut in Heidelberg ([www.ari.uni-heidelberg.de/publikationen/ajb](http://www.ari.uni-heidelberg.de/publikationen/ajb)). The series started in 1899, one year after the first issue of *Science Abstracts* was published, the precursor of INSPEC ([Section 6.1](http://Section 6.1); cf. [www.iee.org.uk/publish/inspec/](http://www.iee.org.uk/publish/inspec/)). Abstracts of many papers which originally did not have an English abstract were given in German. Since 1969 its successor, the *Astronomy & Astrophysics Abstracts* (AAA), published twice a year, have been THE reference work for astronomical bibliography. The slight drawback that it appears about 8 months after the end of its period of literature coverage is compensated by its impressive completeness of "grey literature", including conference proceedings, newsletters and observatory publications. Until about 1993, browsing these books was about the only means for bibliographic searches "without charge" (except for the cost of the books). In 1993 NASA's "Astrophysics Data System" (ADS) Abstract Service with initially 160,000 abstracts became accessible via telnet. After a few months of negotiation about public accessibility outside the US, the service was eventually put on the WWW in early 1994, with abstracts freely accessible to remote users world-wide. Shortly thereafter they turned into (and continue to be) the most popular bibliographic service in astronomy (see [[Kurtz et al. \(1996\)](#), [Eichhorn et al. \(1998\)](#)]).

Upon the announcement during IAU General Assembly XIII (Kyoto, Japan, Aug. 1997) that AAA is likely to stop publication at the end of 1998, some Astronomy librarians compared the completeness of AAA with that of ADS and INSPEC ([Section 6.1](#)). The results show that, in particular, information about conference proceedings and observatory reports is missing from ADS and INSPEC. After the demise of AAA, ADS would be the *de facto* bibliography of astronomy literature, and there is a danger that it will not be as complete as AAA (see [www.eso.org/libraries/iau97/libreport.html](http://www.eso.org/libraries/iau97/libreport.html) for a discussion). It would indeed be to the benefit of all astronomers if some day all abstracts from *Astronomischer Jahresbericht* and AAA (covering 100 years!) became available on the Internet (see [Section 6.1](#) for ARIBIB).

Many bibliographic services in astronomy use a 19-digit reference code or "refcode" ([[Schmitz et al. \(1995\)](#)], see e.g. [cdsweb.u-strasbg.fr/simbad/refcode.html](http://cdsweb.u-strasbg.fr/simbad/refcode.html)). They have the advantage of being unique, understandable to the human eye, and may be used directly to resolve the full reference and to see their abstracts on the web. Lists of refcodes are also maintained by NED and ADS ([adsabs.harvard.edu/abs\\_doc/journal\\_abbr.html](http://adsabs.harvard.edu/abs_doc/journal_abbr.html)). Note, however, that ADS calls them "bibcodes", and that for less common bibliographic sources occasionally these may differ from CDS refcodes. Unique bibcodes do not exist as yet for proceedings volumes and monographs, but work is under way in this area.



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## 6.1. Abstract and Article Servers

NASA's ADS Abstract Service ([adsabs.harvard.edu/abstract\\_service.html](http://adsabs.harvard.edu/abstract_service.html)) is offered at the Center for Astrophysics (CfA) of the Smithsonian Astrophysical Observatory (SAO). It goes back to several 10<sup>5</sup> abstracts prepared by NASA's "Scientific and Technical Information" Group (STI) since 1975. Note that the latter abstracts may not be identical with the published ones and that complete coverage of the journals is not guaranteed. Since 1995 most of the abstracts are being received directly from the journal editors, and coverage is therefore much more complete. The service now contains abstracts from four major areas which need to be searched separately: Astronomy (~ 380,000 abstracts), Instrumentation, Physics & Geophysics and LANL/SISSA astro-ph preprints ([Section 6.2](#)). The preprints expire 6 months after their entry date. The four databases combined offer over 1.1 million references. The service is also useful to browse contents of recent journals using the BIBCODE QUERY or TOC QUERY ([Section 6.5](#)) links. Its popularity is enormous: it was accessed by ~ 10,000 users per month, and about 5 million references per month were returned in response to these queries in late 1997. It has mirror sites in Japan ([ads.nao.ac.jp](http://ads.nao.ac.jp)) and France ([cdsads.u-strasbg.fr/ads\\_abstracts.html](http://cdsads.u-strasbg.fr/ads_abstracts.html)).

The ADS provides very sophisticated search facilities, allowing one to filter by author, by title word(s) or words in the abstract, and even by object name, albeit with the silent help of NED and SIMBAD. The searches can be tuned with various weighting schemes and the resulting list of abstracts will be sorted in decreasing order of relevance (see [adsdoc.harvard.edu/abs\\_doc/abs\\_help.html](http://adsdoc.harvard.edu/abs_doc/abs_help.html) for an extensive manual). Each reference comes with links (if available) to items like (C) citations available (references that cite that article), (D) data tables stored at CDS or ADC, (E) electronic versions of the full paper (for users at subscribing institutions), (G) scanned version of the full paper, (R) references cited by that article, etc. Links between papers (citations and references) are gradually being completed for older papers. Citations are included for papers published since 1981 and were purchased from the "Institute for Scientific Information" (ISI), see below. When the recognition of the full text from the scanned images has been completed in a few years (see below), ADS plans to build its own R and C links.

The ADS also employed page scanners to convert printed pages of back issues of major astronomical journals into images ("bitmaps") accessible from the web. Early in 1995 the ADS started offering this "Article Service" at [adsabs.harvard.edu/article\\_service.html](http://adsabs.harvard.edu/article_service.html). Images of over 60,000 scanned articles are now on line, and over 250,000 pages were retrieved monthly in 1997. The intention is to prepare page scans back to volume 1 for all major journals. Note, however, that these are images of printed pages and not ASCII versions of the full text. Eventually the full article database will be about 500 Gbyte of data. The images of printed pages may eventually be converted into ASCII text via OCR, but currently this exercise is estimated to take a full year of CPU time (excluding the subsequent effort in proof-reading and correcting the OCR result). No full-text search features are available as yet from ADS even for recent articles.



