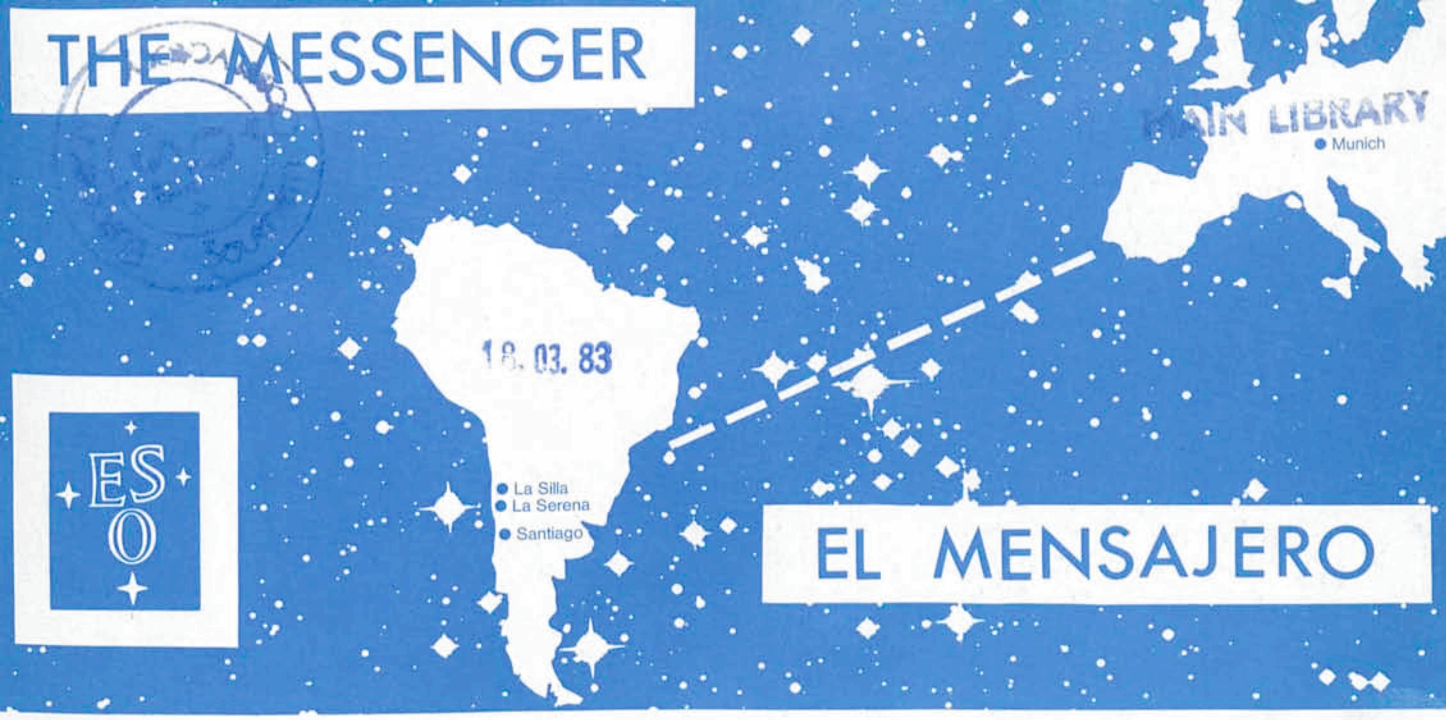

No. 31 – March 1983

Latest News about the European Coordinating Facility for the Space Telescope

On the 23rd of February, a Memorandum of Agreement concerning the European Coordinating Facility for the Space Telescope was signed in Paris by the Director General of the European Space Agency (ESA), Mr. E. Quistgaard, and the Director General of the European Southern Observatory, Prof. L. Woltjer. The ceremony took place in the presence of the members of the ESA Council.

The aim of the agreement is to define the modalities of the cooperation between ESA and ESO for the operation of the ST/ECF, which will be established as a separate unit at ESO in Garching. The prime purpose of the establishment of the ST/ECF is to enhance the capabilities within Europe for the scientific use of the Space Telescope and of the Space Telescope data archive.

