H. DATA IN ASTRONOMY

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Abstract.- The present situation regarding data for astronomy and astrophysics is dominated by two factors: large increase of data and better accessibility, mainly due to the existence of data centres. An attempt to centralize the information of plate vaults is also presented.

1. INTRODUCTION

It is perhaps unnecessary to mention before an astronomers' assembly the importance of data in astronomy and astrophysics, especially if these astronomers are concerned with data. We are certainly not the first to be occupied with astronomical data, since the first star catalogue was established by Hipparcos. Nevertheless, in Hipparcos' time, during the second century B.C., there was no need to speak about data centres: 1080 stars formed this first catalogue. The development of star catalogues was initially due to growth of astrometric data, and once physical methods were used, catalogues with physical data were also compiled. A good example is undoubtedly the Henry Draper Catalogue.

Today also data play an important role in astronomical and astrophysical studies. Catalogues are not always the only result of observations but also a compilation of data for the preparation of an important experiment. To take an example, in a few years ESA will launch an astrometric satellite, Hipparcos, the purpose of which is to obtain data for more than 100,000 stars. At the present time ESA is asking who will be willing to prepare the "Input Catalogue", i.e. the catalogue of all the main data for the programme stars!

Fortunately for people having need of astronomical data, many astronomers are interested in the compilation, storage, etc. of these data. An inquiry made by C. Jaschek (1980) and published by CODATA as the third chapter of the CODATA directory of data sources for science

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and technology reveals that 70 centres or groups of various dimensions are in existence. All the astronomical activities are covered, but not all to the same degree. Many centres - in fact 35 - are concerned with the Sun and the solar system, 35 also with stars and star systems, 4 with various items and only one with radio observations and also only one with galaxies' data. I am not sure that data and data compilation play the same role in each field, but I have the feeling that there is certainly a need for a data centre for non-stellar objects. However, the management of a data centre can only be done by specialists in that particular field and I hope that the initiative will come from colleagues concerned with non-stellar objects.

Data are also important in other sciences and there are in fact many problems in common. Thus, in order to improve the quality, reliability and accessibility of data of importance to science and technology, the International Council of Scientific Unions (ICSU) established in 1966 CODATA, the Committee on Data for Science and Technology. The IAU is represented on CODATA, but mainly with regard to administrative matters, and it is important that all astronomers concerned know of the existence and purpose of CODATA with a view to participating more intensively in its scientific activity. The scientific endeavours of CODATA are largely achieved by task groups, of which I can mention those perhaps related to our science: Accessibility and Dissemination of Data, Computer Uses, Fundamental Constants, Space and Time-dependent Data (of which the chairman is an IAU member), International Training Courses on the Handling of Experimental Data. Under the sponsorship of CODATA and UNESCO a book was published recently entitled Data Handling for Science and Technology, by S.A. Rossmassler and D.G. Watson (1980) and many astronomers would benefit by reading it. My hope is that in the near future more astronomers will collaborate in the activity of CODATA.

2. GROWTH OF DATA

When we consider the various problems related to astrophysical and astronomical data we see that a main problem is the growth of these data. This reflects the development of the traditional activities in astronomy and astrophysics. Woltjer (1978) has shown how the number of large telescopes has grown during this century. During the first half, only one telescope with an aperture of more than 2.5m was in existence until the completion of the Hale telescope in 1948. Now 15 big telescopes are in operation or under construction. The majority of these telescopes have only recently started to produce a large amount of data and it is thought that the growth of data will be even more important in the near future. This growth is also strengthened by data obtained by satellites, which have already produced a large amount of data. The main problem here is perhaps the large quantity in a short period of time. For example, the IUE satellite has obtained 16,000 spectra in two

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years and two months. The data collected by ESA and SRC (one-third of the total) is stored on 500 tapes of 1600 bpi!

