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IUE-ULDA/USSP : the on-line low resolution spectral data archive of the International Ultraviolet Explorer

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Summary. — The on-line IUE Uniform Low Dispersion Archive (ULDA) and the associated ULDA Support Software Package (USSP) are described. The underlying philosophy, the detailed corrections made to the data and the implementation details are summarized. The IUE ULDA/USSP is a new output product of the IUE Project. The low resolution data are made available for direct access to the astronomical community through the existing computer networks. Regular updates to keep the contents of the ULDA current are foreseen. The USSP includes a selection mechanism, a mechanism to transfer the data selected from the National Host to the end user's institute ; it supports various data formats for different data analysis software systems, requires only minimum user registration and collects some usage information. The use of the system has been kept simple and the software is, through the use of strictly controlled code in standard FORTRAN 77, quite easy to adapt to different systems, but it is not transportable in the strictest sense of the word.

Key words : ultraviolet — spectroscopy — archives — programs.

1. Introduction.

The International Ultraviolet Explorer (IUE) is a spacecraft equipped with a 45 cm telescope and spectrographs for the wavelength interval from 1150 Å to 3200 Å. The IUE Project is a joint effort between the National Aeronautics and Space Administration (NASA), the European Space Agency (ESA) and the British Science and Engineering Research Council (SERC). The spacecraft was launched on January 26, 1978 and details of the spacecraft, the scientific instruments and the operational philosophy can be found in Boggess *et al.* (1978) and Faelker *et al.* (1987). The IUE Project has created, already during the operational life of the satellite, a unique spectroscopic data archive. The combined efforts of the project staff at the IUE observatories have succeeded in maintaining this archive well controlled and accessible. Through such activities they have created for the first time in the history of Astronomy a usable spectroscopic data archive. The need for such an archive is obvious if one realizes the data gathering capabilities of even small orbiting observatories. In its, at present 10 years of operational life, IUE has supplied nearly four times more

observing time than even the best ground-based high altitude observatories in a similar time. Also, the ultraviolet spectral region was essentially unexplored before the launch of IUE.

Since the batch data processing ("Pipeline") is a fairly straightforward process in a space observatory, as long as sufficient calibration data are taken, it is obvious that the information contained in the IUE Archive, which consists now of more than 60.000 high (~ 0.2 Å) and low (~ 6 Å) resolution spectra, is much larger than the analysis capabilities of modern day Astronomers can handle. Astronomers have realized this, and responded adequately, as is clearly illustrated by the fact that the dearchiving rate for data in the public domain (six months after pipeline processing date) has been such that on the average, each IUE spectrum has already been used three times. This was one of the main reasons to make the extra efforts needed to improve the accessibility of the IUE Archive.

With an eye on the possible future needs of access under the general intercomputer network structure available

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to most astronomers, and considering Database Centers in general, methods were analyzed to bring the IUE data even closer to the Astronomical Users Community than they already are at this moment. After extensive analysis of the problems, the needs of Astronomers, the communications infrastructure and the resources available within the IUE Project and to most of the common Users, the IUE Project agreed at a 3-Agency Meeting in ESTEC in 1985 to create a new output product : the Uniform Low Dispersion Archive (ULDA) supported by the ULDA Support Software Package (USSP). In this article the underlying concepts, ULDA creation, practical implementation, distribution and access under USSP to the ULDA are described. Further details on the usage and contents of the ULDA/USSP can be found in Driessen and Pasian (1988) and Talavera (1988).

2. Contents of ULDA.

The ULDA is a compacted subset of the IUE Archive, created at the ESA IUE Observatory for the IUE Project, to facilitate the access to the LOW Resolution IUE data and to minimize data handling. It consists of all low resolution ($\sim 6 \text{ \AA}$) spectra taken with IUE in either of its two nominal wavelength ranges (1150-2000 \AA and 1825-3300 \AA) with any of the three cameras which have been and are operational (LWP, LWR, SWP). ULDA Version 1.0 contains all (98.5%) spectra taken in low resolution before 1 Jan 1984, namely 24772 spectra, the data occupying about 50 Mbytes. The data consist of spectra that are absolutely calibrated in terms of flux and wavelength, and are based upon the merged extracted (MELO) file of the normal IUE guest observer (GO) tape, except in the cases explained below. The spectra are given as flux in $\text{erg/s/cm}^2/\text{\AA}$ versus wavelength in angstroms, together with the standard IUESIPS quality factors (epsilons) which denote abnormal pixels (see Tab. I for the meanings of the epsilon flags).