ARIBIB is a bibliographic database with information given in the printed bibliography "Astronomy and Astrophysics Abstracts" (AAA) by the Astronomisches Recheninstitut (ARI) in Heidelberg, Germany. Currently, at [www.ari.uni-heidelberg.de/aribib](http://www.ari.uni-heidelberg.de/aribib) references to the literature of 1983-1997 (Vols. 33-68 of AAA) are freely available, while abstracts may be retrieved only by subscribers of the printed AAA. The ARI intends to prepare abstracts of older literature in a machine-readable format, by scanning earlier volumes of AAA and "Astronomischer Jahresbericht".

The UnCover database of authors and titles of scientific papers (see [Section 6.5](#) for details) may also be used for keyword searches, although it does not offer abstracts.

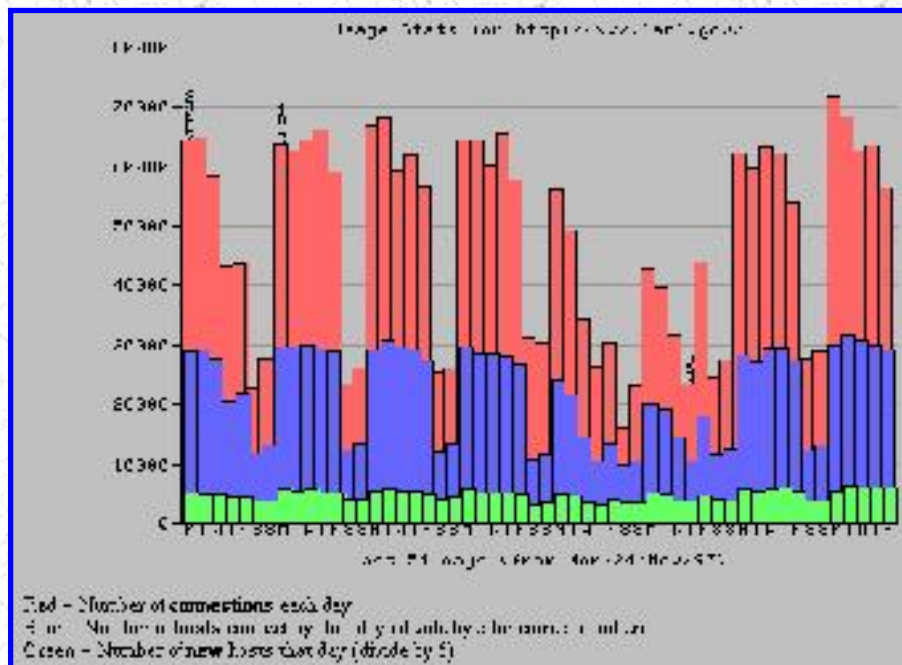
There are numerous well-established commercial bibliographic database services which charge for access. The use of these systems in astronomy has been reviewed by Davenhall (1993) and [[Michold et al. \(1995\)](#)], and [[Thomas \(1997\)](#)] gives a more general overview. Typically these databases cover a range of scientific and engineering subjects and none of them is specifically astronomical. This has the disadvantage that more obscure astronomical journals are not covered, but the advantage that astronomical papers in non-astronomical publications will be included. The Institution of Electrical Engineers (IEE) in the UK produces INSPEC ([www.iee.org.uk/publish/inspec](http://www.iee.org.uk/publish/inspec)) which is the main English-language commercial bibliographic database covering physics (including astrophysics), electrical engineering, electronics, computing, control and information technology. It currently lists some 5 million papers and reports, with over 300,000 new entries being added per year, and it covers the main astronomical journals. An abstract is usually included for each entry. Another important bibliographic database is the Science Citation Index (SCI) produced by the Institute for Scientific Information Inc. (ISI; [www.isinet.com](http://www.isinet.com)) in USA. The SCI contains details drawn from over 7500 journals and (via the *Index to Scientific and Technical Proceedings*, ISTP) over 4200 conferences per year. While the SCI does not contain abstracts, it offers cross-references to all the citations in each paper that is included, a unique and extremely valuable feature. Often commercial bibliographic services are not accessed directly, but rather through a third-party vendor. Typically such a vendor will make a number of bibliographic databases available, having homogenized their appearance and customized their contents to a greater or lesser extent. There is a number of such vendors; one example is the "Scientific and Technical Information Network" (STN; [www.cas.org/stn.html](http://www.cas.org/stn.html)) which includes links to about 200 databases.

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## 6.2. Preprint Servers

The availability of electronic means has reduced the delay between acceptance and publication of papers in refereed journals from 6-10 down to 3-6 months (or even 1 month in case of letters or short communications), largely because authors prepare their own manuscripts electronically in the formatting requirements of the journals. Nevertheless, for conference proceedings the figure remains between 10 and 20 months. Such a delay did (and still does) crucially affect certain types of research. Thus, for several decades, the ``remedy" to this delay has been a frequent exchange of preprints among astronomers, and until very recently, the preprint shelves used to be the most frequented areas in libraries. This situation has gradually changed since April 1992, when both SISSA (International School for Advanced Studies, Trieste, Italy) and LANL (Los Alamos National Laboratory, USA) started to keep mirror archives of electronically submitted preprints ([xxx.lanl.gov](http://xxx.lanl.gov)). In the first years of their existence, preprints were dominant in the fields of theoretical cosmology and particle physics, and about 35 astro-ph preprints were submitted monthly in mid-1993. The popularity of this service has increased impressively since then: over 60,000 *daily* accesses to [xxx.lanl.gov](http://xxx.lanl.gov) from 6,000 different hosts (see [Fig. 3](#)), and about 300 preprints submitted per month in 1997/8 only for astro-ph (and ~ 1800 altogether), with a fair balance between all parts of observational and theoretical astrophysics; mirror sites have been installed in 12 other countries (Australia, Brazil, China, France, Germany, Israel, Japan, Russia, South Korea, Spain, Taiwan, and the UK, see [xxx.lanl.gov/servers.html](http://xxx.lanl.gov/servers.html)). A further mirror site is under construction in India. References to electronic preprints from LANL/SISSA are made more and more frequently in refereed journals, and the LANL/SISSA server also provides links to citations to, and references from, their electronic preprints to other preprints of the same collection.





**Figure 3.** Daily accesses to the LANL preprint server. The regular 2-day dips are weekends, while the wider dips are due to Thanksgiving, Christmas and New Year 1997/98.