The growth of data in stellar astronomy was studied recently by C. Jaschek (1978). In some cases (trigonometric parallaxes, visual binaries) this growth is decreasing, whilst in others it is increasing, sometimes exponentially (variable stars, asteroids, orbits, *uvby*β and Geneva photometries). New catalogues (Hauck and Mermilliod 1980, Rufener 1981) for both the above-mentioned photometric systems have been published since Jaschek's paper and the amount of data in these catalogues confirms his results. For the Geneva system the number of stars passes from ~5000 to ~15,000 between 1976 and 1980! (see table 1). However, the situation is perhaps not so optimistic. 15,000 stars represents only 6.6% of the HD catalogue and if we are interested in a special sample, many photometric data are likely to be absent. But the situation is not always bad, for example less than 10% of the stars belonging to the Gliese Catalogue of Nearby Stars have no photometric data at all (Hauck and Mermilliod 1981).

Table 1. Growth of photometric data

A. *uvby*β system

1965	1.2	10^3
1973	7.5	10^3
1975	9.3	10^3
1977	1.44	10^4
1978	1.9	10^4

$N=1238e^{0.21\Delta t}$ $\quad \Delta t=t-1965$

B. Geneva system

1964	3.4	10^2
1966	6.8	10^2
1971	1.4	10^3
1976	4.6	10^3
1978	1.3	10^4
1980	1.5	10^4

$N=345e^{0.24\Delta t}$ $\quad \Delta t=t-1964$

3. CRITICAL EVALUATION OF DATA

Critical evaluation of astronomical and astrophysical data is certainly a tedious job, but very important for all our community. In stellar astronomy the progress situation is very different from one field to another. With regard to variable stars and parallaxes we need

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a new catalogue in both cases and hopefully these catalogues are in preparation respectively at Moscow and Yale Observatory. For radial velocities the situation is definitely worse, but it is good again if we consider star positions, spectral types and photometric data.

The computer can play an important role in the compilation and homogenization of data. We can use it to obtain weights by intercomparison of lists and thus we are able to calculate a weighted mean as homogeneous data. But we can also keep only one set of data per star by giving the order of preference amongst all the references. Such a procedure was recently applied by M. Jaschek (1978) to stars having an MK type. The resulting catalogue contains ~30,000 stars. This work is based on the La Plata Catalogue (C. Jaschek et al. 1964) and the regularly updated compilation of Mrs. P. Kennedy. Another effort in this direction may also be mentioned, that made by W. Buscombe (see this colloquium). In photoelectric photometry we apply the other procedure as described by Nicolet and Hauck (1977). The most important work published during these last years is without doubt Nicolet's catalogue of UBV measurements. This catalogue has the merit of giving UBV homogeneous data for 53,845 stars. In addition, an indication of quality is given for the V magnitude, U-B and B-V colour indices of each star. This work was possible only by using a computer and because the previous compilations of Blanco et al. (1964) and Mermilliod and Nicolet (1977) were also available on magnetic tape.

It is certainly difficult to recommend such and such a method to homogenize data. The one to be used will depend on the field. Nevertheless, in all cases it is necessary for the reader to have access not only to homogeneous data but also to primary data or, in other words, it is necessary to be able to identify the sources of the compiler. This is also very easy by using a computer.

4. ACCESSIBILITY OF DATA

The accessibility of data is certainly a major problem today. Literature and scientific journals play an important role but cannot assume the full burden. Data centres are definitely a good solution but nevertheless only a partial one. The merits of the existing centres are numerous and I wish to mention especially the fact that their existence is possible since many data files are in machine-readable form. This existence has in turn encouraged many authors to put their data on tape. The fact of having data in machine-readable form is a good step to better access to the data. Another merit of data centres is the preservation of data, their better distribution and the possibility of treating various problems more easily, for example those linked to the various identifications for the same star.

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The present data centres in our field are relatively well located and certainly of sufficient number. Nevertheless, the situation is not perfect. Firstly I think that it should be improved by stronger collaboration between astronomers obtaining data and those compiling these data (and the improvement should be in the sense that the data should be sent to the compilers in machine-readable form). Secondly, we are hoping that data networks will be more numerous in the near future. Starlink and the Japanese network are certainly good examples, but with a limited (geographically speaking) interest. It is my hope that astronomical data networks develop on a wider basis.

In figure 1 I present an organigram of links between the acquisition, homogenization and distribution of astronomical data. At the present time it is only a prospective view, but I am nevertheless confident that we can realize this plan without too much difficulty but with a large amount of goodwill. Thus we will have contributed to improving accessibility to astronomical data.