TABLE I. — *Epsilon quality flags.*

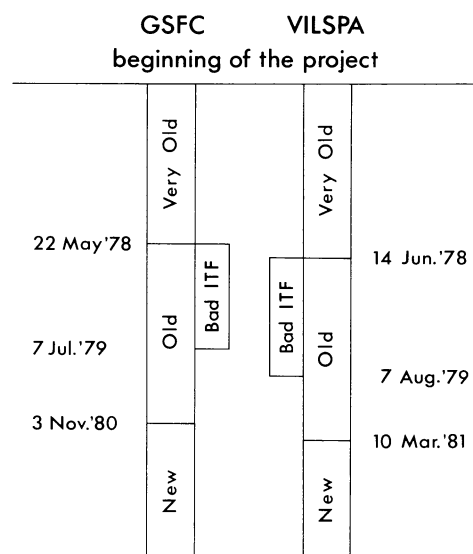
100	normal pixel
-200	extrapolated ITF pixel
-220	microphonic noise
-250	filtered bright spot
-300	unfiltered bright spot
-800	reseau mark
-1600	saturated pixel
-3200	pixel outside photometrically corrected region

In many cases the IUE archive already contains versions of old images that have been reprocessed with the New IUESIPS software (Bohlin *et al.*, 1981). Under these circumstances the New Extraction has been adopted in the ULDA in preference to the older extraction. It is expected that the future versions of ULDA will ultimately consist entirely of spectra reprocessed with the New IUESIPS. No reprocessing from the raw images has been or will be undertaken specifically for the ULDA.

3. ULDA creation.

All data in the ULDA are reduced with the standard software as they are in the IUE Archive at the time of creation of the current version of the ULDA (for version 1.0 the creation date is 1 January 1988). The software package used to perform the standard IUE data reduction and to generate the standard IUE output tapes, IUESIPS, has evolved continuously throughout the life of the Project, mainly to remove software deficiencies and errors, and to enhance the quality of the data. As a consequence of this, a non-homogeneity exists between data processed at different times. The evolution of IUESIPS and the changes are documented in detail by Thompson (1984), Turnrose *et al.* (1984) and Gass and Thompson (1985). In these references each chronological entry (i.e. Configuration) describes when the errors were found, which was the error of deficiency, the affected images and the action taken to correct the error.

Corrections to IUE data for the ULDA : a considerable number of the IUESIPS configurations are not relevant for the ULDA project. Some, because they only apply to high dispersion images and others, because they affect only the label portions and have no influence on the data themselves. However, some configurations define major changes : they correct serious errors or overcome serious deficiencies in the original processing. In order to identify the corrections applied to the data in the ULDA, four periods are defined (see also Fig. 1) :



ITF Values:

Very Old Software	= 2
Old Software	= 3
New Software	= 4
Bad ITF (SWP)	= 1

Affected Images:

	GSFC	VILSPA
ITF = 1	312	140
ITF = 2	6752	3139
ITF = 0	1593	636

FIGURE 1. — Schematic overview of the various major changes in the IUE data reduction software (IUESIPS). These different configurations identify the corrections applied to the data contained in the ULDA.

Very Old Software : from the beginning of the Project (26 January 1978) up to May 22nd 1978 at GSFC and June 14th 1978 at VILSPA ;

Old Software Bad ITF : May 22nd, 1978 – July 7th, 1979 at GSFC and from June 14th, 1978 – August 7th 1979 at VILSPA ;

Old Software : May 22nd, 1978 – November 3rd 1980 at GSFC and June 14th, 1978 – March 10th 1981 at VILSPA ;

New Software : from November 3rd, 1980 at GSFC and from March 10th, 1981 at VILSPA (IUESIPS Image Processing Manual, 1987).

The details of the corrections applied to the data contained in the ULDA are in the following :

3.1 FLUX CORRECTION. — Because of the redefinition of the flux number (FN) – the linearized unit in which uncalibrated IUE Spectra are defined – between the Very Old Software and subsequent versions of IUESIPS, the FN have been scaled by the known factors before applying the absolute calibration. This applies to all Low Dispersion Images processed with the Very Old Software for cameras LWR and SWP. It is needed because of the changes in the net flux extraction method (Turnrose *et al.*, 1984), and it is in practice done through a direct multiplication of the extracted FN by a constant, depending on the camera, in the Merged Extracted Spectra :

$$\text{LWR New FN} = \text{Old FN} * 1.78$$

$$\text{SWP New FN} = \text{Old FN} * 1.83$$

3.2 WAVELENGTH CORRECTION. — The wavelength dispersion constants have been checked for discrepancies known to exist at early dates. This anomaly is due to the usage of bi-weekly dispersion constant calibrations in Low Dispersion for both LWR and SWP cameras and wrong offsets used to place the Large Aperture (Turnrose *et al.*, 1979). It applies to the Very Old and Bad ITF Software periods. The correction applied is described in Harvel *et al.* (1979) and it is performed by comparing the original dispersion constants with an adopted set of more accurate mean values of the dispersion constants (see Tab. II).