To achieve this aim, the ST/ECF shall provide a convenient source of detailed knowledge in Europe of the Space Telescope and its associated instruments, ensure coordination of software developments for ST within Europe and with the ST Science Institute in the U.S., and contribute to the archiving, cataloguing and disseminating of ST data to European scientists. ESA and ESO will each provide seven persons towards the staffing of the ST/ECF. ESO will have the primary responsibility for the day-to-day functioning of the ST/ECF. It is expected that the ST/ECF will begin functioning in a limited way later this year.

Fiber Optics at ESO

Part I: Coupling of the CES with the 3.6 m Telescope Using a 40 m Fiber Link

D. Enard and G. Lund, ESO

During an experimental run made in November 1982, two entirely different and independent fiber optic systems were tested at the 3.6 m telescope. In the present article, a description is given of the first, which consisted essentially of an optical fiber link between the 3.6 m prime focus and the CES input slit.

In the next issue of the Messenger, the multiple-object fiber-spectroscopy system will be described.

Technical Description

The purpose of this project was to determine the usefulness of a long single fiber link between the 3.6 m prime focus and the CES spectrograph using a suitable adaptation of the output beam divergence together with an image slicer.

The essential components developed for this project were: the fiber link with its end connectors, the mechanical and optical guiding elements, provision for illuminating the fiber with calibration lamps, and the output beam optics coupled with an image slicer. A brief description of the above components is provided in the following paragraphs:

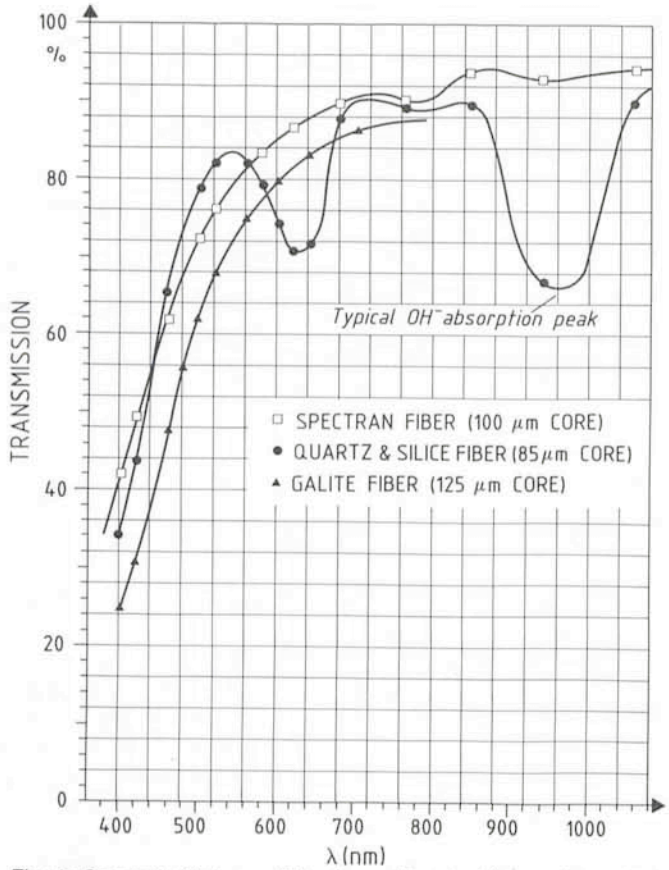

Fig. 1: *Spectral efficiency of the three 40 metre fiber optics cables. Considerable attenuation at blue wavelengths is evident in all three fibers, although a useful spectral range from 5000 Å to 1 μm is available. (Most commercial fibers are optimized at 0.85 μm or 1.3 μm for telecommunications applications). All measurements were made at f/2.8.*

