REQUIREMENTS OF A NETWORK TELESCOPE

Ian Elliott
Dublin Institute for Advanced Studies
Dunsink Observatory
Dublin 15
Ireland

ABSTRACT General purpose telescopes fail to provide a cost-effective means of obtaining photometric data for asteroseismology. A continuous observing run on a particular star is best suited to automatic operation with a dedicated photoelectric telescope. As optical requirements for on-axis photometry are less severe than those for imaging, low-cost light-weight mirrors permit a saving in the size and cost of mount and dome. A stiff mounting with a low moment of inertia permits rapid movement under computer control. Adoption of a permanently mounted photometer and the elimination of manual controls also leads to design and operating economies. Maintenance can be shared with other instruments and travel and subsistence requirements are minimised. Therefore remote operation of a network of automatic telescopes at good sites could provide high quality data at reasonable cost.

1. INTRODUCTION

1.1 Co-ordinated multisite observations

In observing variable stars with properties which change rapidly it is often necessary to obtain continuous data sequences longer than the eight or more hours normally available at a single site. This requirement arises in the case of the rapidly oscillating Ap stars which show low-amplitude variations with periods between 6 and 14 minutes as well as slower variations of the order of days due to rotation. For instance four nights of contemporaneous observations of the rapidly oscillating Ap star HR1217 from two sites proved inadequate for a full analysis of its frequency spectrum (Ref.1) and an intensive observing campaign lasting more than three weeks is planned for November 1986 (Ref.2).

In general, contemporaneous observations require co-operation between several sites well distributed in longitude with the participants agreeing on the procedures to be adopted. The need for an international organization to co-ordinate multisite observations has been pointed out (Ref 3).

J. Christensen-Dalsgaard and S. Frandsen (eds.), Advances in Helio- and Asteroseismology, 541–544.

1.2 Difficulties with existing ground-based telescopes

Most stellar telescopes are general-purpose instruments which perform the dual roles of light collection and imaging when appropriate auxiliary instruments are fitted. The photoelectric observation of stellar oscillations requires considerable effort to be devoted to a particular object and such proposals usually have to compete for telescope time with imaging proposals which may appear more productive. The changing of auxiliary instruments usually requires skilled personnel and can sometimes affect performance adversely. Moreover, the scheduling of multisite observations can be difficult if applications for telescope time have to be submitted many months in advance.

Photoelectric observations of rapid variables require low noise levels (preferably not more than one millimagnitude in the amplitude spectrum) so all sources of noise must be minimised. The effects of extinction and transparency variations are best reduced by frequent reference to a nearby comparison star of similar spectral type. Photoelectric observations are relatively simple but tedious and require the constant attention of an astronomer or a night assistant; automatic data collection and pointing is desirable but most conventional telescopes have large moments of inertia and are not well suited for the rapid movements required under computer control.

Given the many difficulties of using existing ground-based telescopes, it is natural to seek a solution by use of purpose-built instruments. We consider the characteristics of an automatic photoelectric telescope suitable for observations of stellar oscillations.

2.2 Optical requirements

Since we are considering a telescope solely for photoelectric use, only on-axis imaging is required and a light-weight low-cost mirror may be used. Servo controls can provide active compensation of thin mirror surfaces and permit diameter/thickness ratios greater than 12. The mirror itself can be formed by slumping in a mould followed by grinding and polishing.

A cassegrain configuration with the photometer permanently fixed in place behind the primary has many advantages, not least that of being compact. Another possibility is to use a Nasmyth configuration with a plane third mirror at 45 degrees to the optic axis.

2.3 Mechanical requirements

While an equatorial mount is economical for primary mirror apertures of one metre or less, the symmetrical arrangement of the alt-az or alt-alt mounts is more suitable for larger telescopes. Moreover, since automatic operation is intended, it is possible to use unconventional mounting arrangements such as the boule system adopted by Labeyrie (Ref.4). DC servo motors are suitable for slewing and stepper motors

and can be used for fine motion drives. Position feedback information is supplied by optical encoders on each axis. Backlash can be eliminated by providing friction disk drives on both axes.

2.4 Control and data acquisition

Many types of computer have been used successfully to control telescopes but recent advances in VLSI technology offer attractive alternatives. The INMOS Transputer contains a central processing unit, memory and communications on one chip and provides parallel processing under the concurrent language Occam. The problem of dealing with interrupts in realtime applications can be handled elegantly with parallel processing and computing power may be distributed around the system by allocating a Transputer to each major function.

2.5 Networking

The setting up of wide-area data networks has important implications for the management of automatic photoelectric telescopes. Proposals have been made for the inter-connection of existing national astronomical data networks to provide worldwide communications for the astronomical community (Ref.5). In principle, it would be possible for an observer at his home institution to send observing instructions to a number of telescopes each placed at a favourable site and linked to the international network. Since photometric observations generate only modest amounts of data, it would be feasible to monitor the quality of the observations and to take whatever action was necessary. At each site, maintenance of the telescope would be the part-time responsibility of a technician. As it would not be necessary for astronomers to travel to the sites, there would be appreciable savings in travel and subsistence expenses.

3. A WORKING SOLUTION

3.1 The Fairborn Observatory

Since November 1983, automatic photoelectric telescopes (APTs) have been operated successfully by Fairborn Observatory first in Ohio and later in Arizona (Ref.6). Russell Genet, L.J. Boyd and D.S. Hall operate 25cm and 40cm APTs at Mount Hopkins and make regular automatic observations of RS Can Ven stars. Genet in collaboration with DFM Engineering proposes to build a one-metre f/1.8 APT at a cost of approximately US$80,000.

The design of the Fairborn telescopes has evolved over the years and the experience gained has been documented by Trueblood and Genet (Ref.7). The design follows the general principles outlined in the previous section and uses a novel method for searching for and centering on target stars. The method relies on the careful choice of a

reference star near the target star so that the reference star is well isolated and far from stars of similar brightness. In the search mode the telescope describes a square spiral on the sky until the image of the reference star falls on the detector ; the star is then centered by offsetting in four directions until equal signals are obtained and finally the telescope moves to the target star for measurements. The method has proved to be effective and reliable.

4. CONCLUSION

Automatic photoelectric telescopes offer an economic means of making observations which are crucial for some aspects of asteroseismology. Use of lightweight mirrors, stiff mounts and permanently mounted detectors leads to structures which are suited to computer control. The telescopes may be located at sites chosen for the photometric quality of their skies and only technical support staff for maintenance is required. Operating costs should be low especially if the telescopes are linked to an international data network.

REFERENCES

1. Kurtz, D.W., Schneider, H and Weiss, W.W., 1985, 'Pulsational mode constraints for the rapidly oscillating Ap star HR1217', *Mon. Not.R. astr. Soc.* 215, 77-82

2. Kurtz, D.W., 1986. Private communication

3. Sterkin, C and Christensen-Dalsgaard, J, 1985, 'New IAU Commission?' *IAU Bulletin No.53*

4. Labeyrie, A, 1981, 'Scientific **Importance** of High Angular Resolution' *ESO Conference Proceedings*, March 1981, *p225.*

5. Jaschek C.et al. 1986, Bull.Inform. CDS 30, 5-53.

6. Boyd, L.J., Genet, R.M. and Hall, D.S., 1985 'APTs: Automatic Photoelectric Telescopes', *Sky and Tel.*, July 1985, 16-19.

7. Trueblood, Mark and Genet, Russell, 1985, *Microcomputer Control of Telescopes*, Willmann-Bell Inc.