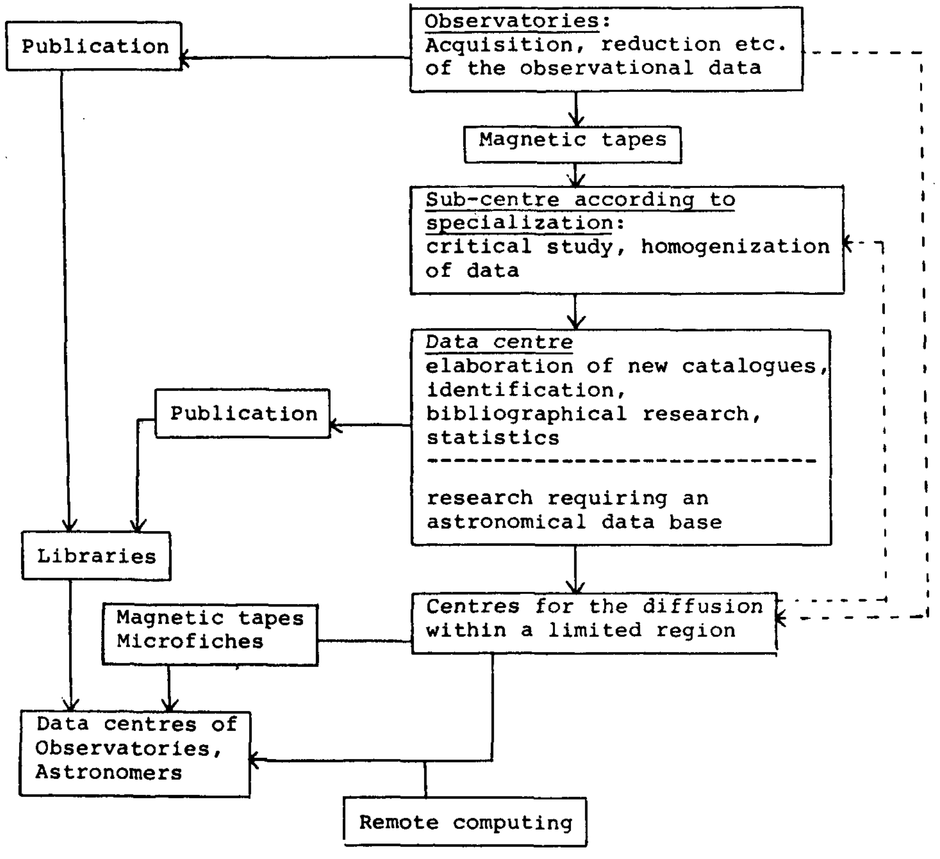

Figure 1. Organigram of links between the acquisition, homogenization and distribution of astronomical data

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Our care to improve accessibility to the data has led to the discovery that there was an important problem concerning the plate vaults. Many plates are stored in various observatories and it is difficult to know which spectra or which fields are available. The Working Group on Astronomical Data of IAU Commission 5 has examined the possibility of improving access to plate vaults. From our point of view this improvement could result from a centralization of information (or at least a minimum of information) concerning the plates stored in each plate vault. As an example, duplication of work could be avoided.

We carried out an enquiry last summer among observatories possessing a plate vault. The response rate to the questionnaire was very high (88%) and the percentage of answers in favour of centralization also very high (86% of the replies on this point). I wish to express my gratitude to all who replied to our questionnaire.

The replies we received concern more than 1.5 10^6 plates and the major problem will be the organization of a central file. Table 2 gives a summary of the replies and table 3 details of each observatory's reply. Five observatories answered favourably to the question "Would you be willing to act as 'centralizer'", three would accept also but with restrictions, and proposals were made to ask the Stellar Data Center to act in this way. We may therefore envisage the future on a solid basis. In my opinion it would be interesting to keep a master file which is regularly updated by information from all observatories and to distribute copies to three or four other locations. As at present only a few observatories have a catalogue of plates in their plate vault which is usable by computer, it would be somewhat ambitious to wish to centralize too much information. On the contrary, a minimum of information is the only way of ensuring success.