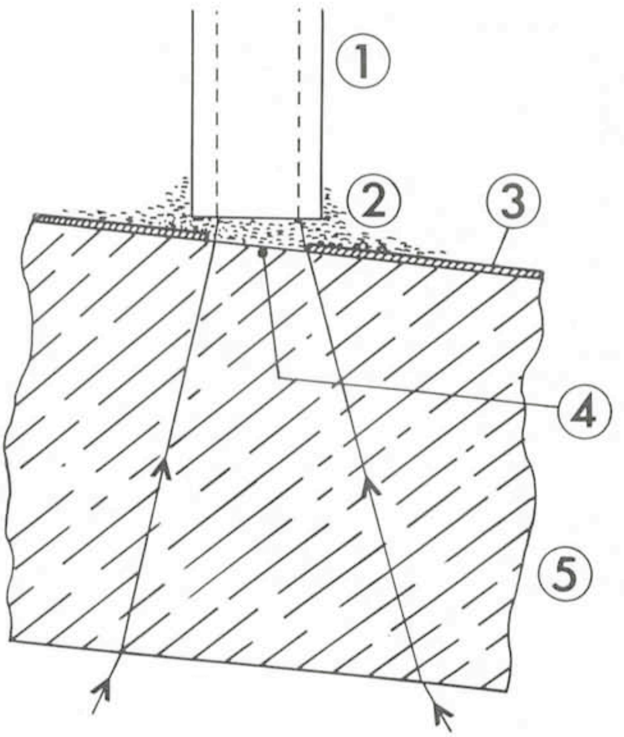

Fig. 2: *Schematic view of the fiber input-inclined diaphragm assembly. This design enables the focussed star image to fall, via a hole in the mirrored diaphragm, onto the input end of the fiber. Any coronal residual of the image is viewed at the edges of the hole via a TV camera. The numbered components are: 1. Optical fiber; 2. Immersion liquid; 3. Aluminized surface; 4. Non-Aluminized hole; 5. Silica cover plate.*

1. Fiber Link

Three different optical fibers (each roughly 38 m long and housed in a protective cable) were prepared for this experimental run. They were distinguished mainly by their core diameters (85 μ, 100 μ and 125 μ) and to a certain extent by their laboratory measured spectral transmission (Fig. 1) and their output beam divergence. Both ends of each fiber were mounted in a specially developed ESO connector. As shown in Fig. 2, the fiber input end was covered by an inclined diaphragm whose rear surface acts as a mirror except for a hole slightly larger than the fiber core. An oil immersion was employed to ensure satisfactory optical matching between the fiber and diaphragm.

At the output end of the link a similar connector was used to accurately align the fiber with a beam focussing system. An immersion oil was used between fiber and lens for correct optical matching.

2. Acquisition, Guiding and the Prime Focus Adaptor

When correctly aligned in the primary focal plane, the image of the star of interest is focussed onto the fiber input end, as illustrated in Fig. 2. The principle of the prime focus adaptor, designed for ease of acquisition and guiding, is illustrated in Fig. 3; for the purpose of initial acquisition the mechanical support, holding together the prism-lens assembly (used for calibration) and the acquisition mirror, is swung in front of the incident beam permitting the star of interest to be found within a field of roughly 6′ × 6′. At the same time either of the calibration lamps may be switched on for determining the spectral calibration and flat-field response of the spectrograph. The lamp beams are focussed onto the fiber end via the prism lens arrangement.

In order to center the star accurately onto the fiber, the prism-mirror assembly is swung out of the telescope beam, thus allowing reflected light from the fiber diaphragm to be re-imaged with a magnification factor ~ 3 (via lens triplet 2, mirror 2 and mirror 3) onto the TV camera. In this mode, since the fiber diaphragm is aluminized except for a hole aligned with the fiber