You may subscribe to receive a *daily* list of new preprints. To avoid this flood of emails you could rather send an email to [astro-ph@xxx.lanl.gov](mailto:astro-ph@xxx.lanl.gov) just after the end of month mm of year yy, with subject ``list YYMM'', e.g. ``list 9710'', to receive a full list of preprints archived in October 1997. To get the description of all the functionalities of the preprint server (e.g. how to submit or update your own preprints), send an email to the above address with ``Subj:get bighelp.txt''. If you want to check for the presence of a certain preprint, send an email with ``Subj:find keyword'', where keyword is an author or part of the title of the paper. You need to add a year if you want to search further back than the default of one year from the current date. Once you have located the preprint(s) that you are interested in, the most efficient (least time-consuming) method to obtain a copy is to request it by its sequence number YYMMNNN, via email to the same address with Subj:get YYMMNNN. It comes in a self-extracting uuencoded file which you need to save in a file, say XYZ, strip off the mail header, and just execute it with the command `csh XYZ`. A common shortcoming is that authors sometimes do not include all necessary style files with their papers. Generally these can be obtained separately from the server by email with Subj: get whatever.sty. Another solution to this problem is to use the web interface at [xxx.lanl.gov/ps/astro-ph/YYMMNNN](http://xxx.lanl.gov/ps/astro-ph/YYMMNNN), where (unlike the email or ftp service) the complete PS files of papers are indeed available (and are in fact created on the fly upon request).

Submission of a preprint to the LANL/SISSA server is today the most efficient way of world-wide ``distribution'' without expenses for paper or postage, since the preprint will be available to the entire community within 24 hours from receipt, provided it passes some technical checks of file integrity and processability. Note, however, that electronic preprint servers contain papers in different stages of publication: accepted, submitted to a refereed journal or to appear in conference proceedings. Occasionally the authors do not explain the status of the paper, and the preprint server may have been the only site to which the paper has ever been submitted. Of course, a reference made to a preprint of work that was never published should be regarded with caution in case it was subsequently rejected by a journal. Note also that only a fraction of all papers published in refereed journals (perhaps 30-50% now) is available from LANL/SISSA prior to publication. Many other preprints are offered from web pages of individual researchers or from institutional pages. A substantial collection of links to other sources of preprints is provided at [www.ucm.es/info/Astrof/biblio.html#preprints](http://www.ucm.es/info/Astrof/biblio.html#preprints).

The International Centre for Theoretical Physics in Trieste, Italy, provides the ``One-Shot World-Wide Preprints Search'' at [www.ictp.trieste.it/indexes/preprints.html](http://www.ictp.trieste.it/indexes/preprints.html).

You can also check a list of ``Papers Submitted to Selected Astronomical Publications'' at [www.noao.edu/apj/ypages/yp.html](http://www.noao.edu/apj/ypages/yp.html). A list of papers submitted to the *Astronomical Journal* can be viewed at [128.95.99.33/ajcgi/papers](http://128.95.99.33/ajcgi/papers). Note that these are *submitted* and not necessarily *accepted* articles. The pages come with links to email the authors, which is very helpful if you wish to ask some of them for a copy. There is also a page with ``Titles and abstracts of ApJ Letters accepted but not yet published'' at [cfa-](http://cfa-)

[www.harvard.edu/aas/apjl\\_abstracts.html](http://www.harvard.edu/aas/apjl_abstracts.html).

A ``Distributed Database of Online Astronomy Preprints and Documents" is currently in the early stages of development. While not functional as yet, there is a web page describing the project. People wanting to monitor progress, or make suggestions, are invited to look at the URL [doright.stsci.edu/Epreps](http://doright.stsci.edu/Epreps).

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### 6.3. Preprint Lists from NRAO and STScI

Although the LANL/SISSA server has become very popular recently, there are still a large number of preprints being distributed *only* on paper. The ideal places to get reasonably complete listings of these are the following.

The STEPsheet ("Space Telescope Exhibited Preprints") is a list of all preprints received during the last two weeks at the STScI and is prepared by its librarian, Sarah Stevens-Rayburn. It is delivered by email, and subscription requests should be sent to [library@stsci.edu](mailto:library@stsci.edu). Each list contains well over 100 titles.

Note that the preprints themselves are not distributed by the STScI librarian and must be requested from the individual authors. The full current STScI database contains everything received in the last several years, along with all papers received since 1982 and not yet published. Both databases are searchable at [sesame.stsci.edu/library.html](http://sesame.stsci.edu/library.html).

The RAPsheet ("Radio Astronomy Preprints") is a listing of all preprints received in the Charlottesville library of the National Radio Astronomy Observatory (NRAO) in the preceding two weeks (contact: [library@nrao.edu](mailto:library@nrao.edu)). Interested persons should request copies of preprints from the authors. The tables of contents of all incoming journals and meeting proceedings are perused in order to find published references and to update the records. A database of preprints received since 1986, along with their added references, and including unpublished ones since 1978, is also searchable at [annie.cv.nrao.edu/rapsqbe.htm](http://annie.cv.nrao.edu/rapsqbe.htm).

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## 6.4. Electronic Journals

Most of the major astronomical journals are now available over the Internet. While they tended to be freely available for a test period of one to two years, most of them now ask a license which can be obtained for free only if the host institute of the user is subscribed to the printed version. Nevertheless, for most journals the tables of contents are accessible on the WWW for free (see [Section 6.5](#)). A very useful compilation of links to electronic journals and other bibliographical services is provided at [www.ucm.es/info/Astrof/biblio.html](http://www.ucm.es/info/Astrof/biblio.html).

Under the "AAS Electronic Journal Project" ([www.aas.org/Epubs/eapjl/eapjl.html](http://www.aas.org/Epubs/eapjl/eapjl.html); cf. [Boyce (1997)]) the *Astrophysical Journal* (ApJ) had been made available electronically since 1996 ([www.journals.uchicago.edu/ApJ/journal](http://www.journals.uchicago.edu/ApJ/journal)). As of April 1997, access to the full text of the ApJ Electronic Edition is available only to institutional and individual subscribers. What you *can* do without subscribing, is to browse the contents pages of even the latest issues. The policy of AAS is to sell a license for the whole set of both back and current issues. Licensees will have to keep paying in order to see any issues of the journal. In return AAS will continue to maintain electronic links between references, a facility which the database of scanned back journals at the ADS article service does not offer.

