SOME THOUGHTS ON THE HOW AND WHY OF P.E.P.

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Abstract

A non-technical discussion of the desirability of producing photoelectric photometry (PEP) observations, with the basic instrumental requirements and simple methods for the reduction of data.

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Many of you may feel that making photoelectric observations is too complicated, too expensive, or the reduction of the data too difficult, for you to even consider. This most certainly should not be true for so many of you who truly love the study of variable stars. I would like very much to see just a small percentage of our observers move over to PEP. Of all observers listed in the last J.A.A.V.S.O., only 1.5% reported PEP observations.

New observational problems present themselves, and with them come new opportunities to contribute very meaningful data. But very often, due to the nature of the observations needed, photoelectric observations are required. Two of us, Larry Lovell and I, are doing just that. Under the direction of Dr. Douglas S. Hall, Dyer Observatory, we have under observation a group of peculiar binary stars that as yet have no official classification. Some of them are listed in the catalogs of suspected variables, which means that the range will be very small. So far, the greatest range we have detected was $0\overset{m}{.}11$. A definite light curve resulted from data collected for that star, but from two others the variability is so small that, as yet, no light curve can be determined. At least one has been determined to be a radio star. It is obvious that this is an observational problem that requires the use of photoelectric photometry. Professional astronomers always tell me, when I ask about the need for PEP observations, that there will always be many useful and interesting programs that can be carried out with moderate sized instruments.

Photometry, as it is usually practiced, is simply a comparison of the amount of light captured by the telescope, that comes from two different stars. One form is known as "differential photometry,": determining the ratio of the intensity of light from two stars, hence their magnitude difference. Usually, only when determining the values for sequence stars, would you state that an unknown star is of such and such a magnitude. Just as in visual observing, you hope that the comparison star is constant, so we use a check star. The difference between the comparison and check stars should remain the same, within observational scatter. This will commonly be $0\overset{m}{.}01$ or less, depending on how good the sky is and how much brighter the stars you are working on are above your limiting magnitude. A photometer will detect the very thinnest of clouds, so if there are any, the observational scatter might be anything.

What are the requirements of the telescope that is to be considered for PEP observing? If at all possible it should be a reflector of at least 6-inch aperture; the larger the better. The telescope must be equatorially mounted and have a reliable drive in right ascension. Circles and slow motions are useful but are not really necessary. What is required is the capability of keeping a star within a circle roughly the angular diameter of Jupiter for about two minutes at a time. If your telescope will do that, then you can mount a photometer on it and make photoelectric observations.

The equipment will consist of the following. The photometer head is mounted in place of the telescope eyepiece, and contains the photomultiplier, light filters, and the means for viewing and positioning the object to be observed. It is also designed to permit only the light from one star to be admitted to the photomultiplier. Another unit required is the high voltage power supply. The photomultiplier tube requires this in order to produce a signal when light from a star is directed to its cathode. It must be very stable because any change in it will appear as a signal to the amplifier, the same as a changing of the light intensity. The amplifier, with its associated read-out device, is the point in the system from which data are taken. The read-out may be a meter or both a meter and a strip chart recorder. One of the controls on the amplifier is a sensitivity switch, which is often calibrated in half-magnitude steps for convenience in reducing data. This control is set so that when a star is being measured, the meter or the pen on the chart is positioned within the upper 2/3 of the scale. This is done in order that the reading will have the largest numerical value which gives the best reading resolution and thus the best accuracy. The number given each position on the sensitivity switch increases with sensitivity.

A simple measurement of the difference in magnitude between two stars may be determined in the following manner, provided that the stars are not more than a few degrees apart. Star A produces a reading of 70 with the half-magnitude switch set at number 4. Star B produces a reading of 80 with the half-magnitude switch set at number 3. For two reasons it might be assumed that star B is the brighter. First, its reading is numerically higher, and second the sensitivity switch is at a lower number. This is in the same sense that a first magnitude star is brighter than a second magnitude star. We now divide the smaller reading by the larger, and obtain 0.88. With this we enter into Merrill's table (Wood, 1963), and find that this value is equivalent to $0\overset{m}{.}14$. To this we add the difference in the two sensitivity switch settings which is one, multiplied by $0\overset{m}{.}5$. So we have $0\overset{m}{.}14$ plus $0\overset{m}{.}5$ equals $0\overset{m}{.}64$ difference between stars A and B. This is the basic idea of the reduction of photoelectric data, not a normal observing procedure. A more conventional procedure for observing in one color might be a series: comparison, variable, comparison, variable, and comparison. The first two comparison star readings are averaged, this value is then used with the first variable reading to determine the first delta magnitude. Then the second and third comparison star readings are averaged and used in another calculation with the second variable reading. The two resultant magnitude determinations may now be averaged if desired, which might be the case for a long period star. If it is an eclipser and the sky is good, even 3 or 4 minutes between readings on the variable will show a change in the light and will show up when plotting the points.

To go beyond differential photometry and obtain and reduce UBV observations usually requires the assistance of a professional astronomer. No one would deny that it is a complex procedure, but my experience is that professional guidance and assistance is not too difficult to obtain.

There is much useful observing to be done with little more complication than the above example. For example, there are many secondary eclipses whose depth is too shallow for visual methods.

My experiences in observing photoelectrically over the past several years have been very satisfying and at times exciting. When you work with PEP your work is on a true professional level, the big difference is, I've been told by a professional, that you can do it for pleasure. They call it work.

REFERENCE

Wood, Frank Bradshaw. 1963, Photoelectric Astronomy for Amateurs, page 218.