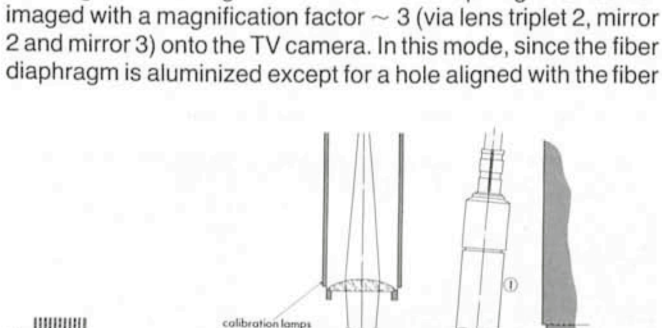

Fig. 3: *Schematic view of the adaptor-guiding unit. This assembly is installed at the prime focus of the 3.6 m telescope. Essential elements not described in the figure are: 1. ESO connector and diaphragm assembly (Fig. 2); 2. Calibration prism-lens assembly; 3. High-gain TV camera.*

core, the correctly guided star is observed as a "black hole" surrounded by a bright corona whose extent depends upon the TV camera gain and the actual seeing conditions. At a later date, an autoguiding system could be used directly with this TV image.

3. Output beam optics

The f/3 prime focus input beam profile is transferred through the fiber almost undisturbed, with only a few per cent of the input energy being scattered beyond the nominal f/3 beam (Fig. 4).

A cemented triplet objective produces a 10× magnified image of the fiber output end at the entrance slit of the spectrograph, thus reducing the beam aperture to f/30 which is then compatible with the spectrograph optics.

If a certain degradation in resolution can be tolerated, the normal CES input slit can be used at a wide setting so that most of the light enters the instrument. If the condition of maximal resolution is determinant for a particular observation, this slit can be replaced by an image slicer. The image slicer used during the test period was designed by H. Richardson (E. Richardson, "Image Slicers for Image-Tube Spectrographs", ESO/CERN Conference on Auxiliary Instrumentation for Large Telescopes, May 2–5, 1972, p. 275), and is essentially an image anamarphoser comprising an input cylindrical lens, an input slit, two split offset spherical mirrors and an output slit. If considered as a black box, the slicer can be thought of as allowing one direct slice of the image through the exit slit, and placing above and below this slice one (or more) slice(s) taken from each of the two remaining (and otherwise lost) crescent-shaped edges of the image. Higher order slices are also present but are not made use of in this design because of the limited diode length of the reticon. This system, if well adjusted, provides a theoretical gain of around 2.5 for an exit slit width of 230 μ and a uniformly illuminated fiber end 85 μ in diameter. Such a configuration is of course only useful if the detector pixels are sufficiently dimensioned (as is the case with the CES reticon for up to 3 slices) to make use of the elongated entrance slit spectrum.

Test Results

The 3 cabled fibers prepared for this experiment were installed on the telescope in less than a day. They were fed down through the prime focus via the Serrurier structure and one of the coudé tubes into the coudé room.

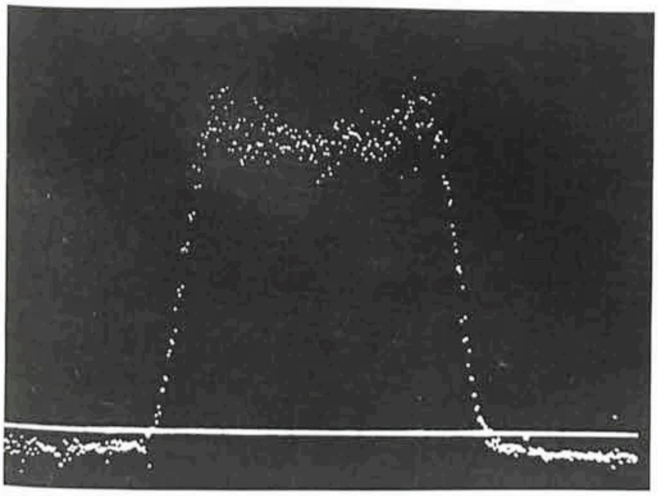

Fig. 4: *Output beam profile of the fiber. This profile was obtained with the complete fiber link and a bright star. A reticon was set at a certain distance from the fiber end and used to record the angular distribution of light at the fiber output. Calculations show that more than 95 % of the energy in this beam is admitted into an f/3 optical system.*

Tentative Time-table of Council Sessions and Committee Meetings in 1983

April 6–8	Committee of Council (Chile)
May 3–4	Finance Committee
May 5	Users Committee
May 20	Scientific and Technical Committee (Cargèse, Corsica)
June 6	Council (Observatoire de Haute-Provence)
June 8–9	Observing Programmes Committee
November 8	Scientific and Technical Committee
November 9–10	Finance Committee
November 11	Committee of Council
November 29–30	Observing Programmes Committee
December 1–2	Council

All meetings will take place at ESO in Garching unless stated otherwise.

