The Liverpool Robotic Telescope

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Abstract

The 2.0-m Liverpool Telescope will be a fully robotic telescope that operates without night time supervision. It will be sited in La Palma from Autumn 2000. We discuss the principal science drivers the telescope will address (long-term monitoring, rapid response, satellite support and small-scale surveys) and why they are best suited to robotic observing. Finally we note the implications of robotic operation for instrument design.

Key words: Robotic Telescopes; Telescope Operations

1 Introduction

The Liverpool Telescope will be the first telescope produced by Telescope Technologies Ltd, a subsidiary company of Liverpool John Moores University. It has a 2.0-m f/3 primary and a final focal ratio of f/10. The altitude-azimuth ("alt-az") mount is designed for high natural frequency ($>$ 15 Hz) and the predicted pointing performance is under 2 arcsec rms. At the time of writing the telescope is under construction in Merseyside. First light on La Palma is scheduled for Autumn 2000.

The normal mode of operation of the Liverpool Telescope will be fully robotic. This means that the telescope will not be supervised either locally or remotely during its routine operation. Instead it will carry out a programme of observations selected from those held in a database (Steele 1998) according to a flexible scheduling algorithm (Steele 1997). In this paper we describe the "Science Drivers" that have lead us to make the Liverpool Telescope robotic along with the advantages resulting from robotic operation for those types of science. In addition we describe the implications for instrument design.

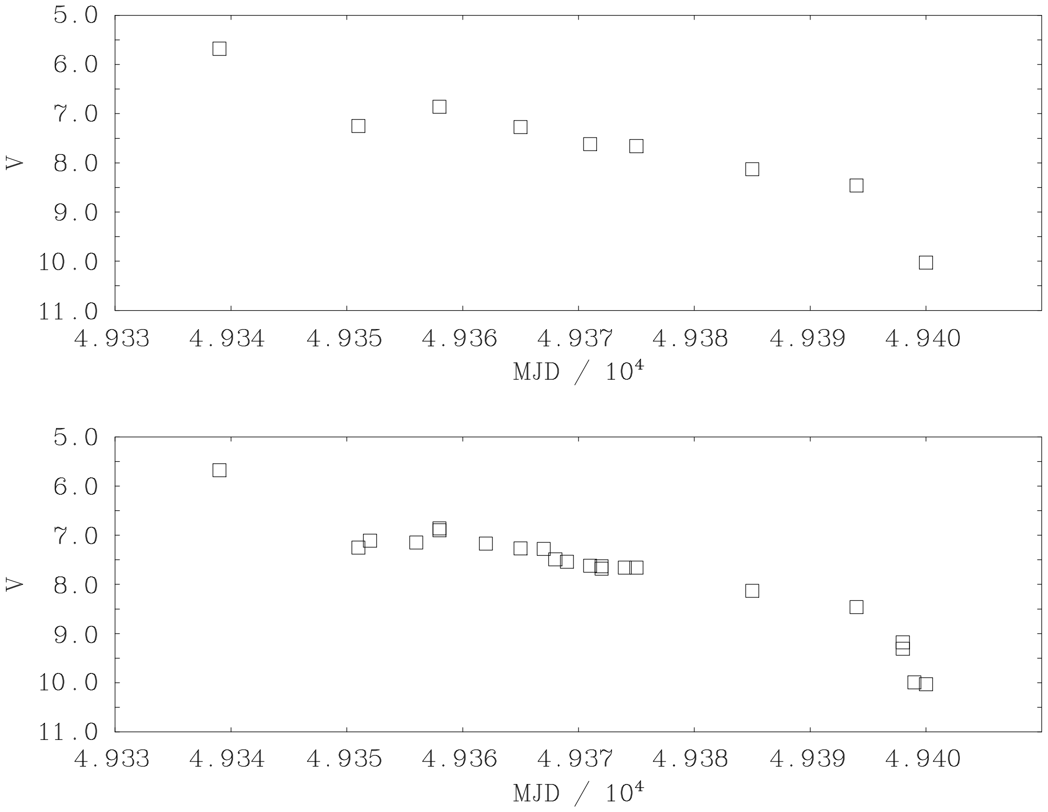

Fig. 1. Photometry of Nova Cas 1993 (lower panel) and the effect of sampling $\sim$ once per week (upper panel) [data from Hric et al. 1998]