TABLE II. — *Mean dispersion constants used in ULDA for Wavelength correction (see sect 3.2).*

Camera	LWR		SWP	
	Large	Small	Large	Small
Constants				
A0	-316.82	-298.22	963.97	981.37
A1	0.30242	0.30242	-0.46657	-0.46657
B0	-247.26	-266.6	-283.38	-263.68
B1	0.22577	0.22577	0.37618	0.37618

3.3 BAD ITF CORRECTION. — The spectra affected by the wrong SWP ITF have been corrected using the SNAFU correction algorithm of Holm *et al.* (1982). This error was caused by the use of a SWP ITF with incorrect

20% exposure level. It applies to the Old Software Bad ITF period and only to the SWP camera. The correction is made to the Line-by-Line spectra. Since this correction is wavelength dependent, the wavelength correction is performed on the Line-by-Line before the Bad ITF correction is applied.

3.4 ABSOLUTE CALIBRATION CORRECTION. — All spectra have been calibrated with the version of the absolute calibration corresponding to the New software, resulting in a uniform absolute calibration of the ULDA over the wavelength ranges 1150-1950Å (SWP) and 1900-3200Å (LWR and LWP). Note that the New software wavelength step is half that of the Old software. This correction is needed since early in the project no absolute calibration existed in the standard processing. It applies to all Low Dispersion images processed during both Very Old and Old Software period. This correction is performed by applying the Inverse Sensitivity functions for the New Software as given in Bohlin and Holm (1980), Turnrose *et al.* (1980) and Cassatella and Harris (1983), to the IUE Net spectrum. The result is a time integrated Absolutely Calibrated Net Spectrum without exposure time division, as in the normal IUESIPS G.O. Tapes.

3.5 HEADER INFORMATION. — The headers of all images have been compared with the merged log to check the exposure times, aperture used etc.

3.6 EXPOSURE TIMES. — The results of absolute calibration are time integrated fluxes (ergs/cm²/Å), while a complete absolute calibration (ergs/sec/cm²/Å) requires the knowledge of the Exposure Times. This time is recorded in the IUE Image Header Label during the Observation (IUESIPS Image Processing Manual, 1984, 1987), using start and end time of exposure. In many cases however, this time does not correspond to the exact duration of the exposure (e.g. double aperture images, trailed spectra or multiple exposures) or it is missing (e.g. exposure length smaller than one second). For these reasons, the Label Exposure times were crosschecked with the times in the VILSPA Data Bank and in case of discrepancy, a more profound check was made using the hand-written Logs and observing scripts. In most cases an obvious error was identifiable in the header time, and the merged log value was adopted. In some cases the merged log value was evidently wrong and the correct exposure time has been adopted for ULDA. The result of this check is a set of corrected exposure times plus a helpful list of dubious situations, such as trailed spectra where a standard length of 20 arc sec has been assumed for the Large Apertures. The final operation is, then, to divide the Calibrated Net Spectrum by the exposure time in order to achieve an Absolutely Calibrated Net Spectrum.

For number of special techniques, which tend to be treated inconsistently in the merged log, a uniform approach has been taken for the ULDA :

a) all Large Aperture (LAP) trailed exposures have been recorded with nominal exposure time : (20 times the

number of iterations)/trail rate (arcsec/sec). (See Panek, 1982 for more accurate measurements of LW and SW large apertures).

b) small Aperture (SAP) trailed exp.times : (3.1 times the number of iterations)/trail rate ;

c) when both apertures have been processed following a single exposure of the target in one of them, the exposure time of the "Serendipity" exposure has been taken as the total camera-on time, normally equal to the exposure in the other aperture (this excludes the occasional case where a serendipity LAP exposure was terminated early by closing the LAP). Many of these serendipitous exposures are not listed in the merged log ;

d) serendipity exposures in SAP during LAP trails have been given the merged log exposure time, usually equal to the LAP trail exposure time. This is highly dubious and is flagged as such in ULDA ;

e) serendipity exposures in LAP during SAP trails are recorded with $t = 20/\text{trail rate}$ and are flagged as dubious in ULDA ;

f) for extracted NULL images an arbitrary exposure time of 1.0 s has been adopted to avoid divide by zero problems ;

g) TFLOOD exposures superposed on other exposures

have been ignored. This includes stellar images and also WAVCAL images where the UV calibration lamp time has been adopted ;

h) extractions from TFLOOD images have the total lamp ignition time as adopted exposure time ;

i) exposure times of HIRES spectra superposed on : LORES image have been disregarded, but the image is flagged as dubious ;

j) for Multiple exposures in any one aperture, with or without change of position, the total exposure time has been adopted and only the merged spectrum is considered. The user should be wary of the interpretation of these spectra although they are not necessarily flagged as dubious from a technical point of view.

In addition to the above cases, there are two other circumstances that might lead to uncertainties in the absolute calibration. The first concerns the small aperture spectra. The transmission of the small aperture varies between 25% and 75% of the large aperture transmission depending on the centering of the target in the aperture guiding, focus etc. (Talavera, 1987). Therefore the absolute fluxes for the small aperture spectra should not be regarded as photometrically accurate, even though the ULDA does not flag them as technically dubious.