Table 2. Summary of Replies

Number of questionnaires sent: 48 Returned: 42 (88%)
32 observatories have a plate vault
2 " " plates but not an organized plate vault
2 " will have a plate vault in the near future
6 " do not have any plates
Number of plates involved: at least 1.5 10^6
Nearly all plate vaults are accessible to visitors
20 observatories are willing to loan their plates outside
8 " " " with some restrictions
32 " have a list or card file of plates (for all or only a part)
In 9 cases the file is usable by computer
31 answers are favourable to centralization of information

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Table 3 - Replies to the Questionnaire

Observatory	Plate vault?	Person in charge	No. of plates	Loan of plates outside	Card file or list	File usable by computer
Australia						
Anglo-Australian Observatory P.O. Box 296, EPPING, N.S.W. 2121	Yes	D. Malin	approx. 2000	subject to some conditions	Both	card/tape
Austria						
Institut für Astronomie Türkenschanzstr. 17, 1180 WIEN	Yes	A. Schnell	~ 3100	subject to some conditions	List	No
Canada						
Mont Mégantic Observatory C.P. 6128, MONTREAL, Quebec H3C 3J7	No					
David Dunlap Observatory RICHMOND HILL, Ontario L4C 4Y6	Yes	C.T. Bolton	46000 +	Yes	Yes	No
Dominion Astrophysical Observatory 5071 West Saanich Road, VICTORIA, B.C.	Yes	E.K. Lee	110000	Yes	File	Yes
Chile						
Observatorio Interamericano de Cerro Tololo, Casilla 63-D, LA SERENA	No					
France						
Observatoire de Haute Provence Saint Michel l'Observatoire 04300 FORCALQUIER	Yes	H. Genevoix	98000	No	Yes	No
C.E.R.G.A. ST VALLIER DE THIEY	Yes	J.-L. Heudier	400 increasing	Yes	Yes	Yes
Observatoire de Toulouse 1 avenue Camille Flammarion 31500 TOULOUSE	Yes	R. Nadal	9012	Yes	2 Lists	No
Germany, Federal Republic						
European Southern Observatory GARCHING bei MÜNCHEN	Yes	R.M. West	4000	Only some	Computer list	Will be
Hamburger Sternwarte Gojenbergsweg 112, 205 HAMBURG	No					
Landessternwarte Königstuhl HEIDELBERG 1	Yes	G. Klare	15200	No	Schurig-Götz atlases + catalogues	Yes
Max-Planck-Institut für Astronomie 69 HEIDELBERG 1	Foreseen					
Germany, Democratic Republic						
Sternwarte Sonneberg, 6400 SONNEBERG	Yes	W. Wenzel	170000	No	Lists	Under consideration
Karl-Schwarzschild Observatorium 6901 TAUTENBURG	Yes	S. Marx	5500	Yes	Yes	No
Indonesia						
Bosscha Observatory, LEMBANG, Java	Yes	B. Hidayat	7000	Yes	Yes	No
Israel						
Weizmann Institute of Science, REHOVOT	No					
Italy						
Astrophysical Observatory of the University of Padova 36012 ASIAGO (Vicenza)	Yes	R. Barbon	37498 (direct phot.) 21135 (spect. & ob. prism)	Yes	List (partial card file)	Yes
Osservatorio Astronomico Universitario via Zamboni 33, 40100 BOLOGNA	Yes	F. Bonoli	19000	Not all plates	In preparation	--
Osservatorio Astronomico di Brera (Milano-Merate), via Brera 28 20121 MILANO	Yes	E. Antonello	9000	No	No	--

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Table 3 - Replies to the Questionnaire (contd.)