2 Liverpool Telescope Science Drivers

2.1 Monitoring

There are many types of observational astronomy programmes that require monitoring on time-scales greater than a week. The difficulties of carrying out such programmes on a conventionally scheduled telescope are well known. A robotic telescope will allow us to properly explore the time domain of variability between 1 week and 1 year for the first time. An example of where this is essential is in understanding the properties of galactic novae. The lower panel of Figure 1 shows the light curve of the dust nova V705 Cas (Nova Cas 1993) as obtained by a collaborative programme (Hric et al. 1998) between the Skalnate-Pleso, Stara Lemsa, Hlohovec and Brno observatories, where observations were obtained at a mean frequency of $\sim$ once per 2 days. The upper panel shows the same data but with points artificially removed to make the sampling time $\sim$ once/week. From the lower light curve it is clear that there was a plateau between MJD 49350 and 49392, followed by a sharp decline. However if the only data available was that in the upper panel, one might easily have concluded that there was a constant decline over the whole period, leading to an incorrect derivation of the nova type and speed class, and hence distance and luminosity. This is important as, for example, understanding the luminosity and speed class relationship of novae occurring in external galaxies allows an investigation into the relationship between the physical processes occurring and the metallicity of the environment. If the rate of decline is poorly determined due to poor light curve sampling, such relationships are lost in the noise. There are many other examples of time variable phenomena also to be investigated with the Liverpool Telescope. Examples include using extra-galactic supernovae to determine cosmological parameters, understanding the time-scales and statistics of Be star phase changes, and contributions to multi-wavelength monitoring campaigns of quasars in order to determine the scale sizes involved in such objects. In all these cases a robotic telescope makes obtaining such observations routinely practical.

2.2 Rapid Response

There are many areas of astronomy where rapid response to an event is required. One extreme example of this is γ-ray bursts (GRB). It has recently become clear that understanding the light curve of the optical transient in the first few minutes after the γ-ray event is crucial in discriminating between different models. In addition at this stage the GRB is luminous enough that an optical spectrum could potentially be obtained. There are many proposed satellite missions (e.g. SWIFT, GLAST, BOLT) which aim to provide accurate (< 1 arcmin) GRB coordinates within seconds of the event occurring. A robotic telescope that can "override" its current observations and slew to the coordinates within a few minutes naturally has the best chance of observing such events on the shortest possible timescale. Such a mode of operation is being designed into the Liverpool Telescope from the start. Aside from GRB there are many additional areas that may be addressed with a rapid response facility, including near-Earth asteroids, long period comets and optical follow-up of X-ray outbursts from high mass X-ray binaries.

2.3 Satellite Support

Observers who have time scheduled on satellite facilities presently experience great difficulty in acquiring simultaneous optical and near-IR observations from existing ground based telescopes. Such time is frequently allocated at short notice, for example when a source enters an active (or quiescent!) phase. A quantitative analysis (Cordova 1985) has found that approximately 60% of EXOSAT programmes required simultaneous data, but only one quarter of these successfully obtained it, often due to scheduling difficulties.

2.4 Small Scale Surveys

Small scale surveys can often make important contributions to science, both in providing photometric calibration for wider field surveys and in their own right. There are several reasons why surveys such as this are well suited to robotic telescopes. Firstly they often require special conditions (e.g. excellent seeing). The flexible schedule of a robotic telescope makes this possible. Secondly the nature of robotic observing (via. standardized procedures) means that the survey data is taken in a consistent fashion. This makes data reduction simpler and ensures that the final data set is as homologous as possible. Finally the non-time critical nature of survey work assists the telescope scheduling algorithm, as surveys can be used as "fillers" when there are no time critical observations to be done.

3 Instruments for Robotic Operation

In order to obtain the advantages of robotic operation outlined in the above discussion, it is necessary that all of the potential instruments are available for use at any time, with a maximum latency on instrument changes of order 1 minute. Mechanically this is achieved by our A&G box design, which has a retractable, folding mirror allowing the telescope beam to be directed to one of four side ports or to a "straight-through" position. All of the instruments will be permanently mounted on the telescope and must be closed-cycle cooled for unattended operation. Of course they must also be highly reliable. We have defined a generic software interface that all instruments must implement. This abstracts observing into a series of commands such as ACQUIRE, CALIBRATE and EXPOSE that can be issued to an instrument without the robotic system having to understand how an instrument works. We can therefore add new instruments without having to change the robotic software.

References

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