The electronic *Astronomical Journal* ([www.journals.uchicago.edu/AJ/journal](http://www.journals.uchicago.edu/AJ/journal)) came on-line in January 1998. *Astronomy & Astrophysics* (A&A) and its *Supplement Series* (A&AS) are available at [link.springer.de/link/service/journals/00230/tocs.htm](http://link.springer.de/link/service/journals/00230/tocs.htm), and at [www.edpsciences.com/docinfos/AAS/OnlineAAS.html](http://www.edpsciences.com/docinfos/AAS/OnlineAAS.html), respectively. Abstracts of both journals can be viewed at [cdsweb.u-strasbg.fr/Abstract.html](http://cdsweb.u-strasbg.fr/Abstract.html).

The journal *New Astronomy*, initially designed to appear electronic-only released its first issue in September 1996 (see [www.elsevier.nl/locate/newast](http://www.elsevier.nl/locate/newast)). One may subscribe to a service alerting about new articles appearing in *New Astronomy* by sending email to [newast-e@elsevier.nl](mailto:newast-e@elsevier.nl) with Subj: subscribe newast-c.

Several other journals are available electronically, e.g. the *Publications of the Astronomical Society of the Pacific* (PASP; [www.journals.uchicago.edu/PASP/journal](http://www.journals.uchicago.edu/PASP/journal)); the *Proceedings of the Astronomical Society of Australia* (PASA) has started an experimental web server, beginning from Vol. 14(1997), at [www.atnf.csiro.au/pasa](http://www.atnf.csiro.au/pasa); Pis'ma Astronomicheskii Zhurnal offers English abstracts at [hea.iki.rssi.ru/pazh](http://hea.iki.rssi.ru/pazh), and Bulletin of the American Astronomical Society (BAAS) at [www.aas.org/publications/baas/baas.html](http://www.aas.org/publications/baas/baas.html). The IAU "Informational Bulletin of Variable Stars" (IBVS) has been scanned back to its volume 1 (1961) and is available at [www.konkoly.hu/IBVS/IBVS.html](http://www.konkoly.hu/IBVS/IBVS.html). One volume (#45) of the Bulletin d'Information of CDS (BICDS) is at [cdsweb.u-strasbg.fr/Bull.html](http://cdsweb.u-strasbg.fr/Bull.html).



The *Journal of Astronomical Data* (JAD), announced during the 22<sup>nd</sup> IAU General Assembly in 1994 as the future journal for the publication of bulky data sets on CD-ROM, has produced three volumes on CD-ROM since October 1995, available at cost from [www.twinpress.nl/jad.htm](http://www.twinpress.nl/jad.htm).

More and more electronic journals are linking their references directly to the ADS Abstract Service, thus working toward a virtual library on the Internet.

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## 6.5. Tables of Contents

The ADS abstract service ([Section 6.1](#)) offers to browse specific volumes of journals via the TOC QUERY button on URL [adsabs.harvard.edu/abstract\\_service.html](http://adsabs.harvard.edu/abstract_service.html). For those journals not accessible by the TOC QUERY you can use the BIBCODE QUERY, e.g. to browse the *Bull. Astron. Soc. India*, search for bibcode 1997BASI...25.

**UnCover** at the "Colorado Alliance of Research Libraries" (CARL) is a database of tables of contents of over 17,000 multidisciplinary journals. It can be accessed at URL [uncweb.carl.org](http://uncweb.carl.org), or via telnet to [pac.carl.org](http://pac.carl.org) or [database.carl.org](http://database.carl.org). It contains article titles and authors only, and offers keyword searches for both. Data ingest started in September 1988. In late 1997 it included more than 7,000,000 articles, and 4,000 articles were added daily. About sixty astronomy-related journals are present, including ApJ, A&A, AJ, ApJS, MNRAS, PASP, Nature, Science, and many others which are less widely distributed. One of the most useful features is that the contents pages of individual journals can be viewed by volume and issue. This provides an important independent resource to monitor the current astronomical literature, especially if one's library cannot afford to subscribe to more than the major journals. Copies of all retrieved articles can be ordered (by FAX only) for a charge indicated by the database. UnCover also provides links to access other library databases and to browse the library catalogues of several North American libraries.

For some of the journals not covered by bibliographic services the Publishers' web pages may offer tables of contents, like e.g. for the *Monthly Notices of the Royal Astronomical Society* (MNRAS) at [www.blackwell-science.com/~cgilib/jnlpage.bin?Journal=MNRAS&File=MNRAS&Page=contents](http://www.blackwell-science.com/~cgilib/jnlpage.bin?Journal=MNRAS&File=MNRAS&Page=contents). To browse *Chinese Astronomy & Astrophysics* click on "Contents Services" at [www.elsevier.com/inca/publications/store/5/8/5/](http://www.elsevier.com/inca/publications/store/5/8/5/). For *Astrophysics & Space Science* see [www.wkap.nl/jrnltoctoc.htm/0004-640X](http://www.wkap.nl/jrnltoctoc.htm/0004-640X). The National Academy of Sciences of the USA offers the contents pages and full texts of its Proceedings and colloquia at [www.pnas.org](http://www.pnas.org). The American Physical Society has its *Reviews of Modern Physics* at [rmp.aps.org](http://rmp.aps.org). The *Icarus* journal offers its tables of contents and lists of submitted papers at the URL [astrosun.tn.cornell.edu/Icarus/](http://astrosun.tn.cornell.edu/Icarus/). Tabular and other data from papers in *Icarus* are published on the AAS CD-ROMs.

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## 6.6. ``Grey Literature'': Newsletters, Observatory Publications, etc.

A compilation of links to various astronomical newsletters is provided by P. Eenens at [www.astro.ugto.mx/~eenens/hot/othernews.html](http://www.astro.ugto.mx/~eenens/hot/othernews.html). In 1994/95, Cathy Van Atta at NOAO (now retired) and a few others prepared a list of astronomical Newsletters. S. Stevens-Rayburn (STScI) has put this list on URL [sesame.stsci.edu/lib/NEWSLETTER.htm](http://sesame.stsci.edu/lib/NEWSLETTER.htm) and invites volunteers to complete and update the information. A catalogue of over 4,000 individual Observatory Publications, ranging from the 18th century to the present, has been prepared by Brenda Corbin and is available from within the USNO Library Online Catalog ``Urania" (click on ``Library Resources" at [www.usno.navy.mil/library/lib.html](http://www.usno.navy.mil/library/lib.html)).

