How to get Unlimited Observing time on a 4 metre Telescope.

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Abstract

As the astronomical community moves ever more towards fewer and larger telescopes it is not just desirable but essential to make the maximum possible use of these new facilities. The Hitchhiker parallel CCD camera has been specially designed to increase the scientific output of a large telescope by imaging the off-axis field of view. The large data set collected by this instrument consists of deep CCD multicolour data of the distant Universe and is extremely well suited to the study of faint galaxies and their evolution, as well as other areas. The instrument's design and some of its projects are briefly discussed below and demonstrates the scientific value such instruments could have if incorporated on all new telescopes.

Introduction

Unlimited observing time on a 4 metre telescope, sounds like an astronomers dream come true. But at Cardiff this dream has been turned into reality. For over a year now students and staff have been able to collect high quality CCD data whenever desired. This has been made possible by a new step forward in instrument technology and telescope efficiency. The camera known as hitchhiker was installed on the William Herschel Telescope (WHT) at La Palma in November 1990 and fully operational by February 1991. This novel instrument contains two unique features in the realm of CCD imaging. Firstly, it images the off-axis field of view allowing it to be operated whenever small field of view or spectroscopic instruments are being used. Secondly, it uses two CCD's to image one 6 by 4 arcmin field in two broadband colours simultaneously.

So, not only does Hitchhiker increase the scientific output of the telescope by collecting otherwise wasted light, but doubles up again because of its dual colour capability. As the majority of work on a large telescope tends to be spectroscopic Hitchhiker can be used for most nights of the year. The obvious constraints on the instrument are that its direction and exposure time are governed by the spectroscopic observer who always has priority. However the amount of data potentially available is enormous and this allows us to pick and choose which programs to observe with and at which times of the year. For example Hitchhiker is currently only run during darktime when the galactic plane is not overhead. Even so the dataset collected is still large and suitable to a wide range of survey projects.

Camera design

In essence the Hitchhiker parallel CCD camera (Disney et al 92) uses two P88200 EEV CCDs (770 x 1152) to image a single 6 x 4 arcmin field of view, through two broadband filters by using a beam splitter. This gives 0.3 arcsecond resolution pixels and the center of the field of view is 7 arcmins from the WHT field center. The CCD system is controlled by a 386 IBM compatible PC and is completely independent of the WHT control computers. Inside the camera itself are six motors, also controlled from the PC, which move the focussing optics, filter wheels and dichroic slide. Currently Hitchhiker can observe in B and R, V and I or B and I broadband filters, this combination allows for accurate colour measurement with only one calibration point necessary.

