LITE: the Large Imaging Telescope

Abstract

We describe a new German–French project aimed at a very deep CCD survey in the southern hemisphere. It is based on a 2.5 m class telescope with a field of 1.5 degrees or more, dedicated to high-resolution, deep CCD imaging. This telescope is intended to become a complement to the ESO VLT and to be installed in the Paranal area. The operations should start in 1999.

It was realized very early in the development of the ESO 16-metre equivalent Very Large Telescope (VLT) that wide-field imaging is too complicated and costly to implement on the VLT itself and should be done with a smaller telescope.

Accompanying imaging observations are essential for the optimal use of the VLT. Let's take an example. For large scale structure studies, the VLT allows the measurement of redshifts in a 30 arcmin field-of-view of galaxies of magnitude 23 or even fainter. They are too faint to be reliably detected on Schmidt plates, so the input observation catalog must be obtained from deep CCD imaging. In this example, outstanding image quality is needed to make a clear separation between faint galaxies and stars. The best compromise for obtaining such images is a middle size telescope of about 2.5 m diameter and equipped with a wide field CCD camera.

These considerations have led the French astronomical community to propose the construction of such a special telescope. The definition of this project, now referred to as the Large Imaging Telescope (LITE), started in Spring 1992 with the establishment of a consortium of several French laboratories, including Observatoire de Meudon, Institut d'Astrophysique de Paris, Observatoire Midi Pyrénées, Observatoire de Besançon, Observatoire de Marseille, and led by the Department of Astrophysics and Particle Physics in Saclay. At the same time, a German group from Sonneberg Observatory, Tautenburg Observatory and the Institute of Astrophysics in Potsdam were working on a project of a second generation Schmidt telescope to pursue the type of research which has long been done at these institutes. Richard West and Ray Wilson of ESO, who were aware of both projects, acted as the go-betweens of the two groups who, in a meeting held at the ESO Headquarters in Garching in December 1992, decided to join their efforts. The telescope is the responsibility of the German group, while the CCD camera and its acquisition system will be designed and constructed in France.

While this project was originally designed for observations of mainly cosmological interest, it has the technical capability to cover a much broader range of astrophysical problems. The consortium is now working on several programs, e.g.:

1) galactic structure and low mass star luminosity function and proper motion on a 10 year time scale;
2) study of variable stars;
3) properties of nearby galaxies;
4) luminosity function and morphology-density relation of galaxies;
5) survey of emission line galaxies and quasars;
6) large scale structures combined with redshift measurements with the VLT;
7) gravitational lensing effect due to dark matter distribution on very large scale;
8) very deep multicolor survey to study galaxy evolution on cosmological time scale;
9) detection of supernovae up to $z = 0.5$;
10) a second generation experiment for detection of brown dwarfs by micro-lensing effects on stars in the Magellanic Clouds.

Three types of observational programmes are envisaged:

1) a multicolour astrometric and photometric survey in individual fields selected according to Galactic structure and stellar program;
2) a multicolour and slitless, low resolution spectroscopical survey of typically 100 square degrees for cosmological observations and supernova research;
3) observations in front of the Magellanic Clouds for detection of brown dwarfs.

All of these programmes require very good image quality.

The scientific requirements call for LITE being a telescope of 2.5 m diameter with a mean image quality, including seeing, of 0.8 arcsec (or better) over a field of 1.5 degrees (or more). This can only be achieved with good sampling of the image PSF by the CCDs. For a typical pixel pitch of 15 microns, 0.3 arcsec pixels are achieved with 10 m focal length; this corresponds to an f/4 aperture ratio. We first designed a quasi Ritchey–Chrétien system with a Gascoigne corrector, but we have finally adopted a new optical concept worked out at the Tautenburg Observatory, with the assistance of Ray Wilson from ESO. It is a modified version of the 3 mirror Paul-Baker telescope which provides a plane focal surface at the 'prime focus' location, behind the secondary mirror. A preliminary design study has shown that for a telescope with 2.5 m diameter and focal ratio f/4, and image quality of 0.4 arcsec can be obtained at the edge of a 2.5 degree field, and significantly better towards the centre. Compared to the initial Cassegrain solution, this design has two important advantages, the absence of chromatic aberrations because there are only reflecting mirrors, and a very easy baffling system to suppress stray light.