The second group consists of spectra with short exposure times. The nominal exposure time written in the log, is converted into an integer multiple of 0.4096 secs by the exposure time counter. There is also a dead time of about 0.12 second, so that the error in the nominal exposure time of 1 sec may be 50% , whereas for exposures of 40 seconds or longer, the discrepancy is less than 1% and can be ignored. These short exposure times are not flagged in ULDA version 1.0 and have been treated correctly in ULDA version 2.0 and higher.

Comparison with reprocessed spectra : in order to evaluate the uniformity of the ULDA, a comparison with actually reprocessed spectra was made of spectra processed for the ULDA. Spectra were taken from each major software group, for all cameras and apertures. For Very Old software, the flux calibration agreed to 10% for well exposed images, but could differ by up to 30% for poorly exposed images. The wavelength scale could be in error by several Angstroms, largely due to the lack of THDA (temperature) corrections for the early images. The Old software test images, corrected for the ITF SNAFU error gave results within 5% of re-processed flux except for poorly exposed images where differences of 10% were seen. The difference of the wavelength calibration was normally less than 2 Å (i.e. less than 1 pixel) and is probably due to poor THDA correction in the early images. Subsequent versions of the ULDA will include the points mentioned above and will incorporate reprocessed versions of old images as they occur. Version 2.0 of the ULDA will extend from launch to 1 January 1987, and will be available in early 1989.

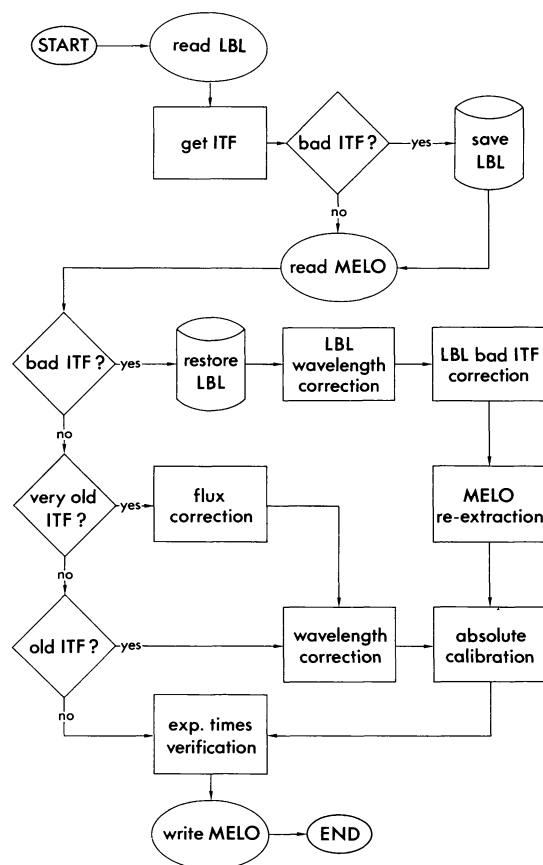


FIGURE 2. — Flow diagram showing the steps involved in the creation of the ULDA. The various corrections identified are discussed in detail in section 3.

4. Homogenisation of identifiers.

Since Astronomical objects are being explored in many different wavelength ranges (Gamma-ray, X-ray, UV, visible, IR, radio, etc), it comes as no surprise that many objects appear under different names in the IUE observing log. This increasing confusion in the astronomical nomenclature and the problems of object designation are summarized elsewhere (e.g. Jasheck *et al.*, 1980; Fernandez *et al.*, 1983).

In 1984 the IUE Long Range Planning Committee recommended to the IUE project that it consider adopting the nomenclature hierarchy of the International Astronomical Union (IAU). In the absence of a formal agreement and considering the fact that the IUE satellite provides principally spectroscopic data, the identification of stars was chosen to follow that used in the primary spectroscopic catalogs (Warren, 1985; Barylak, 1987).

The homogenization of the ULDA data took SIMBAD

(= Set of Identifications, Measurements and bibliography of Astronomical Data – see e.g. Egret and Wenger, 1987) as reference. The object designations were homogenized and accurate equatorial coordinates for the equinox of 1950.0 were provided and added to the VILSPA Data Base. Since the coordinates in the IUE Merged Log record the slit position, rather than the position of the object, these have been maintained. The ULDA contains thus the homogenized identifiers together with the original coordinates as supplied by the observer.

The nomenclature hierarchy presently adopted and implemented by the IUE project for the ULDA is shown in table III (the numbers in the first column of table III give the hierarchical sequence; see the references for further explanations of the given catalogs).