A list of IAU Colloquia prepared by STScI librarian S. Stevens-Rayburn is offered at [sesame.stsci.edu/lib/other.html](http://sesame.stsci.edu/lib/other.html). A Union List of Astronomy Serials II (ULAS II) compiled by Judy L. Bausch can be searched at [sesame.stsci.edu/lib/union.html](http://sesame.stsci.edu/lib/union.html). It provides information on ~ 2300 (primarily) non-commercial publications of observatories and institutions concerned with research in astronomy. For each item, it lists the holding records of 42 contributing libraries, representing the most comprehensive astronomical collections in North America, with selected holdings from China, Europe, India, and South America as well.

A database of book reviews in astronomy from 1987 to the present has been prepared by Marlene Cummins and is available at [www.astro.utoronto.ca/reviews1.html](http://www.astro.utoronto.ca/reviews1.html).

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## 6.7. Library Holdings

The card catalogues of hundreds of libraries from all disciplines (including the Library of Congress, which can be accessed on the WWW at [lcweb2.loc.gov/catalog](http://lcweb2.loc.gov/catalog)) are available over the net, and the number is continuously growing. The Libweb directory at [sunsite.berkeley.edu/Libweb](http://sunsite.berkeley.edu/Libweb) lists library catalogues which are accessible on the WWW. Libweb is frequently updated and currently provides addresses of over 1700 libraries from 70 countries. A more complete listing of astronomy-related libraries can be found at [www.stsci.edu/astroweb/cat-library.html](http://www.stsci.edu/astroweb/cat-library.html), the "Libraries Resources" section of the AstroWeb. The STScI library holdings are searchable at [sesame.stsci.edu/library.html](http://sesame.stsci.edu/library.html), and those of ESO at [www.eso.org/libraries/webcat.html](http://www.eso.org/libraries/webcat.html).



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## 7. DIRECTORIES AND YELLOW-PAGE SERVICES

Occasionally, if not frequently, one needs to search for the e-mail of an astronomer somewhere in the world. There are many ways to find out and several may have to be tried. You should start with the "RGO email directory". It is maintained by C.R. Benn and R. Martin and is made up of three parts. One is a list of ~ 13,000 personal emails, another one offers phone/FAX numbers and emails or URLs of ~ 950 astronomical research institutes, and a third one has postal addresses for ~ 650 institutions. You should make sure that your departmental secretary knows about the latter two! All lists are updated frequently and available for consultation at [star-www.rl.ac.uk/astrolist/astrosearch.html](http://star-www.rl.ac.uk/astrolist/astrosearch.html). The impatient and frequent user of these directories should draw a local copy from time to time (three files at [ftp.ast.cam.ac.uk/guide/astro\\*.lis](ftp://ftp.ast.cam.ac.uk/guide/astro*.lis)), or ask your system manager to install a site-wide command to interrogate these lists and draw updated copies from time to time. To request inclusion in this directory or communicate updated addresses, send a message to [email@ast.cam.ac.uk](mailto:email@ast.cam.ac.uk).

Be sure that you never (ab)use such lists of thousands of addresses to send your announcements to the entire list. You will most likely offend the majority of the recipients who are not interested in your message, which may be even regarded as "spamming" (see e.g. [cdsweb.u-strasbg.fr/~heck/spams.htm](http://cdsweb.u-strasbg.fr/~heck/spams.htm) for a collection of links to defend users from unsolicited email). However, these email directories may be useful for the legitimate task of selecting a well-defined subset of researchers as a distribution list for specific announcements.

The RGO email guide depends on personal and institutional input for its updates and turns out to be fairly incomplete especially for North American astronomers. Complete addresses for AAS members can be found in the AAS Membership Directory which appears in print annually and is distributed to AAS members only. The AAS membership directory has been put on-line experimentally and made searchable at [directory.aas.org](http://directory.aas.org), but it cannot be downloaded entirely.

Since 1995 the IAU membership directory has been accessible at the LSW Heidelberg web site, but in early 1998 it moved to [www.iau.org/members.html](http://www.iau.org/members.html). The address database is managed by the IAU office in Paris ([www.iau.org](http://www.iau.org)), and requests for updates have to be sent there by email ([iau@iap.fr](mailto:iau@iap.fr)). From these the IAU office prepares an updated database every few months which is then put on-line. Hopefully this web address for the IAU membership directory will remain stable in the future, and not change every three years with the election of a new General Secretary at each IAU General Assembly.

The European Astronomical Society (EAS) is preparing its membership directory under URL [www.iap.fr/eas/directory.html](http://www.iap.fr/eas/directory.html). It provides links to membership directories of several national astronomical societies in Europe (see [www.iap.fr/eas/societies.html](http://www.iap.fr/eas/societies.html)).

The ``Star\*sFamily" of directories is maintained at CDS ([\[Heck \(1997\)\]](#)) and divided into three parts. ``StarWorlds" ([cdsweb.u-strasbg.fr/~heck/sfworlds.htm](http://cdsweb.u-strasbg.fr/~heck/sfworlds.htm)) offers addresses and many practical details for ~6,000 organizations, institutions, associations, companies related to astronomy and space sciences from about 100 countries, including about 5,000 direct links to their homepages. ``StarHeads" ([cdsweb.u-strasbg.fr/~heck/sfheads.htm](http://cdsweb.u-strasbg.fr/~heck/sfheads.htm)) is a compilation of links to personal WWW homepages of about 4500 astronomers and related scientists. For ``StarBits" see [Section 9](#).

Another way to search for email addresses is a search engine (mirrored at various sites) which can be accessed via **telnet bruno.cs.colorado.edu**, login as user **netfind**. You should give either first, last or login name of the person you look for, plus keywords containing the institution and/or the city, state, or country where the person works.

There are more, rather ``informal" ways of tracing emails of astronomers. One is to check whether they have contributed preprints to the SISSA/LANL server ([Section 6.2](#)) recently. If so, the address from which they sent it will be listed in the search result returned to you. Another way is the command **finger xx@node.domain**, where xx is either the family name or a best guess of a login name of the individual you seek. However, some nodes prefer ``privacy" and disable this command. One last resort is to send an email to postmaster at the node where you believe the person is or used to be.

