THE OBSERVATION OF RED VARIABLES

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Abstract

The accuracy of the estimates of the brightness of red variables may be improved by using observational techniques which are defined as accurately as possible and which are used by all observers. In this article an attempt to achieve this goal is made by reviewing the possible sources that enhance the spread.

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1. Introduction

When looking through the pages of *AAVSO Report No. 38* one sees that in the case of well-observed variables the spread is one to two magnitudes. The spread seems to be maximal with C-type variables such as U Cyg, S Cep, R Lep, X Cas, etc. Yet my experience as recorder of the Werkgroep Veranderlijke Sterren (Variable Star Section) of the Nederlandse Vereniging voor Weer-en Sterrenkunde (Netherlands Association for Meteorology and Astronomy) is that the spread can be reduced by instructing the observers how to observe as accurately as possible. Before 1981 the Werkgroep published its observations in reports that were published by the Kapteyn Astronomical Laboratory of Groningen University. Now they are sent to AAVSO. It is striking that observers improve the quality of the observations when they know that their estimates are compared (with the possibility of rejection) before they are published.

There are several factors that influence the accuracy of the estimates. They concern both the eye and the telescope and charts used, and are dealt with in this article.

2. Averted Vision

As it is well-known (Landolt-Bornstein 1965; Sidgwick 1979) the retina is composed of cones that are sensitive to color and the rods that are sensitive to light only. The spectral sensitivity of the cones and the rods differ; the rods have maximal sensitivity at λ = 515nm and the cones at λ = 555nm. That is the reason that an observer always has to use the same part of the retina when making the estimates. Since the macula lutea only contains cones (these are less sensitive to light than the rods) we must use a part of the retina either left or right of it, otherwise it is not possible to make faint estimates. In practice this condition can be met in the following way. Bring the brighter comparison star into the center of the field, then look about 1/5 field diameter left or right of it. Do the same thing successively with the variable and the fainter comparison star. Repeat this procedure until a reliable estimate is obtained. It is important to move the telescope quickly. In other words, avoid staring. Don't glance longer than a second at a star. When the variable is faint one can leave the telescope at rest and successively glance at the brighter comparison star, the variable, and the fainter comparison star in the same way as in the case of a brighter variable. This procedure is allowed whenever the stars are not too far from the center of the field (in other words: when the stars are not subject to differential extinction because of vignetting). It is not allowed to look at the variable and the comparison stars simultaneously since in that case the condition that the same part of the retina is used is not met. It is not advisable to use a part of the retina under or above the macula lutea since the density of the rods and the sensitivity to light is less there.

3. Purkinje Effect

A blue and a red star that have the same brightness are not estimated as equal in small and large telescopes. In small telescopes the blue star seems brighter whereas the reverse is true in large telescopes. The reason is that the cones are more sensitive to red light than to blue light than are the rods. In small telescopes only the rods are excited. Hence the greater apparent brightness of the blue star. In the larger telescope, however, the cones that are present in the part of the retina that one uses are also excited when observing the red star. As a result, the color of a red variable is visible even when using averted vision if the star is sufficiently bright. Because the cones are more sensitive to red light than to blue light the red star seems the brighter one.

As a result of this Purkinje effect a systematic error can be introduced when a red variable is bright. To avoid this systematic error it is in my opinion important to prevent the cones from being excited. This can be achieved in two ways. Either de-focus the stars until no color is visible before making the estimate; or when a variable shows its color even when de-focussed (as is the case with variables such as V CrB and U Cyg at maximum when using a 150 mm telescope) use a smaller telescope or the finder.

4. Sky Background and Magnification

Another factor that influences the estimate is the sky background. Our experience is that in the case of twilight or moonlight a more reliable estimate is obtained when a higher power is used than when the sky is dark. The reason is that as a result of the higher magnification the contrast between the stars and the sky background is increased.

When a variable is faint a magnification of at least 1 D (aperture in mm)(exit pupil $\leq$1 mm) is necessary to obtain a good estimate. One should bear in mind that at a power of 1.5 D one gains no less than 2.5 magnitudes than when using a power of 0.17 D (exit pupil 6 mm) (Bowen 1947; Feijth 1983). This greater gain, however, is achievable only when the stars may be regarded as point sources, i.e. when the seeing is such that diffraction disks are visible. When the seeing is poor the gain at higher magnification is less.

5. Position Angle Error

Position angle error is an effect that may increase the spread considerably. The rule is that during the estimate the head is held such that the line connecting the comparison star(s) and the variable is parallel to that connecting the eyes (Mayall 1967; Mattei *et al.* 1980). If possible use those comparison stars that are approximately in line with the variable. An error of no less than $0^{m}.5$ may result when the head is not turned such as described above, even when using the same telescope.

Problems may arise even taking the position angle error into account when the variable passes the meridian when the comparison stars are north or south of the variable. Namely, one encounters a reversal of the image after passage of the meridian. My experience is that in such a case differences up to $0^{m}.5$ may result. And one cannot tell which estimate is best! In such a case I take the average. This problem does not exist when the variable and the comparison stars approximately have the same declination. In such a case the stars can be observed with the same field orientation without the head twisting excessively provided that in the case of a Newtonian the tube is rotatable (in my opinion a Newtonian that cannot be rotated is unusable for variable star observations when mounted equatorially). Sometimes comparison star magnitudes seem erroneous when seen in a certain field orientation whereas the same magnitudes seem correct when the field orientation is different. This is also a consequence of position angle error. Therefore comparison stars are preferred that approximately have the same declination as the variable.

6. Misidentification

It may happen that an observer estimates the wrong star (Mayall 1967; Mattei *et al.* 1980). There are several cases that can be discerned.

a) Misreading the chart

This can be overcome by carefully comparing the field of the telescope and the chart. It is essential to use charts that show *all* stars above a visual threshold value. Only the (a) and (b) charts meet this condition. This is not the case with charts made after photographic sources. It may happen that stars are omitted when drawing the charts.

Inexperienced observers are advised to add a new variable to their program when the variable is at maximum. As the star grows fainter one becomes more accustomed to the field, therefore decreasing the chance of misidentification.

b) Suggestion

When a variable is faint it sometimes happens that an observer "sees" the variable while it is well below his threshold value. Therefore I'd like to advise estimating a star only when it is easily visible (about half a magnitude above the limiting magnitude).

c) Close companions

When a variable has a close companion (e.g. R Cas, SV Dra, S Lyn, RU Peg) it can be easily mistaken for the variable when the brightnesses are about the same. Checking the chart immediately after having made the estimate is essential. Never trust to memory!

d) Errors in the chart

It may happen (especially with "preliminary charts") that a close field star is mistaken for the variable and that the nearby faint field stars are plotted only approximately. Regular observation is necessary to reveal such errors. It is also necessary to have access to a photographic star atlas (preferably the *Palomar Sky Survey* or Vehrenberg's *Atlas Stellarum*) that can be consulted in case of doubt.

This problem, however, holds only for those observers who can see stars fainter than thirteenth magnitude.

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