A systematic exception to the hierarchical structure has been made for extended objects, containing many stars, such as bright galaxies or globular clusters. For these

TABLE III. — *Hierarchy for the homogenization of the identifiers adopted by the IUE Project.*

Hierarchy/Catalog	Explanation	/ Ref.	Example
0. IUE	IUE specific		IUE NULL
1. HD	Henry Draper	1.	HD 219749
2. BD	Bonner Durchm.	2.	BD +28 5211
3. CD	Cordoba Durchm.	3.	CD -26 1340
4. CPD	Cape Durchm.	4.	CPD -69 2698
5. V*	Variable stars	5.	V* BF CYG
6. WD	White Dwarf	6.	WD 2034-53
7. GD	Giclas WD	7.	GD 323
8. NGC	New General Cat.	8.	NGC 4151
9. IC	Index catalog	8.	IC 2003
10. PK	Perek-Kohoutek	9.	PK 059+09 1
11. MC	Magellanic clouds		MC SK 80
12. MRK	Markarian	10.	MRK 509
13. ESOB	ESO (B) Catalog	11.	ESOB 113-IG45
14. MCG	Catalog of Galax	12.	MCG +08-11-0011
15. PG	Palomar Green	13.	PG 0108+101
16. QSO	Hewitt Burbidge	14.	QSO 0414-060
17. ABCG	Abell clusters	15.	ABCG 36
18. ZZ	Solar System		ZZ COM 1982J
19. NOVA	Novae		NOVA MUS 1983
20. SN	Supernovae		SN 1983N
21. AOO	Any Other Objects		AOO PKS 1543+091

References to table 3.: (1) Cannon *et al.*, 1918, 1925, 1949; (2) Argelander, 1903; (3) Thome, 1892; Perrine, 1932; (4) Gill and Kapteyn, 1896; (5) Kukarkin *et al.*, 1969, 1970, 1971; (6) Cook and Sion, 1977; (7) Giclas *et al.*, 1965, 1967, 1970, 1972, 1975, 1978; (8) Dreyer, 1953; (9) Perek and Kohoutek, 1967; (10) Markarian and Lipovetskij, 1967, 1969, 1971-1974; (11) Lauberts, 1982; (12) Vorontsov-Vel'yaminov *et al.*, 1962-1964, 1968, 1974; (13) Green *et al.*, 1986; (14) Hewitt and Burbidge 1980; (15) Abell, 1958.

Four "super-groups" were created to avoid an excessive number of catalogs, i.e.:

- 0. IUE : which contains all IUE specific images such as WAVECAL, NULL, CALUV, T FLOOD, UV FLOOD, etc.

- 18. ZZ : the "Z"olar "Z"ystem catalog introduced by the Centre de Donnees Stellaire (CDS).

- 11. MC : which holds all objects in both the Small and Large Magellanic Cloud (i.e. catalogs LMC, SMC, FD, SK, AZV)

- 21. AOO: the catalog of "A"ll "O"ther "O"bjects which holds objects not included in any of the above given catalogs or supergroups.

objects the NGC catalogue has preference over the stellar catalogs (e.g. Omega Centauri is NGC 5139 rather than HD 116790).

The format (see examples in Tab. III) of the homogeneous object identifiers has been defined according to the "First Dictionary of the Nomenclature of Celestial Objects", table II, column 3 (Fernandez *et al.*, 1983).

5. USSP

5.1 CHOICE OF THE USSP CONCEPT. — Extensive analysis of the expected usage of the ULDA led to the definition of the USSP (ULDA Software Support Package), whose overall concept is specified by the following requirements :

- a) the spectra must be accessible to scientists in many institutes spread over a number of countries ;
- b) all users must have the SAME data available to them, i.e. any updates and additions to the ULDA should be accessible to all registered users ;
- c) retrieval of spectra must be both fast and easy to perform, preferably coming as close as possible to having the spectra on line ;
- d) it should be easy to use ;
- e) the data should be available for manipulation independent of the specific data analysis software available to the individual scientist ;
- f) no intermediaries between the scientist and the ULDA (i.e. self-registration without intervention by IUE Project) ;
- g) crash tolerant ;
- h) the system looks after itself wherever possible. (e.g. workfiles) ;
- i) the program language must be commonly available, i.e. the system is not portable but *easily* adaptable.

5.2 STRUCTURAL OVERVIEW OF THE USSP. — The USSP is a distributed software system whose goal is to come close to putting a large number of IUE spectra on line to scientists

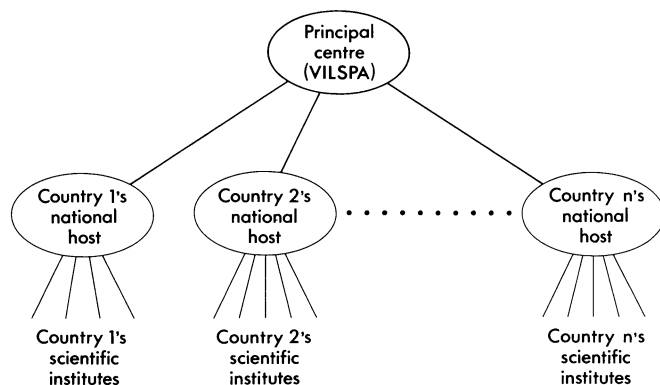


FIGURE 3. — Tree structure representing the underlying philosophy of the ULDA Support Software Package (USSP). It is clear that this type of distributed configuration has the great advantage that the system can actually grow without affecting the overall system performance. This has had very strong influence on the design of the software since the Principal Center can not supply continuous running support. Therefore the system design was strongly driven by an attempt to be as maintenance free as possible.

working in many institutes, in different countries. The system is designed to utilize most of the commonly available computer networks and to allow users to search for, select and get copies of spectra on their computers in a form ready for manipulation under their own image processing system, all within a single sitting.