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## 8. MEETINGS AND JOBS

Since about 1990, the librarian at the Canada-France-Hawaii Telescope (CFHT, Hawaii), E. Bryson, has maintained a list of forthcoming astronomical meetings, including those back to Sept. 1996, at the URL [cadwww.dao.nrc.ca/meetings/meetings.html](http://cadwww.dao.nrc.ca/meetings/meetings.html). One may subscribe to receive updates of this list of meetings by request to [library@cfht.hawaii.edu](mailto:library@cfht.hawaii.edu). It is now the most complete reference in the world for future astronomy meetings. Organizers of meetings should send their announcements to [library@cfht.hawaii.edu](mailto:library@cfht.hawaii.edu) to guarantee immediate and world-wide diffusion. Official meetings of the IAU and some other meetings of interest to astronomers are announced in the IAU Information Bulletin (see [www.iau.org/bulletin.html](http://www.iau.org/bulletin.html)). A list of all past IAU Symposia is available at [www.iau.org/pastsym.html](http://www.iau.org/pastsym.html).

Probably the most complete collection of job advertisements in astronomy is the "AAS Job Register" at [www.aas.org/JobRegister/aasjobs.html](http://www.aas.org/JobRegister/aasjobs.html). The European Astronomical Society (EAS) maintains a Job Register at [www.iap.fr/eas/jobs.html](http://www.iap.fr/eas/jobs.html). STARJOBS is an electronic notice board maintained at the Rutherford Appleton Laboratory. The service is co-sponsored by the EAS and includes announcements of all European astronomical jobs notified to the Starlink astronomical computing project (**telnet** to **star.rl.ac.uk**, login as **starjobs**). One can also copy (via **ftp**) the complete list of jobs as the file [starlink-ftp.rl.ac.uk:/news/news/star\\_jobs.txt](ftp://starlink-ftp.rl.ac.uk:/news/news/star_jobs.txt). For employment opportunities in the Space Industry consult the URL [www.spacejobs.com](http://www.spacejobs.com). The AstroWeb offers links to job offers at [www.cv.nrao.edu/fits/www/yp\\_jobs.html](http://www.cv.nrao.edu/fits/www/yp_jobs.html).

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## 9. DICTIONARIES AND THESAURI

The *Second Dictionary of the Nomenclature of Celestial Objects* (see Lortet, Borde & Ochsenbein (1994)) can be consulted at [vizier.u-strasbg.fr/cgi-bin/Dic](http://vizier.u-strasbg.fr/cgi-bin/Dic) or via **telnet** to **simbad.u-strasbg.fr** (login as **info**, give <CR> as password, then issue the command `info cati XXX` to inquire about the acronym XXX). Authors of survey-type source lists are strongly encouraged to check that designations of their objects do not clash with previous namings and are commensurate with IAU recommendations on nomenclature [cdsweb.u-strasbg.fr/iau-spec.html](http://cdsweb.u-strasbg.fr/iau-spec.html). In order to guarantee that designations of an ongoing survey will not clash with other names, authors or PIs of such surveys should consider to pre-register an acronym for their survey some time before publication at the URL given above. Information on over 4000 acronyms is provided.

Independently, a list of "Astronomical Catalog Designations" has been prepared by INSPEC (see [www.iee.org.uk/publish/inspec/astro\\_ob.html](http://www.iee.org.uk/publish/inspec/astro_ob.html)). It is less complete than the CDS version and deviates in places from the IAU recommendations.

The dictionary "StarBits", maintained by A. Heck (Strasbourg), offers ~ 120,000 abbreviations, acronyms, contractions and symbols from astronomy and space sciences and related fields. It is accessible at [cdsweb.u-strasbg.fr/~heck/sfbits.htm](http://cdsweb.u-strasbg.fr/~heck/sfbits.htm). Astronomers are invited to consult this dictionary to avoid assigning an acronym that has been used previously.

On behalf of the IAU several librarians of large astronomical institutions prepared "The Astronomy Thesaurus" of astronomical terms ([[Shobbrook & Shobbrook \(1993\)](#)]), and later its "Multi-Lingual Supplement" ([[Shobbrook & Shobbrook \(1995\)](#)]) in five different languages (English, French, German, Italian, and Spanish). It is freely available at [www.aao.gov.au/library/thesaurus.html](http://www.aao.gov.au/library/thesaurus.html). It may be useful in many respects, e.g., to translate astronomical terms, to aid authors in better selection of keywords for their papers, and to help librarians improve the classification of publications. The Thesaurus is available via anonymous **ftp** for DOS, MAC and Unix systems ([www.aao.gov.au/lib/thesaurus.html](http://www.aao.gov.au/lib/thesaurus.html)); it has not been updated for some years, but M.Cummins ([astlibr@astro.utoronto.ca](mailto:astlibr@astro.utoronto.ca)) is currently in charge of it and appreciates comments about its future.

As an aside I mention the "Electronic Dictionary of Space Sciences" by J. Kleczek and H. Kleczková, who have collected several 10,000 of words, synonyms and expressions from astronomy, space sciences, space technology, earth- and atmospheric sciences and related mathematics, physics, and engineering fields in five languages: English, French, German, Spanish, and Portuguese (see [www.twinpress.nl/edss.htm](http://www.twinpress.nl/edss.htm) for an electronic version at cost). The "Oxford English Dictionary" (OED; [www.oed.com/](http://www.oed.com/)) is currently being revised to include a far more comprehensive set of astronomical terms than before (see the OED Newsletter at [www.oed.com/public/news/](http://www.oed.com/public/news/); [[Mahoney \(1998\)](#)]).



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## 10. MISCELLANEOUS

### 10.1. Astronomical Software

For an introduction to publicly available astronomical software and numerical libraries see [[Feigelson & Murtagh \(1992\)](#)]. The ``Astronomical Software and Documentation Service" (ASDS) at [asds.stsci.edu/](http://asds.stsci.edu/) contains links to the major astronomical software packages and documentation. It allows one to search for keywords in all the documentation files available. The *Statistical Consulting Center for Astronomy* at Penn State University ([www.stat.psu.edu/%7Emga/scca](http://www.stat.psu.edu/%7Emga/scca)) offers advice and answers to frequently asked questions about statistical applications. The ``StatCodes" (of statistical software for astronomy and related fields, at [www.astro.psu.edu/statcodes](http://www.astro.psu.edu/statcodes)) are now also in ASDS.



