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The Very Large Telescope Project

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Artist's view of an early ESO VLT concept, representing a array of four 8 metre telescopes, of which two are shown to be linked for interferometric capabilities. It now seems preferable to do interferometry by adding to the large dishes a few smaller size (2–3 metre) telescopes that would be movable. (Drawing by J.-M. Leclercqz.)

As emphasized unanimously at the time of the Cargèse workshop[1], a Very Large Telescope (VLT) project is of vital importance to the future vigour of European astronomy. The table given below shows indeed that "competing" projects exist in the US, UK, USSR, all of which are to be completed within about 10 years. The Space Telescope is indicated in the same table for comparison, in order to stress its high cost and its size of "only" 2.4 metres. It is also very important to keep in mind that the Space Telescope and future large ground-based telescopes are to be considered as complementary, not as competitors.

The area of very large telescopes is in continuous development and progress: five international conferences have indeed been devoted to the subject since 1977, the last one in September 1983. The next one will be the IAU Colloquium 79 on "Very Large Telescopes, their Instrumentation and Programs", to be held in ESO (Garching) in April 1984.

Scientific objectives for VLTs have been listed on several occasions: a number of them may, for example, be found in the Proceedings of the Cargèse Workshop[1]; only a few will be mentioned hereafter. In all cases, it turns out that the main use of a VLT will be in the areas of spectroscopy and of high spatial resolution imaging.

The high light gathering power of a VLT will make possible a whole range of observations which at present cannot be made at all or only in a very limited way: they concern primarily low-resolution spectroscopy of very faint objects as well as high-resolution spectroscopy of a wide variety of objects with intermediate brightness. Targets will undoubtedly cover a tremendous range of distances, from solar system sources to objects at the edge of the universe. For illustration, let us simply mention a few tantalizing possibilities:

- Spectroscopic observations of the outer planets and cometary nuclei to search for various molecules with low abundances;
- High spectral resolution observations leading to detailed abundances of elements in stars in different parts of our galaxy, the Magellanic Clouds and other satellite galaxies, which would give essential information on the origin of the elements;
- Stellar seismology: the observation of oscillations like those found on the Sun, which give much information on the stellar internal constitution and rotation;
- High time resolution photometric, spectroscopic and polarimetric observations of compact X-ray sources which may contain black holes, of X-ray burst sources, of dwarf novae and other rapidly varying objects;
- Spectroscopy in the IR of quasars and active galaxies to determine the internal absorption and to study the kinematics of the absorbed region;
- High spectral resolution observations of quasar narrow absorption lines and the consequent mapping of the distribution of intergalactic matter in the universe;
- Spectroscopic observations of very distant galaxies to study their evolution, and from this to gain further information on the expansion of the universe.

High resolution imaging is perhaps one of the most fascinating capabilities of ESO's future VLT: speckle techniques, as well as direct imaging, especially in the infrared where the diffraction limit of the telescope is achieved, would become possible down to extremely faint objects. In areas such as the infrared again, advantage could immediately be taken of the two-dimensional arrays that are presently being developed. This would enable morphological studies of objects ranging all the way from asteroids to galactic nuclei, and perhaps permit the detection of "solar systems" in their early phase of formation.

What is the best way of making these observations possible with the highest efficiency? A study group within ESO has looked into this problem while considering the three following possibilities:

(a) A single dish of 16 m diameter with a segmented mirror;
(b) A multimirror telescope (MMT) with, for example, four 8 m monolithic mirrors;
(c) An array of independent telescopes – for example four 8 m telescopes.

The first option (a) suffers from two basic problems: a very sophisticated and as yet untried control system will be needed to keep the segments aligned to optical specifications, and the long focal length makes it very difficult to construct efficient matching spectrographs. The main advantage of this option would be that in the IR and for optical speckle work the largest possible aperture is desirable. The second option (b) alleviates the spectrographic matching problems, while the extension of conventional mirror technology to 8 metres seems achievable. In principle, it is possible to combine the light from the different mirrors optically, but the additional loss of light makes this less attractive in many applications. The third option (c) is very similar, except that with independent telescopes more flexibility is obtained; furthermore in this configuration, interesting possibilities may exist for interferometry.

An additional element to be considered for the selection of the concept is the technology available to make the primary mirror. Extensive research is currently being carried out at ESO for the New Technology Telescope (NTT) project on the active control of a thin ("deformable") dish. It seems, on the basis of the experience that has been gained that a large, actively

[1] Workshop on ESO's Very Large Telescope, Cargèse 16–19 May, 1983; ESO Conference and Workshop Proceedings No. 17; eds. J.-P. Swings and K. Kjär.

PROJECT	SIZE OR EQUIVALENT DIAMETER	PRESENT COST ESTIMATE (approx.)	CHARACTERISTICS	LOCATION
University of Texas	7.6 m	40 M $	very thin monolith	Davis Mts., Texas
University of California	10 m	50 M $	segmented primary	Mauna Kea, Hawaii
US National New Technology Telescope (NNTT)	15 m	100 M $	segmented primary or multiple mirror	Mauna Kea or Mt. Graham (Arizona)
USSR	25 m	?	segmented primary	?
ESO (VLT)	16 m	270 M DM	array + interferometer?	Chile?
Space Telescope (ST)	2.4 m	1,200 M $	use: 85% US; 15% Europe	launch 1986

Note: It should also be mentioned that large telescope projects (e.g. 17.6 m multi-mirror, very large Schmidt) are presently under study in the United Kingdom.

corrected monolithic mirror would be a reasonable choice for the VLT. At the time of the NTT completion which might also correspond to the start of the construction of the VLT, enough experience will have been acquired (including tests on a real telescope) so that the extrapolation of the NTT technology up to a diameter of about 8–10 m will be possible. The corresponding blank will not necessarily be a solid meniscus but will more likely be a hollow honeycomb structure either made out of glass or metal. There too, the important investigation on metal mirrors carried out in the framework of the NTT project may have an important impact on the VLT.