The USSP's overall architecture has a simple tree structure, as shown in figure 3, built on three classes of centres, each supporting a different part of the USSP. These centres may be thought of as root, branches and leaves.

The root is known as the "principal centre" (presently VILSPA) whose overall responsibility is to supply all branches with the same data : the ULDA, its updates, and the compacted USSP Database, which is subsequently distributed to the branches, are made here. Also a variety of information, collected by the USSP, is assembled here and redistributed to the branches.

The branches are the "national hosts", of which there is one in each country. Their role is to serve their nation's astronomical community. They each hold a copy of the ULDA in the USSP data base and put the software (program QUEST) for searching it and selecting spectra from it, on line. Finally the leaves comprise the end users' computers. A user can search for and select spectra through a remote log-in to his national host. He runs QUEST remotely in the national host and another program, UNSPL, locally to downlink his data in a compact form. UNSPL also puts the spectra into a format matched to his data analysis software. This architecture has three important advantages :

- new countries and end users can be added without affecting the performance of those already supporting the USSP ;
- since there are relatively small number of national hosts, each with a suitable infrastructure, users everywhere have access to the same data without the problems associated with international communications ;
- it does not place the full burden for infrastructure maintenance on the principal centre, which can concentrate on its main task.

This structure has implications which greatly affected both the design and coding of the system : the software is widely spread and therefore special care has to be taken to ensure ease of use. Since it is mainly used remotely it has to be robust and should require a minimum of upkeep. As an example, the search and select program sees to it that the space taken up by users' workfiles will always remain small by automatically deleting those which have expired. While written for VAX's the software is reasonably easy to implement on other computers. The software is definitely not portable — it is just easily adaptable — a requirement which had considerable influence on its design and coding (the latter is in FORTRAN with VAX specific code commented upon and clearly identified).

The end user will only use two USSP programs : QUEST,

to search for and select spectra and UNSPL, to translate the encoded spectra into a format suitable for his data analysis system. However, various other program units are included in the USSP. These range from the essential, such as the program to generate the USSP database, to those which are necessary to support non-essential but important facilities. For example, a record is kept of each spectrum selected together with the date and the person who chose it. Such information, known as 'usage data', is thereafter available to other users. Since the USSP has a distributed structure such information must be collected periodically from all the national hosts, merged and redistributed, which requires software at both the principal centre and national hosts.

6. How to select data (Program Quest).

Scientists can retrieve spectra by logging in remotely to their national host and running an interactive program called QUEST to search for and select spectra. The selected spectra are collected at the national host as a single compressed file, suitable for transmission back to their own computers where they will be converted into a format ready for immediate use by the program UNSPL (see Sect. 7).

Retrieval of the spectra is a two stage process : one performs a database search-and-select of the spectra wanted. Since the primary requirement was that this process, and all QUEST's other functions, should be fast and simple to use, the search-and-select mechanism does not have the extensive flexibility normally associated with Database systems. These are usually extremely expensive in terms of response time. Currently a search (25000 spectra) takes a few seconds, though it could take up to five seconds for a relatively complex parallel search, depending on the total load on the host computer. Ease of use is achieved by always prompting the user for what he can do next, giving free examples wherever feasible and allowing user inputs to be as format free as is reasonable. On-line help is available.

The user is prompted for each of the four classes of search criteria allowed in turn. The immediate advantage is that the response is driven by the search criteria in a natural way without the need for any keywords. The program logic also avoids the need for logical operators (i.e. .EQ., .LE., .GE., .AND., .OR. or parentheses), all of which are derived from the context. An additional consequence of the ease of use requirement is that the system must be easy to pick up after not using it for some time. For instance, if one forgets one's QUEST ID (given on entry to QUEST and used to name your workfiles) you can display the ID's and owner names for a country when starting up the program.

SEARCH. — The database search allows to search on :

- the list of cameras and/or image numbers and/or apertures ;
- the list of pairs of coordinates (R.A. and Declination). Each position defined, is actually a search window, whose dimensions are automatically selected from the accuracy with which the coordinates were specified ;
- the list of IUE object classes ;

- the list of homogeneous object identifiers ;
- any combinations of these.