Observatory	Plate vault?	Person in charge	No. of plates	Loan of plates outside	Card file or list	File usable by computer
Japan						
Sky Patrol Section, Tokyo Astronomical Observatory, Mitaka, TOKYO 181	Yes	Y. Kozai	5500	Yes	List	No
Kiso Branch of Tokyo Astronomical Obs.	Yes	B. Takase	2850	No	List	Tape
Okayama Astrophysical Station Tokyo Astronomical Observatory	No					
Netherlands						
Sterrewacht Leiden, Huygens Laboratorium Postbus 9513, 2300 RA LEIDEN	Yes	A.A. Schoemaker	~ 30000	Yes	Yes	No
Poland						
Astronomical Observatory N. Copernicus University, 87-100 TORUN	Yes	A. Strobel	1600	No	Card file	No
South Africa						
South African Astronomical Observatory P.O. Box 9, OBSERVATORY 7935	Yes	Director	126000	In certain cases	Incomplete	No
Sweden						
Lund Observatory, Box 1107 22104 LUND	Yes	--	~ 3000	Some	No	No
Uppsala Astronomical Observatory Box 515, 750120 UPPSALA	Yes	Not yet named	Large	Yes	Partial	No
United Kingdom						
Royal Greenwich Observatory, Herstmonceux Castle, HAILSHAM, East Sussex BN27 1RP	Yes	E.D. Clements	90000	Yes	Both	Yes
Royal Observatory, Blackford Hill, EDINBURGH EH9 3HJ, Scotland	Yes	S.B. Tritton	5000	Yes	Yes	Yes
U.S.A.						
University of Michigan, Dept. of Astronomy ANN ARBOR, MI 48109	Yes	W. Hiltner	>8000	No	Partial	No
McDonald Observatory, University of Texas AUSTIN, TX 78712	No					
Harvard College Observatory, 60 Garden St. CAMBRIDGE, MA 02138	Yes	M. Liller J. Kloss (acting)	400000	Seldom	Card file	Yes
Lowell Observatory, P.O. Box 1269 FLAGSTAFF, Arizona 86002	Yes	A. Hoag	Many	Yes	No	No
Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, HONOLULU	Yes	W.K. Bonsack	3500	Yes	No	No
Canada-France-Hawaii Telescope Corporation P.O. Box 1597, KAMUELA	Foreseen	Director	300	Yes	Commenced	Perhaps
Mount Wilson and Las Campanas Observatory 813 Santa Barbara St., PASADENA, CA 91101	Yes	Director	Thousands	Limited	Yes	No
Lick Observatory, University of California, SANTA CRUZ, CA 95064	Yes	G. Herbig	70000 +	Yes	Partial list	No
Kitt Peak National Observatory, P.O. Box 26732, TUCSON, Arizona 85726	Yes	A. Hewitt	~3500	Yes	List	No
Yerkes Observatory, WILLIAMS BAY, Wis 53191	Yes	K. Cudworth	~150000	Yes	Several	No
U.S.S.R.						
Abastumani Astrophysical Observatory 383762 ABASTUMANI, Georgia	Yes	D. Chipashvili	83600 +	Yes	List	No
Special Astrophysical Observatory, USSR Academy of Science, 357140 N. Arkhyz Stavropol Region	Yes	J. Glagolevskij	3300	No	Yes	No

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REFERENCES

Blanco, V.M., Demers, S., Douglass, G.G., and FitzGerald P.M.: 1968, Publ. US Naval Obs. 2nd, p. 21
Hauck, B., and Mermilliod, M.: 1980, Astron. Astrophys. Suppl. 40, p. 1
Hauck, B., and Mermilliod, M.: 1981, Bull. Inf. CDS no 21
Jaschek, C.: 1978, Quart. J. Roy. Astron. Soc. 19, p. 269
Jaschek, C.: 1980, CODATA Bulletin no. 36
Jaschek, C., Coude, H., and de Sierra, A.C.: 1964, Obs. Astron. La Plata, Seria Astronomica XXVIII
Jaschek, M.: 1978, Bull. Inf. CDS 15, p. 212
Mermilliod, J.C., and Nicolet, B.: 1977, Astron. Astrophys. Suppl. 29, p. 259
Nicolet, B., and Hauck, B.: 1977, in Compilation, Critical Evaluation and Distribution of Stellar Data, C. Jaschek and G.A. Wilkins (eds.), D. Reidel, Dordrecht, p. 121
Rossmassler, S.A., and Watson, D.G.: 1981
Rufener, F.: 1981, Astron. Astrophys. Suppl. in press
Woltjer, L.: 1978, in Optical Telescopes of the Future, F. Pacini, W. Richter and R.N. Wilson (eds.) ESO Geneva, p. 5

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