A FOUR STAR PHOTOMETER FOR USE ON SMALL TELESCOPES

D.B. Caton and J.T. Pollock
Department of Physics and Astronomy
Appalachian State University
Boone, North Carolina, U.S.A.

ABSTRACT. An automated photoelectric four-star photometer has been designed for use on the 46-cm reflector at Appalachian State University's Dark Sky Observatory. The system will be composed of integrated detector-amplifiers, stepper-motor controlled x-y stages, and automatic counters.

1. INTRODUCTION

We propose to build a multiple-star photometer for regular use on the 46-cm reflector at ASU's Dark Sky Observatory. There are several advantages to a design allowing up to four objects to be monitored simultaneously. The instrument will be fabricated in our own department shop using readily available sub-assemblies such as mechanical X-Y stages, stepper-motor controllers, integrated detector/amplifier packages, and fiber optics.

2. THE DESIGN

The instrument is coupled to the telescope through a rotational stage, to allow rotation that may be necessary for optimizing alignment with a given stellar field. It is stepper motor driven with a step size of 0.01°, corresponding to 0.017 arc-seconds of setting accuracy (at the edge of the field of view), in the sky. An 'origin-position' detection switch and incremental encoder will allow initialization and verification that the instrument indeed is set up at the correct angle for a given object's field.

Directly attached to the rotating coupling is the upper plate, below which is a full-field filter wheel. Placement of the filters here eliminates many design problems, but adds the complication of needing to map the transparency of each filter. The filters are carried on another rotating stage which was chosen over a simple stepper motor to guarantee that the filters can be repositioned in the beam to within the stage's 0.01° rotational accuracy.

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Each of the four stepper-motor driven X-Y stages are mounted on the middle plate below the filter wheel. Each X-Y stage carries a detector that normally services one quadrant of the field of view, although any detector can reach any point in the 80-mm (30 arc-minute) focal plane circle. The 30-arc minute field will allow one or more comparison stars to be chosen for most fields. The X-Y stages have stepper motors, home position detectors, and incremental encoders built in, and will thus provide for accurate setting to a given star field.

The light from the four beams will be brought to the detectors via four fused silica optical solid fibers held rigidly in a right angle bend. The fibers will also serve as the Fabry lens by randomizing the star+sky image before it reaches the detectors. The diameter of the fiber will limit the sky light collected. The 1-mm bundle will provide a 24 arc-second aperture, large enough to avoid spill-over of the image under adverse seeing conditions.

The detectors to be used will be compact, integrated units consisting of the photomultiplier tube, high voltage supply, output amplifier, and voltage-to-frequency converter. Such units are available in small packages that may be easily mounted on the X-Y stages with only very flexible low-voltage wires needed for hook-up. The detectors will house 3/4" diameter S-20 photomultipliers, ordered specially selected for low dark current.

Viewing will be provided by a set of four coherent fiber bundles attached at a specific offset from the fibers leading to the photomultipliers. Thus, a simple computer-directed offset will bring all four viewing bundles into place; their images will be viewed in the focal plane of a single eyepiece. The computer will be able to reposition the fibers to the star pattern to such a precision that centering one star/bundle will align the entire field. Additionally, a large eyepiece at the rear plate will allow coarse initial setup on the field.

The ten stepper motors will be driven by 'smart' controller systems that are interfaced to a microcomputer via the IEEE-488 bus. Our experience is that circuits of this complexity are best bought rather than prototyped, especially with the declining prices of smart controllers. Additionally, a commercial controller will probably be more reliable, as well as more easily implemented by other observatories wishing to replicate the photometer. The output pulses from the four detectors will be fed to four programmable counters which will also be read by the computer over the IEEE-488 data bus.

By using 'smart' controllers the task of writing the control software will be greatly reduced. Software will be written to transmit to the controllers the positions for each detector for a given field. A manual control mode will aid in setup. Each mechanical stage's position will be read from the encoders to check that all stages indeed reached their destinations. The filter will be set, the counters reset, and an integration can begin. The counters can all be started simultaneously via a group command over the IEEE-488 bus. It is proposed that the software be written in Forth—an ideal control language for this type of application.

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