SELECTION. — Once a set of spectra has been identified through a search, the 'select' command displays the descriptors (i.e. Database entries) of what the search found, one per line and one standard screen (24 entries of 80 characters) at a time. An important feature of Select is that it permits one to save the spectra in one of two formats : straight binary (2K bytes/spectrum) or, a compressed ASCII encoded from suitable for transmission by E-mail or other simple transfer protocols such as KERMIT. In this compressed form, a spectrum, comprising a header, pixels and one quality flag per pixel, requires the equivalent of 26 lines of ASCII text.

If a problem occurred during the downlink of your selected spectra (e.g. the connection was severed), you can reenter QUEST in recovery mode. In this case you will be redirected directly to the SELECT stage of the previous connection. The selection of those spectra which were not successfully transferred can then easily be reinitiated.

7. How to get the data across (Program UNSPL).

The output of the QUEST operation on the ULDA is a user file containing all of the selected spectra in a compressed format, plus two optional formatted files (descriptors and auxiliary information, i.e. "dubious" and "usage" information). Since data are stored in a compact form, they are not suitable to be handled by any conventional data processing system. Therefore, before the user can fruitfully access the data, two additional steps are needed : downlink the user work files from the national host to the user's local directory, and unscramble the user spectral work file, generating individual spectra in a format compatible with the user's local processing system. The unscrambling task is performed by a software module (UNSPL), needed in every individual institution, which can, when a DECnet connection is available, also take care of downlinking the data. Two different options for user workfile access are therefore allowed :

- LOCAL, if the user workfiles have already been downlinked by the user him/herself, possibly changing their names ;
- NETWORK, if a connection of the local system to the national archive host via DECnet is available. In this case, downlink of the user workfiles is possible. Since the format of the output of QUEST (see above) is compressed to optimize transition time, it is necessary to decompress and reformat the data, and to split the single compressed file into a set of spectrum oriented files compatible with the data processing environment used for further scientific analysis.

Three output formats are available under the distributed USSP, namely ASCII table format, IUE FITS (with image extension) and MIDAS ; in addition the possibility exists to have a LOCAL format (the local institute's own) if such an option has been activated by the local system manager at installation time. The standard formats will be described

in detail in section 8. In the case of generalized computer links, the user is prompted for three parameters : the name of the already downlinked work file containing the selected spectra, a flag indicating if ASCII conversion was performed prior to the downlink and the format for the output files. In the case of DECnet/VMS based computer links, if the user wishes to downlink his workfiles, he is prompted for his user id at the national host ; if downlink is not desired (e.g. the files have already been downlinked), the user is prompted for the name of the downlinked spectral file. The data file records are read one at a time : section 1 of each record to build the header information for each spectrum ; section 2 of each record to form the spectrum data ; and section 3 of each record is decompressed and translated into the standard IUE values to form the epsilons for the spectrum. If an error occurs, possibly due to transmission defects during the downlinking phase, and output files are not produced, a warning message is issued. For the described operations on the spectral file, a log file of the local session is available. This records the operations performed, files created and possible errors that occurred during the session itself. Messages are also displayed on the user's terminal.

8. Choice of data formats.

Currently, the supported formats for the output files are ASCII table, disc FITS (with image extension) and MIDAS. The name of each output file in the user's environment is formed with the contents of camera, image number and aperture keywords, with an extension uniquely defining the file format.

ASCII table format : in the ASCII table format, the compressed spectral user work file is split in a number of ASCII files containing one spectrum each. These files have a matrix format, the first column containing wavelength, the second absolute fluxes and the third epsilons (see Tab. I). This simple format can easily be converted into many data analysis systems, and allows understandable direct printouts of the spectra.

FITS format : the second output format provided for the data files is FITS, with the "image" extension [Wells, Greisen, Harten (1981) ; Harten, Grosbol, Greisen, Wells (1987) and Munoz (1986)]. The compressed spectral user work file is split in a number of FITS files containing one spectrum each. The following FITS keywords are filled :

SIMPLE,	with "T", indicating standard FITS format ;
BITPIX,	with 16, indicating 16 bits/pixel ;
NAXIS,	with 1, indicating 1 axis ;
NAXIS1,	with the number of pixels in the spectrum ;
CRPIX1,	with 1, indicating the reference pixel location ;
CRVAL1,	with the start wavelength in Ångströms ;
CDEL1,	with the wavelength step in Ångströms ;
CTYPE1,	with "LAMBDA", indicating that wavelength is expressed in Ångströms ;
CAMERA,	with the IUE camera name ;

IMAGE,	with the image number ;
APERTURE,	with the aperture ("L" or "S") ;
DISPERSN,	with "LOW", indicating the dispersion ;
BSCALE,	with the scale factor ;
BZERO,	with the scale offset ;
DATAMAX,	with the computed maximum data value ;
DATAMIN,	with the computed minimum data value ;
RA,	with the right ascension ;
DEC,	with the declination.