Fig. 1 clearly illustrates that the present fibers cannot be used efficiently in the blue over relatively long distances and for this reason no attempt was made to work in this spectral region. Most of the observations were made at wavelengths greater than 5600 Å. The adapter and guiding unit developed for the prime focus were found to be totally satisfactory: star acquisition and guiding with the TV camera was extremely easy and the calibrations obtained through the fibers led to integration times equivalent to those necessary with the spectrograph calibration system. Although no adequate comparison has yet been performed, it is expected that calibrations achieved via an optical fiber should give improved overall accuracy.

1. Fiber Efficiency

Efficiency comparisons using different combinations of fiber and slit (or image slicer) were handicapped by the extreme sensitivity of the system to seeing. This is unfortunately a parameter which, by its own nature, evolves quite rapidly and unpredictably.

From the tests performed over 3 nights it seems that 2 of the fibers (Quartz and Silice 85 μm diameter and Galite 125 μm) gave comparable results whereas the 100 μm fiber, which in the laboratory exhibited considerable aperture degradation, was found to be inferior. The similarity in results obtained with the 85 μm and 125 μm fibers can be explained by the fact that although the former has a smaller collecting area, this drawback is compensated for by a superior matching of output image to entrance slit size.

2. Image Slicer Performance

The efficiency of the image slicer was measured by comparing its throughput with that obtained with a conventional slit of the same width. The gain was in this case found to be about 2, whereas a factor of 3 to 4 (depending on fiber diameter and seeing) was achieved with no image slicer by opening the spectrograph slit sufficiently to accommodate the projected image of the fiber output. This result stresses the extreme dependence of the overall system efficiency upon seeing and image slicer efficiency.

3. Astronomical Results

During the last test night, the relatively faint LMC star HD 269700 was observed (Fig. 5). This star has a magnitude of 10.54, and was observed with the 85 μm fiber together with a

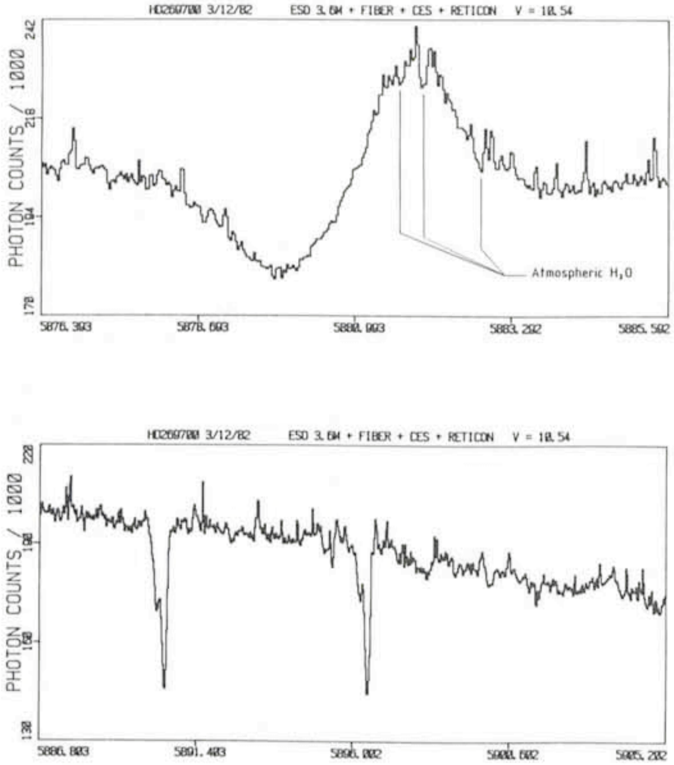

Fig. 5: *Reticon spectrum of the LMC star HD 269700 (M_v = 10.54). This spectrum was obtained after 3.5 hours of integration using the 3.6 m telescope and a 85 μm core fiber.*
(a): the P Cygni profile of He I. The detected emission and absorption line velocities are respectively 320.76 and 216.5 km sec^{-1}.
(b): Na I interstellar absorption lines. The two deep lines are galactic components, whereas several other fainter components associated with the LMC itself can also be detected.