As a result of these various considerations, option (c) seems at the moment the most attractive. A similar conclusion was also reached by ESO's Scientific and Technical Committee at its meeting on 8 November, 1983, where it was clearly recommended that ESO should consider its VLT as a limited array of large telescopes, and start as soon as possible on the definition of the first of its 8–10 metre elements.

Interferometry is only meaningful if some of the telescopes are mobile. Again, the cost aspects of making a telescope mobile but at the same time stable to high accuracy, need be studied. Alternatively, at least in the IR it may be profitable to do interferometry with a combination of fixed 8 m and mobile smaller telescopes. This point also needs further study.

Another set of studies which started a few months ago is that related to the choice of a site for the VLT. The absolute requirement for the site for an expensive telescope to be operated at its highest efficiency is excellent seeing. This is already the case when only standard applications like various types of spectroscopy, or faint object observation, or infrared photometry are considered. It is still more strongly the case in interferometric applications where the signal-to-noise ratio may vary with as much as the 3rd or 4th power of the seeing parameter. A second and important requirement is very low humidity for IR studies; regions with strong winds are also to be avoided.

One should also note that the selection of a site is not without consequence for the definition of the concept. For instance it may not be obvious to find an excellent site on which both a coherent long baseline array and the large telescopes can fit together without affecting the performance of one or the other.

A workshop on "Site Testing for Future Large Telescopes" was held very recently (Oct. 4–6) at ESO in Chile in order to "review what is being done to test and compare the very best sites in the world and what more should be done in the coming few years". Meteorological observations and measurements of total precipitable water content have already been started in a few very dry sites in northern Chile. Seeing studies should be taken up next year if these first measurements are satisfactory.

Together with the measurements for site selection, technical studies are being initiated, as well as a detailed discussion of the implications on the scientific objectives. Suggestions and research proposals from institutes in the ESO countries on subjects related to the VLT (either on concepts, technology, instrumentation, or in more specific areas such as wide band high efficiency coatings, image slicers, fiber optics . . .) will be sollicited.

The Proceedings of the Workshop on "ESO's Very Large Telescope" are available from ESO-Garching. The price for the 270-page volume is DM 40.— and has to be prepaid (preferably by cheque).

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A New Class of Cataclysmic Variables: the Intermediate Polars

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Introduction

Several newly discovered hard X-ray sources (kT > 2 keV) were identified with binary systems, characterized by an orbital period of 3 to 4 hours and by strong emission lines in the optical and ultraviolet superimposed on a blue continuum. (Fig. 1, 2). Moreover, these systems exhibit strong periodic and coherent variations on a time scale of ten minutes, the so-called "pulsations", with a full amplitude from 10 to 40%. (Fig. 3). These

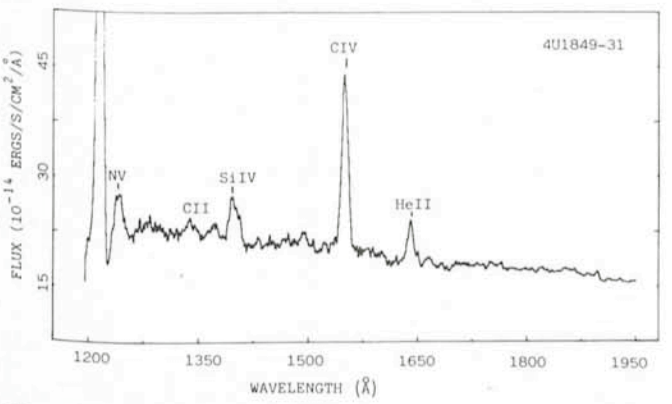

Fig. 1: *Average IUE spectrum of 4U1849–31.*

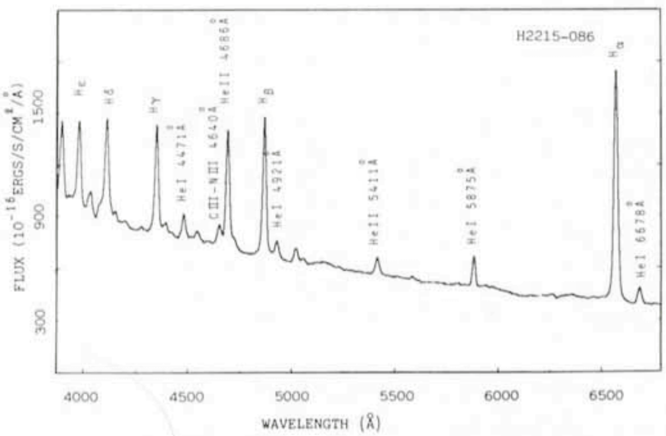

Fig. 2: *Average optical spectrum of H2215–086 obtained at the 3.6 m telescope using the IDS attached at the Boller and Chivens spectrograph. Note the strong He II 4686 Å line.*