Block 2 of the FITS file contains the spectrum pixels. In the extension header the following FITS keyword are filled :

XTENSION,	with "IMAGE", indicating Image extension ;
BITPIX,	with 16, indicating 16 bits/pixel ;
NAXIS,	with 1, indicating 1 axis ;
NAXIS1,	with the number of pixels in the spectrum ;
EXTNAME,	with "EPSILONS", indicating that the extension contains epsilons ;
CRPIX1,	with 1, indicating the reference pixel location ;
CRVAL1,	with the start wavelength in Ångströms ;
CDEL1,	with the wavelength step in Ångströms ;
CTYPE1,	with "LAMBDA", indicating that wavelength ; is expressed in Ångströms.

Block 4 of the FITS file contains epsilons, one per pixel, generated from the compressed flags in the user data files.

MIDAS format : MIDAS is a data processing environment and system commonly available in Europe. The compressed spectral user work file is split in a number of files in MIDAS format [ESO/IPG (1987)] : the spectral data of each spectrum constitute a one dimensional "bulk data frame" (BDF) file, while an additional file of type table (TBL) is provided to hold the epsilons of each spectrum. The following MIDAS file descriptors (equal in both BDF and TBL files) are filled :

IDENT,	with the camera, image number and aperture IUE key words ;
NAXIS,	with 1, indicating 1 axis ;
NPIX,	with the number of pixels ;
START,	with the start wavelength in Ångströms ;
STEP,	with the wavelength step in Ångströms ;
CUNIT,	with "ANGSTROM", indicating the axis units ;
LHCUTS,	with computed minimum and maximum data values ;
COORDIN,	with right ascension and declination.

9. User registration.

In order to use the USSP each user must register himself under Quest with a user identification (ID), and use the same ID for all subsequent use of the USSP. Registration is a simple interactive procedure, during which a name and address (postal or computer) have to be supplied. IDs must be 3-8 letters long, with the first two letters

comprising an abbreviation for the user's country of origin. (These abbreviations are defined within the USSP). Once registration has been accomplished, a record is kept of the details supplied, and the USSP will recognise the ID on future occasions. This procedure is necessary as all the USSP files generated by users within each participating country are written to a single computer area ; this location is assumed by the UNscrambler/ SPLitter program (UNSPL) which performs the file transfer on ULDA data selected by QUEST. In order to differentiate between users' files, the user ID is used in creating filenames, thus making it possible to establish file ownership directly from the filename only.

10. Usage data.

A collection of data like the ULDA is expected to be used by such a variety of users that some minimal data usage information has to be maintained in the USSP package. A special flag is set in the database of the ULDA to inform a user that a spectrum has already been retrieved before. The management of these data is done through two files, each maintained at the National Centers : the first is updated locally whenever QUEST is used to select spectra, and contains the identification of the requested spectra (Camera Image No. and Aperture), the user id., the date and a precoded reason for retrieval ; the second is a file created by merging all local usage files. Periodically all local usage files are collected at the Principal Center, where a merge is done to create a new global usage file, which is then redistributed to all National Centers. There the duplicate entries between the local and the new global usage file will be removed before making the last one accessible on-line. This way, the usage information available in each country is homogenized, and users can check if the data they want to study, have been retrieved in the recent past (an expiration date is set for such data). If someone requests the usage data of a selected spectrum while running QUEST, he will be supplied with the following information : the names and addresses of previous requestors, the dates of corresponding previous selections and the motive for the use of the spectrum. It is expected that this will prevent duplication of effort and encourage international collaboration.

A number of actions have to be performed on these files for routine maintenance or for information purposes. The two programs which take care of the usage information are SAGE which runs at the National Host and PRINCE which does the merge at the Principal Center. Of course, the usage data can also be used to generate statistical information on the usage of the ULDA contents. The most obvious of these are included in the PRINCE module.

11. Summary.

We have described the overall structure of the IUE ULDA/USSP. This comprises a homogenized database obtained with the IUE spectrographs in low resolution mode. The dataset is supplied to a number of National Hosts which maintain this spectral archive to allow direct on-line access to its data by interested astronomers. The principal Centre, at present the ESA IUE Observatory, which has produced the ULDA and part of the USSP, (also the management of the creation of the support software USSP) fulfils a coordinating role in the overall structure in updating the ULDA data regularly (every two years) and also merges and redistributes some of the auxiliary information created in the usage of the ULDA/USSP to the National Hosts. The total data content of ULDA version 1.0 is 24772 spectra which represents a 98.5% completeness for the period up to January 1, 1984. The data and support software have now been installed in 12 National Hosts which support the access from 16 countries. Although the system has been set up on a nationally distributed basis, to maximize its usage and minimize its maintenance, there are no restrictions on its use on an international basis. Every country, wishing to make ULDA/USSP installation in a National Host, will be supplied with a copy of the USSP Database (i.e. the ULDA data set) and the USSP software package, by the Principal Center VILSPA. This is the first time in Astronomy that a fully calibrated and relatively uniform spectroscopic data set has been made directly accessible to the general community.

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