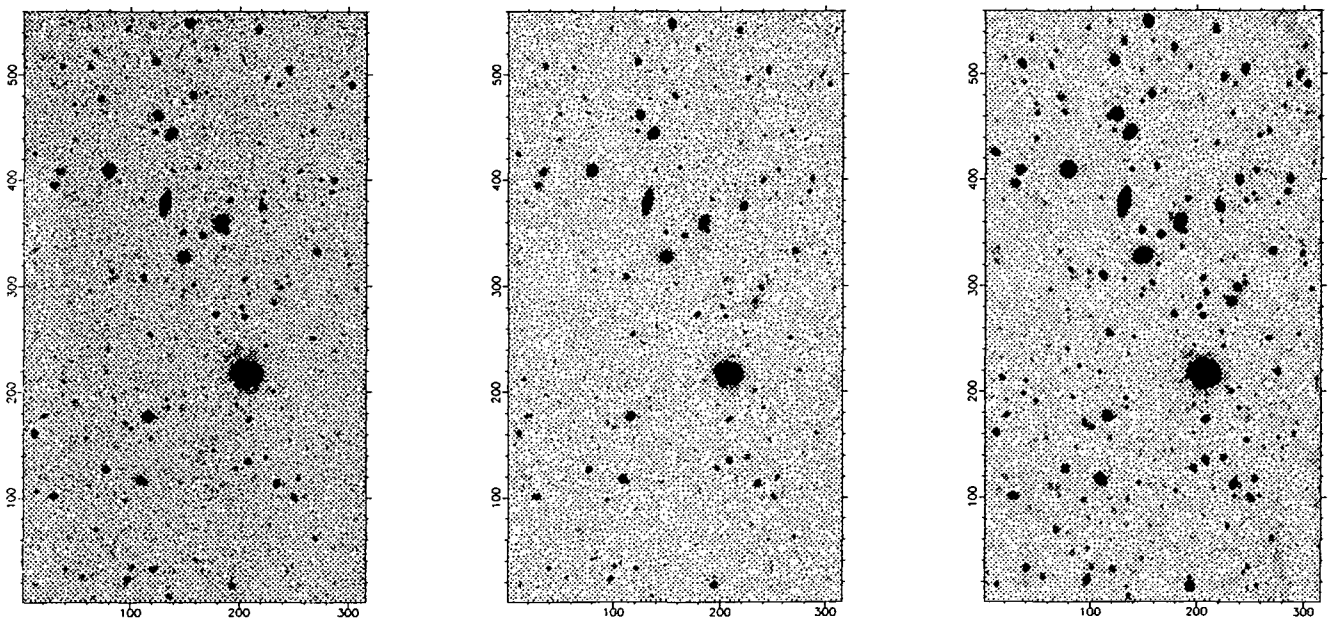
Science projects underway

Hitchhiker has now covered about 1.3 square degrees of sky in two or more filters and in exposure times varying from 10 minutes to 2 hours. For comparison a single half hour exposure by Hitchhiker will sample a similar volume to a half hour schmidt plate. This reflects the much greater depth to which Hitchhiker can observe as its field of view is only about $\frac{1}{7000}^{th}$ of a schmidt plate. The data is suitable for any survey program where there are few constraints on the direction from which the data comes. The Cardiff group have a large number of scientific projects in mind, most important amongst these at the moment are;

- **Searching for very low surface brightness galaxies** — Cardiff have always been heavily involved in the survey for low surface brightness objects (Davies 92) and Hitchhiker data surveys a considerably deeper/fainter portion of the sky than other surveys. Careful reduction techniques have been developed which preserve structure on scales upto an arcminute.

- **Studying faint galaxies and clusters** — Recently (Tyson 88; Metcalfe 91; Lilly et al 91) there has been much work on matching the observed number counts to predicted cosmological models. Whilst Hitchhiker is unlikely to achieve the very deep number counts obtained from long integration CCD frames it is able to survey a large fraction of a square degree to greater depth than before and with accurate relative colours. Already Hitchhiker is obtaining multicolour number counts for objects upto blue magnitudes 26.5 and red magnitudes 26.0 (Driver 92). See pictures below.
- **Supernova candidates** — A number of supernova candidates are observed and provided they are quickly identified spectroscopic follow ups could be made.
- **Searching for primaeval galaxies** — As well as specific survey projects along established areas of research it is hoped that Hitchhiker will uncover a number of serendipitous discoveries. Very similar to the search for high luminosity low surface brightness galaxies is the search for primaeval galaxies (Uson 91) and this area of research can be carried out within the LSB program.
- **Searching for gravitational lenses** — Many groups in the UK and abroad are interested in studying the very distant universe via gravitational lenses and Hitchhiker should be capable of detecting many new lensing candidates.
- **Faint stars** — Although the group at Cardiff are primarily concerned with the study of faint and LSB galaxies collaborators are intending to use Hitchhiker data to study the halo distribution of faint stars and brown dwarves.

The images below show the same 5 by 3.5 arcmin field but in three broadband colours B, V and R, the exposure times are 2 hours, 30 mins and 2 hours respectively. In excess of 1000 galaxies have been identified on all three frames and there broadband colours measured (Driver 92). Finally recall that this data was collected whilst simultaneous spectroscopic observations were in progress.



Conclusion

The Hitchhiker camera offers us a unique opportunity to sample large volumes of the Universe with multi-colour CCD exposures. Parallel observing works and is an efficient cost-effective way for sky surveys to keep in touch with the development of very large telescopes. These large telescopes and their on-axis instruments need to be fed a diet of comparable survey data if they are to be fully utilized. Overall, we think it is essential to consider incorporating similar instruments in the design and construction of all new, large telescopes — not doing so can be viewed as an excessive waste of money and potential scientific knowledge.

References

Davies, J.D., 1992. Invited Review this conference.
Disney, M.J. et al 1992. Mon. Not. R. astr. Soc submitted.
Driver, S.P. et al 1992 *Colours of Faint Galaxies* In preparation.
Lilly, S.J. et al 1991. Astrophys. J., **369**, 79.
Metcalfe, N. et al 1991 Mon. Not. R. astr. Soc., **249**, 498.
Tyson, J.A. 1988. Astr. J., **96**, 1.
Uson, M.J. et al 1991. Physical Review Letters., **Vol 67, No 24**, 3328.