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## 10.2. Observatory and Telescope Manuals

The librarian at CFHT (Hawaii), E. Bryson, has collected observatory and telescope manuals in electronic form from all over the world. Several dozen such documents are now available through the ASDS ([Section 10.1](#)) at [asds.stsci.edu/](http://asds.stsci.edu/). The documents may be searched by keywords.

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### 10.3. IAU Circulars, Minor Planets, ATEL, and Ephemerides

Information about time-critical phenomena has been distributed by the IAU "Central Bureau for Astronomical Telegrams" (CBAT; [cfa-www.harvard.edu/cfa/ps/cbat.html](http://cfa-www.harvard.edu/cfa/ps/cbat.html)) via "IAU Circulars" since October 1922. The IAU "Minor Planet Center" (MPC; [cfa-www.harvard.edu/cfa/ps/mpc.html](http://cfa-www.harvard.edu/cfa/ps/mpc.html)) is responsible for the collection and dissemination of astrometric observations and orbits for minor planets and comets, via the "Minor Planet Electronic Circulars" (MPEC; [cfa-www.harvard.edu/cfa/ps/services/MPEC.html](http://cfa-www.harvard.edu/cfa/ps/services/MPEC.html)), distributed on paper as the "Minor Planet Circulars" since before 1947. Through collaboration with CBAT and MPC, the ADS Abstract Service includes electronic circulars of these two sites. The title, author, and object names are freely available through the ADS, and the whole text of each circular is indexed by ADS so that it is found on searches. The references returned from the ADS include an on-line link to the full circular at CBAT and MPC.

In December 1997 the "Astronomer's Telegram" (ATEL; [Rutledge (1998)]) was released. It is a web-based publication system for short notices on time-critical information and is available at [fire.berkeley.edu:8080/](http://fire.berkeley.edu:8080/)). Submission of telegrams is restricted to professional astronomers and requires special permission. The potential authors are given a special authentication code to be used at the time of submission, which is entirely automated and unmoderated, without any human intervention. Readers can freely access the telegrams or ask to be on a mailing list to receive telegrams within minutes of their submission. During the first six months of its existence about five telegrams per month were received.

Ephemerides and orbital elements of comets and minor planets can be consulted e.g. at [cfa-www.harvard.edu/iau/Ephemerides/index.html](http://cfa-www.harvard.edu/iau/Ephemerides/index.html) or at JPL's HORIZONS system ([ssd.jpl.nasa.gov/horizons.html](http://ssd.jpl.nasa.gov/horizons.html)). A free, interactive program for fancy calculations of ephemeris, visibility curves from any site on Earth, and graphical displays of finding charts based on the HST Guide Star Catalogue, orbits of solar system bodies, views of Earth and Moon, and much more is available (for X-Windows systems with Motif) for download at [www.clearskyinstitute.com/xephem/](http://www.clearskyinstitute.com/xephem/).

The "Astronomy Calculator", available at [w3.one.net/~rback/frames.html](http://w3.one.net/~rback/frames.html), aspires to provide general information about the phases of the moon, lunar eclipse, next annual meteor shower and planets.

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## 10.4. Atomic Data

A multitude of links to databases containing atomic and molecular data can be found at [cfa-www.harvard.edu](http://cfa-www.harvard.edu), in [.../amdata/ampdata/otherdb.html](http://.../amdata/ampdata/otherdb.html) or [.../~esmond/amdata.html](http://.../~esmond/amdata.html).

The ``Opacity Project" (OP) at [vizier.u-strasbg.fr/OP.html](http://vizier.u-strasbg.fr/OP.html) offers extensive atomic data required to estimate stellar envelope opacities.

The original implementation of the ``Vienna Atomic Line Data Base" (VALD; Piskunov et al. (1995) is available at [plasma-gate.weizmann.ac.il/VALD.html](http://plasma-gate.weizmann.ac.il/VALD.html). The VALD manual (at [plasma-gate.weizmann.ac.il/VALD.html](http://plasma-gate.weizmann.ac.il/VALD.html)) is part of a summary of ``Databases for Atomic and Plasma Physics" (DBfAPP) of the Weizmann Institute (see [plasma-gate.weizmann.ac.il/DBfAPP.html](http://plasma-gate.weizmann.ac.il/DBfAPP.html)). An updated and improved interface for VALD is under construction (at [www.astro.uu.se/vald](http://www.astro.uu.se/vald)), though actual data traffic will continue to be handled via e-mail. This page will include all necessary links including documentation, registration form, requests forms and examples. Send inquiries to F. Kupka (email: [valdadm@jan.ast.univie.ac.at](mailto:valdadm@jan.ast.univie.ac.at)).

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## 10.5. Libraries

Two distribution lists are available specifically for astronomy librarians to share relevant information on widely varying subjects. Astrolib (started in 1988) with ~ 200 members is managed by E.Bouton ([library@nrao.edu](mailto:library@nrao.edu)), librarian at the National Radio Astronomy Observatory (NRAO). The European Group of Astronomy Librarians (EGAL), is managed by I.Howard ([howard@ast.cam.ac.uk](mailto:howard@ast.cam.ac.uk)), librarian at the Royal Greenwich Observatory (RGO). J.Regan ([library@mso.anu.edu.au](mailto:library@mso.anu.edu.au)) is currently trying to set up a group in Asia and the Pacific Rim. People wishing to post announcements to libraries including physics and mathematics departments should get in touch with the moderator of the email distribution list of PAMnet, a network of Physics, Astronomy and Mathematics librarians. Send your inquiry to [david.e.stern@yale.edu](mailto:david.e.stern@yale.edu).

U.Grothkopf, ESO librarian, maintains a list of names, addresses, phone and fax numbers, email address and homepage URLs of astronomy librarians and libraries world-wide. A useful search engine ([www.eso.org/libraries/astro-addresses.html](http://www.eso.org/libraries/astro-addresses.html)) can find librarians even from incomplete information. Librarians not on the list are encouraged to send information to [esolib@eso.org](mailto:esolib@eso.org).



