ADVANCES IN PHOTOELECTRIC PHOTOMETRY

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Abstract

Recent advances in photoelectric equipment, software, and documentation have made it easier and more convenient to make photoelectric observations of variable stars at smaller observatories.

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Advances in electronics over the past five years are being applied to the design of photoelectric equipment which is low in cost, yet performs well. The same advances in electronics have resulted in low cost and readily available microcomputers which are being used to reduce and analyze photoelectric observations of variable stars. These microcomputers are also being used to record the photoelectric observations directly and to control the photometer and even the telescope. As a result, smaller observatories can now afford the capabilities that just a few years ago were available only at the largest observatories.

This paper will briefly review some recent advances and current research in photoelectric photometry as it applies to smaller observatories. Much of this research is being done by members of the American Association of Variable Star Observers (AAVSO) and the International Amateur-Professional Photoelectric Photometry (IAPPP) association, and both amateur and professional astronomers are making significant contributions.

The key portion of any photoelectric system is the photometer head, where the incoming starlight is converted to an electrical signal. Stokes (1981) has designed a photometer head that can be assembled with ordinary hand tools. It is based on a readily available "Bud" box, and uses the mechanical portion of radio switches as the detents for the diaphragms and flip mirror. Louth (1980) has described another photometer head that is suitable for home construction. This cleverly designed head features a mechanism that offsets the diaphragm so that the sky background near each star can be measured without moving the telescope itself. A perennial problem encountered in home-made heads is the obtaining of proper filters at reasonable prices. Commercially available filters come in 2-inch squares, while only 1-inch squares are needed. The IAPPP has instituted a filter service that is available to all IAPPP and AAVSO members. Individual UBV filters or a complete set of 1-inch squares can now be obtained at cost from Jeffrey L. Hopkins, Hopkins-Phoenix Observatory, 7812 W. Clayton Drive, Phoenix, AZ 85033.

For proper operation, the photomultiplier must be supplied with about 1000 volts Direct Current (DC) closely regulated to maintain a constant value. Hopkins (1981a) has described a high voltage power supply for photomultipliers that is designed for easy home construction. The parts for this all-solid-state power supply cost about $20.00, and are all readily available except the ferrite core for the step-up transformer, which may be obtained at cost from Hopkins (address above). Another high-voltage power supply suitable for home construction has been designed by Boyd (1981a). This power supply uses a new low-cost, solid-state bandgap reference to maintain a precise voltage output.

The signal from the photomultiplier in the photometer head is very weak and needs amplification. One approach is to use a DC amplifier. Hopkins' (1981b) DC amplifier utilizes a recently available, low-cost, chopper-stabilized operational amplifier to assure drift-free operation. This unit has been specifically designed for easy home construction. Another approach is to count the weak electrical pulses that correspond to the photons received. This requires a broad-band amplifier and a discriminator to detect the crossing of a fixed threshold level by the output of the photomultiplier. Until recently these "amplifier/discriminators" were expensive, but DuPuy (1980) has used a recently available integrated circuit chip costing only $20.00 as the heart of an easily-built amplifier/discriminator. Boyd (1980b) has developed a two-chip amplifier/discriminator which is also low in cost and easily constructed.

The past year has seen the introduction of two new commercial photometer systems at prices affordable by smaller observatories. One unit, manufactured by Optec, Inc., is a thermoelectrically cooled version of the earlier all-solid-state photometer described by Persha (1980). The sensor is a photodiode instead of a photomultiplier tube. Cooling increases both the sensitivity and the stability of the unit. The other unit, manufactured by EMI Gencom, Inc., employs an end-on photomultiplier tube and pulse-counting electronics with a digital display (Wolpert 1981). Because many smaller observatories do not have the facilities to build a complete photometric system, the availability of these low-cost but high-performance commercial systems represents an important advancement.

The use of microcomputers to record the data from the photometer directly eliminates much of the time and effort required by manual data handling. Genet (1980a, 1981) has used a Radio-Shack TRS-80 microcomputer to record and analyze photoelectric data directly at the Fairborn Observatory. Seeds (1981) has similarly used the Apple microcomputer at Franklin and Marshall College. While these systems have performed very well, the microcomputers involved are still expensive, and special interfacing electronics are required. Genet is now investigating the application of the new Sinclair ZX81 microcomputer to this task. The ZX81 microcomputer costs only $150.00, and the system being developed by Genet includes automatic control of the diaphragm and filter wheels on the photometer head.

At many observatories, skies are often of marginal photometric quality. One way of overcoming this difficulty is to measure the variable and the comparison star simultaneously with a dual-channel photometer. Then atmospheric disturbances affect both channels equally and are removed when the differential magnitudes are calculated. In the past, such dual-channel systems have tended to be both large and expensive. Grauer and Bond (1981) have reported very good results at a less than ideal site (Louisiana State University) with a dual-channel system designed by Nather (1973). Mannery (1981) has given many details on his dual-channel system which uses an Apple microcomputer to control the diaphragm and filter wheels and simultaneously record the data from both channels. Fernie (1981) and Genet are both working on two-telescope dual-channel photometer systems.

The ultimate in efficiency from an observer's point of view is complete automation of both the photometer and the telescope. Skillman (1980) has reported very favorable results with his automated system which uses Apple and KIM microcomputers coupled to a 12 1/2-inch Cassegrain telescope. Boyd (1981b) has recently completed the design and construction of an automated photometer and telescope which is controlled by a single microcomputer. While such automated systems remain beyond the reach of most small observatories, they indicate the forefronts in the development of computerized photometry.

Microcomputers have also been used to reduce and analyze the photoelectric data from variable stars. Genet (1980b) has reported an analysis program written in BASIC to reduce differential photometry, allow for atmospheric extinction, and transform to the UBV system. Ghedini (1982) is developing a complete set of reduction and analysis programs in BASIC which cover the range from simple reduction of photoelectric observations to derivation of times of minima (or maxima), and even the determination of the relative orbital elements of eclipsing binary stars.

One of the most serious problems facing observers who desire to get started in photoelectric measurements of variable stars is finding current information on equipment, observing techniques, and data reduction. This information is spread throughout the literature, and in many cases much of the practical techniques involved have not been published at all. A current and reasonably comprehensive book on photoelectric photometry by Hall and Genet (1981) is now available, and another by Henden and Kaitchuck (1982) will be available shortly. Taken together with Ghedini's software book and the earlier book by Wood (1963), the smaller observatories will have, in a consolidated and convenient format, most of the information they need to make scientifically useful photoelectric observations of variable stars.

Honeycutt (1981) has suggested some of the directions future research might take to improve photometry. The use of optical fibers could greatly simplify the construction of dual-channel systems. Although still quite expensive, charge-coupled-device (CCD) arrays are expected to drop in price over the next several years. The use of CCD arrays would make multi-channel photometry possible as well as improve the quality of photometry of faint stars.

In summary, the revolution in electronics has been of great benefit to the photometry of variable stars. Current research being carried on by both amateur and professional astronomers should result in even greater efficiency in the techniques by which photoelectric data are gathered and analyzed. Perhaps of equal significance, this research is resulting in equipment which is low in cost and easily constructed as well as in comprehensive software capabilities for microcomputers. New books written specifically for smaller observatories are making it easier to get started in photoelectric photometry. Small observatory photoelectric photometry of variable stars has come a long way since AAVSO member Boss (1923), the first amateur astronomer to make electrical measurements of the light of a variable star.

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