large slit; the resolution was thus degraded by a factor of about 3 to a value of 160 mÅ (FWHM). The seeing during this observation was excellent, and possibly as much as 80 % of the light was captured by the fiber. The signal to noise ratio was about 100 and the gain compared with similar observations with the CAT corresponds to about 2 magnitudes, equivalent to the ratio of the collecting areas of the 2 telescopes. This stresses the important result that the fiber link itself can, under certain conditions, be extremely efficient and that the 2 main sources of loss are those due to input coupling with the telescope (limited by the seeing) and those due to coupling with the spectrograph (limited by the slit width).

Conclusions

It has been demonstrated that a fiber optics link could be used efficiently to couple an instrument to a telescope over distances of several tens of metres. The coupling efficiency is limited by two conflicting requirements: a large fiber should be used for good compatibility with the average seeing disk, whereas considerations of optimal slit matching would require a smaller fiber to be used.

Because of its circular collecting area, the fiber is more sensitive to seeing degradation than a normal spectrograph slit. For this reason, the potential efficiency of future systems will be to a large extent dependent upon the development of an image slicer capable of efficiently (~ 100 %) anamorphizing the output light distribution into a form entirely compatible with the spectrograph input requirements. Such an image slicer would then permit much larger fibers (limited in diameter only by the useable entrance slit or detector length) to be envisaged, thus significantly reducing the seeing dependence. This problem is not only relevant to the particular case of the CES, but is also of prominent interest for the development of future very large telescopes for which the instrumental coupling efficiency will be a critical parameter.

Before long a CCD will be installed on the CES and the present limitation in detector length will disappear, enabling a larger fiber diameter and consequently higher slicing factor to be implemented.

This new detector, when used together with an improved image slicer and fiber optics link, will yield a gain of 3 to 4 magnitudes at the 3.6 m telescope when compared with the present CAT/RETICON configuration.

It is hoped that within the first half of 1984, a fully operational and optimized fiber optics link will be ready for routine use by astronomers.

Acknowledgements

The recent experimental run made at La Silla was made possible only by the active cooperation of many staff members of ESO (at Garching and La Silla). In particular, we would like to thank S. Balon, B. Buzzoni, R. Ferlet, G. Huster, J. L. Lizon and E. Maurice for their respective contributions.

ESO Workshop on "Primordial Helium"

Some 60 participants attended a workshop on Primordial Helium and related light elements at Garching on February 2–3, 1983.

Theoreticians opened the workshop by stressing the importance of abundance measurements for the primordial elements. They outlined how recent developments in particle physics and cosmology have created great interest in determining accurate primordial abundances.

The various observational approaches to determining Y_P (the primordial helium abundance) were elaborated by many speakers. It was striking to see that from the smallest systems (planets, individual stars) to the largest (extragalactic HII regions) abundances could be obtained with reasonable accuracy. We heard about investigations of the Sun, the atmospheres of Jupiter and Saturn, and young and old stellar systems. Opposite viewpoints were expressed with respect to prospects of obtaining accurate abundance determinations from globular clusters. Possibly the greatest controversy concerned approaches to Y_P using galactic and extragalactic HII regions – this involved observers, specialists in the interpretation of atomic spectra, and theorists of stellar and galactic evolution. New possibilities were investigated, involving supernova remnants, active galactic nuclei, and absorption lines in QSO spectra.

Reviews of the latest results concerning other light elements were also given – deuterium, lithium-7 and helium-3. These were considered, together with the best estimates of Y_P, in a very lively discussion session at the end of the workshop, and theoreticians elaborated their views on the status of the standard Big-Bang Cosmology and explored alternatives.

The proceedings of the workshop will be published by ESO within a few months.

P.A.S. and D.K.