As a baseline, the CCD camera will be organized around thin, back–side illuminated Thomson CCDs, each with 2048 x 2048 pixels and 15 micron length. These CCDs are being developed for the VLT, and the thick version should become available in 1993 and the thin one in 1994. The three-side buttability allows to make strips of 2 CCD width. A 1 square degree surface can be covered with 36 CCDs. Readout time of the whole array will be as low as 30 seconds, thanks to a parallel acquisition system. Cryogenic temperatures will be provided by a closed cycle cooler in order to simplify the operations.

The natural site for this telescope is near the VLT, in the Paranal area, where it may take advantage of the excellent seeing and the large number of photometric nights as compared to the other Chilean sites. Discussions will take place with ESO to study this possibility.

The definition phase of the project will be undertaken in 1993. We must still settle the details of the German-French collaboration, work out the relationships between the consortium and ESO, and obtain the funding. The actual start of the project is expected in 1994 and the beginning of the observations in 1999. In the present status of the project, nothing has been absolutely fixed and new groups are welcome to join. If you are interested, please do not hesitate to contact us. We expect to make a first presentation of the project at the IAU Symposium in Potsdam in August.

Projects similar to ours are under development, in particular the Sloan Digital Sky Survey (SDSS) in the USA. We wish to emphasize the differences between our project and the SDSS. The main goal of the SDSS is to make a survey over a large fraction of the entire sky ($\sim \pi$ steradian), both in photometry and in spectroscopy, and with the same telescope. However, the use of the SDSS 2.5 m telescope for spectroscopic measurements will naturally limit the observations to moderately faint galaxies only. The necessity of the all sky survey pushes towards the largest possible field, but at the detriment of image quality, and to a transit instrument which simplifies the operations.

In our case, the spectroscopic observations are planned with the much larger VLT, which, of course, can reach much deeper. Due to the increasing number of objects at fainter magnitudes, we cannot expect to cover a large fraction of the sky. On the contrary, we shall only be able to obtain images significantly deeper than the SDSS by limiting the sky coverage. For LITE, the priority of optimization is then image quality first, and field-of-view second. In addition, the pointing mode of operation is more suitable for very deep imaging than a transit mode. While many scientific areas are common to both instruments, the trade-offs are different, and the scientific programmes will be different too.

We believe that the combination of the VLT and LITE will offer a unique capability of probing the deep sky and will become a prominent instrument for future cosmological studies.

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Linking the Sonneberg Field Patrol to Project LITE[3]

1. Introduction

A quarter of a century ago, a paper was published with the title 'Structure of the Galaxy Investigated by Means of the Variable Stars of the Sonneberg Field Patrol' (Richter 1968; Bräuer & Fuhrmann 1992). The time is ripe: like the Prince who breaks the spell on Sleeping Beauty, LITE with its European wide-field telescope of the 2.5 m class can revive the issue at stake in that paper.

Variable stars are clearly defined groups of objects, easy to recognize and with well-determined properties, such as mass, luminosity, spectral type, age, population membership and metallicity, which are correlated with kinematic and dynamic characteristics. Because of those qualities, variable stars are particularly suitable for studying the structure and evolution of the Galaxy. Work on galactic structure by means of variable stars was carried out by Payne-Gaposchkin, Kukarkin, Parenago, Sherwood and Plaut in their classical papers (Payne-Gaposchkin 1954; Kukarkin 1949; Kukarkin & Parenago 1963; Plaut 1965; Sherwood & Plaut 1975), by Richter (1968) in Sonneberg and by others (see Ch. 7 in Hoffmeister et al. [1984]).

The Sonneberg Field Patrol (SFP) is a photographic programme brought into being by Cuno Hoffmeister in 1923 with the aim of discovering and classifying variable stars in 41 fields of 100 square degrees each and with a limiting magnitude of 17.5 – 18 pg, in order to collect a homogeneous sample for statistical use (Hoffmeister 1938) (see also Richter 1992). Field size and limiting magnitude are mutually dependent; on the one hand, since bright objects are rare, it is obvious that a large area must be covered in order to obtain a statistical sample of a useable size, while on the other hand the limiting magnitude must not be too faint lest the area density should be too high and the star images overlap.

Now at first sight the LITE telescope with its field of 1 degree (or little more) and limiting magnitude of 26 would seem to be of little use for such statistical studies. But the situation is not quite what it seems. The increase in surface density (i.e. the concentration of stars on the globe) will grow with magnitude in geometric progression only as long as the spatial density remains constant. In reality, owing to the finiteness of the Galaxy the size of that increment generally goes down as the

[3] The Large Imaging Telescope, a joint project..., October 23, 1992 (Draft Edition)