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## 10.6. Astronomy Education on the Internet

Given that the Internet offers almost unlimited possibilities for interactive courses, more and more of these can be found on the web, see e.g. [Benacchio et al. (1998)]. The ``AstroEd" page, at [www-hpcc.astro.washington.edu/scied/astro/astroindex.html](http://www-hpcc.astro.washington.edu/scied/astro/astroindex.html), provides links to on-line astronomy education resources and some on-line courses. The National Research Council's project ``Resources for Involving Scientists in Education" (RISE) features a web site at [www.nas.edu/rise/examp.htm](http://www.nas.edu/rise/examp.htm). An interesting example is given by the University of Oregon ([www.zebu.uoregon.edu](http://www.zebu.uoregon.edu)), where an astronomy book is being developed in ``hypertext". A further advantage of these ``books" is their potential of being kept up-to-date by a groups of professionals.

The European Southern Observatory (ESO) organized an educational programme called ``Astronomy On-line" in December 1997. Its web pages are still available at [www.eso.org/astronomyonline/](http://www.eso.org/astronomyonline/) ([Albrecht et al. (1998)]).

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## 10.7. Others

D. Verner's compilation of people mentioned in acknowledgments of papers in major astronomical journals can be accessed from [www.pa.uky.edu/~verner/aai.html](http://www.pa.uky.edu/~verner/aai.html).



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## 11. ISSUES FOR THE FUTURE

The Internet has been with us for only about a decade. Users of the WWW should be aware that there is still more information, literature, data, etc., existing only in printed form, than is available on the Internet. While the possibilities of information and data retrieval have advanced at a tremendous pace in recent years, there is an infinite number of possible improvements. I shall mention only a few very subjective ones as an example here.

The increasing presence of commercial companies on the Internet is both an enrichment and a plague, the latter because more and more frequently unsolicited emails are being sent to global distribution lists with commercial offers. While this is annoying, and measures should be taken against it (see [cdsweb.u-strasbg.fr/~heck/spams.htm](http://cdsweb.u-strasbg.fr/~heck/spams.htm)), I do not think that it is a reason for astronomers to refrain from being listed in email guides or from making these guides available among colleagues. The damage to easy communication among scientists would be too severe.

The transition from printing large tables on paper to publishing them in electronic form ([Section 3](#)) either in the ADC and CDS archives (or on the AAS CD-ROMs), raises the question about the future of marking-up tables for printing. For many years authors have been obliged to convert their data tables to L<sup>A</sup>T<sub>E</sub>X format. Ironically, AAS requests a charge of US\$ 50 for the service to convert the data tables back to plain ASCII format for publication on their CD-ROM, except for tables marked up with the AAS<sub>T</sub>eX macros (see [www.journals.uchicago.edu/AAS/cdrom/](http://www.journals.uchicago.edu/AAS/cdrom/)). It may be anticipated that the "publication" of tables in electronic form will eventually release authors from this task. However, special non-ASCII symbols, like e.g. Greek letters, will require to be transliterated to ASCII characters in the electronic version.

Unfortunately the journals in astronomy do not yet oblige authors to provide their tabular data to a data centre, as a requisite for publication. An agreement between all major journals and the data centres ADC and CDS is highly desirable, not only for the sake of the completeness of their electronic archives of tabular and catalogue data, but also to remedy the following problem. The clearing house of the IAU Task Group on Astronomical Designations of IAU Commission 5 ([cdsweb.u-strasbg.fr/iau-spec.html](http://cdsweb.u-strasbg.fr/iau-spec.html)) has frequently come across unconventional namings of astronomical objects causing confusion and redundancy of names in object databases like NED and SIMBAD. My experience in the Task Group was that the standard refereeing system of journals does not help to avoid this problem. Ideally, these tables should be run through an automatic cross-checking routine prior to publication or acceptance. For this purpose they should have at least two identifiers (a name and a coordinate) and could then be compared with databases like SIMBAD, NED or LEDA, in order to check the consistency of names and coordinates, and perhaps even part of the data. Of course this is useful only if the objects were known previously.

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## 12. CONCLUDING REMARKS

The Internet and World Wide Web have added just another medium for fast access to large amounts of information. It can save researchers lots of time in retrieving the required information and allows access to unexplored data which are worth many research projects in their own right. However, the flood of information on the web has become so large that now, when searching for a given piece of information, we are about to spend more time in browsing the web than we used to need searching in the library a decade ago (when the amount of available information was substantially less).

In the early years of networking we were happy when we could get electronic copies of astronomical catalogues without the delays through shipments of tapes. Now we are so flooded with them that in the rush of using many of them at the same time we sometimes forget that each one of them is telling us a different story. We must still read their detailed documentation if we want to derive reliable results from the available data. We have gone a good part of the way already to the point where all past issues of the major astronomical journals will be available electronically on the web. However, network saturation still keeps us from skimming a journal in the way that we could in the library.

A compromise has yet to be found between a rigorous refereeing system of web pages (as proposed by some) and the absolute liberty we currently ``enjoy" in offering our own information and expressing our interests on the web. Many people have tried in recent years to offer guides to certain parts of astrophysical information, and the present article is just another example. The challenge for the future is how to protect ourselves from too much redundant or superseded information. While preparing this paper I came across many web pages which at first sight looked promisingly complete. However, when the last update (if given at all) was more than about a year ago, I usually refrained from quoting it here, because of the danger that it would not be maintained any more, or that it would offer too many outdated links. Perhaps a step towards reducing this danger could be a web browser that automatically recognized the date of latest update of a web document and would allow to set filters on that date in a search for relevant links. Actually, the AltaVista search engine ([www.altavista.digital.com](http://www.altavista.digital.com)) allows a range of ``last modified" dates to be used in advanced searches.

I am grateful to the School organizers for the opportunity to give these lectures and for their financial support. My special thanks go to Clive Davenhall, Elizabeth Griffin, and André Fletcher for their careful reading of the manuscript. Useful information or comments on the text were provided by P. Boyce, P. Eenens, G. Eichhorn, D. Fullagar, G. Giovannini, D. Golombek, C. S. Grant, U. Grothkopf, R.J. Hanisch, M. Irwin, F. Kupka, S. Kurtz, N. Loiseau, A. Macdonald, F. Murtagh, F. Ochsenbein, G. Paturel, M. Schmitz, S. A. Trushkin, M. Tsvetkov, and M. J. West. My apologies to those I forgot to mention here.

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