THE SEARCH FOR NEW VARIABLES WITH A BLINK MICROSCOPE

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This paper will describe the method of variable star discovery and verification employed at the Maria Mitchell Observatory, using the Rodman Blink microscope, which was designed and built by Dr. James P. Rodman, and installed in the Observatory in the summer of 1970. Photographic plates are first examined on the blink microscope. Any suspected variables are then located and confirmed as new variables or identified as old variables rediscovered. In what follows, reference will be made to applications of the method in examining plates of a region in Sagittarius and to results of the author's search in that region.

The principle behind a blink microscope is quite simple. It involves viewing two plates of the same star field in rapid alternation. All the stars appear the same on each plate except those whose magnitudes have changed. These appear to blink, due to their change in image size. In practice, however, it is not easy. To compare two plates, they must be centered on very nearly the same field, and their effective exposures must be the same in order to assure the same image size for stars of constant brightness. In practice, equivalent effective exposures are hard to achieve because of varying sky conditions from night to night. Thus, in general, all the stars in the field appear to blink to a certain degree, but stars with a change of magnitude will blink more. The observer must try to discriminate between the two. Plate distortion limits the usable field to an area of approximately nine square degrees in the center of the plate. In addition, plate distortion tends to displace the image of one plate relative to the other as different regions are examined. The Rodman blink microscope has a means of correcting for this effect. One of the mirrors directing the light path to the observer is adjustable, allowing a slight change in orientation, and thereby slightly changing the light path and compensating for the image displacement. Figure 1 shows the optical path of the microscope as seen from above. The light illuminates the plates which are placed perpendicular to the plane of the page, and the stroboscopic wheel interrupts the light paths alternately. After passage through a series of lenses to magnify the image, the two light paths are joined by means of a beam splitter cube. The carriage holding the plates can be moved to provide the means for observing different regions of the plates.

After the plates have been thoroughly examined with the blink microscope, all the suspected variables must be reexamined under an eyepiece. Now is the time to eliminate all those stars whose apparent magnitude changes are a result of the different plate quality. This is sometimes difficult to decide, especially for very small magnitude changes. Also, any dust specks or emulsion defects must be eliminated. These can sometimes be recognized by comparing their shapes under a microscope to stellar images on the same plates, since stellar images may have distinct shapes as a result of plate trailing or plate distortion. Defects may also be eliminated because their reflectivity differs from the rest of the emulsion. In order for a variable to be confirmed one should find it bright on at least two plates and faint on at least another two. For a long period star this is quite easily done by examining plates near in time to the discovery plate. For short period stars, especially eclipsing stars, confirmation can be much more difficult. On one pair of plates I compared, I found two bright stellar-shaped images which did not appear bright on any other Nantucket plates. They may possibly be new flare stars. If the images on the plate are trailed it is possible that a flare star may appear to have a jet as a result of its rapid increase in brightness. Neither of the suspected flare stars showed a jet.

After the variable is confirmed, its coordinates are determined. This is done by locating its position on the Cordoba or on the BD Charts. These coordinates are then checked in Kukarkin's General Catalog of Variable Stars to see if any known variable has approximately the same coordinates. For any that do, there are several methods of attack. First, one looks to see whether there is a published chart of the star's field. If there is, it is very easy to confirm a rediscovery. Unfortunately, for the large majority of stars, there have been no charts published.

For stars with no published charts, there are several alternative methods. If there is a published period or magnitude range for the star, one can examine the suspect on a series of plates to see if it shows the same periodicity. However, this method is time consuming and may not give definitive results. A better method of confirmation is to obtain a more accurate position determination. Four relatively bright stars visible on the plate and surrounding the suspect are located on the Cordoba or BD chart and their coordinates are read from the respective catalog. In the absence of a precision measuring engine, adequate provisional positions may be obtained by placing the plate over a millimeter grid and examining it under the zoom microscope. The grid coordinates of the suspect and four comparison stars are noted. Finally, transformation of the grid coordinates to right ascension and declination gives an acceptable position of the suspect. This method gives an accuracy of about 2^s in right ascension and $0\overset{'}{.}3$ in declination on the Nantucket Sagittarius plates. These coordinates are helpful in establishing the rediscovery of a published variable.

Several other classes of celestial objects may be initially mistaken for variable stars with the blink microscope. These include planets, comets, and asteroids. These objects are especially likely to be found on Sagittarius plates because of the constellation's location on the ecliptic. The brighter planets are not likely to be mistaken for variables because of their large overexposed images on plates of long exposure. Asteroids or comets can be eliminated by observed motion on a series of plates. However, if the object has moved so far as to be out of the field of the next plate, any planets or known asteroids and comets may quickly be identified by checking their positions in annually published ephemerides (e.g., the American Ephemeris and Nautical Almanac for planets and the largest asteroids, Kleine Planeten or its Russian successor for ephemerides of minor planets, and the Handbook of the British Astronomical Association for expected returns of periodic comets). Of course a comet may be recognized as such if it shows a noticeable tail. The star should also be checked in the Catalog of Suspected Variable Stars, because the blink discovery would tend to confirm it as a variable. After all these possibilities have been eliminated, the star can definitely be labelled as a new variable and its period and type should be determined.

Studies of the completeness of variable star surveys by Plaut (1965) and van Gent (1933) indicate that for a given star, the chance of discovery is a function of many variables. For instance, it depends on the number of variable stars in the field being studied, the number of plate pairs blinked, and the quality of the plates. Also affecting the discovery probability are the apparent magnitude, the shape of the light curve and the amplitude of variation. For variables of a given period, the discovery chance is also a function of the time interval between the two plates being compared. For example, one would not be likely to find long period variables on two plates taken the same night, whereas one might very possibly find an RR Lyrae or Algol-type star. If the observer is only looking for a given type of variable, he can, by carefully choosing the interval between plates, enhance the chances of discovery. Anyone interested in the mathematical formulation of the discovery probability is referred to the papers by Plaut and van Gent.

Among the variables I discovered this summer, one is a peculiar explosive type. It was examined on Nantucket plates from 1956 to the present. It was at about the plate limit on all of the plates except about ten. These spanned an interval of only some 80 days during which the variable went through three successive maxima, brightening by about 3.5 magnitudes. (Figure 2). It appeared extremely bright on only four plates. Of particular interest to the present discussion is the fact that two of those four plates had previously been blinked together (by someone else) but since the star was bright on both plates it was not discovered as a variable at that time. This gives an indication of the pure chance element involved in blink microscope work. However, the most recent completeness surveys and results at the Maria Mitchell Observatory also indicate the effectiveness of the method.

This work was done as an undergraduate research assistant at the Maria Mitchell Observatory during the summer of 1973 under the direction of Dr. Dorrit Hoffleit.

REFERENCES

Plaut, L. 1965, Stars and Stellar Systems 5, 302.
van Gent, H. 1933, B.A.N. 7, 21.

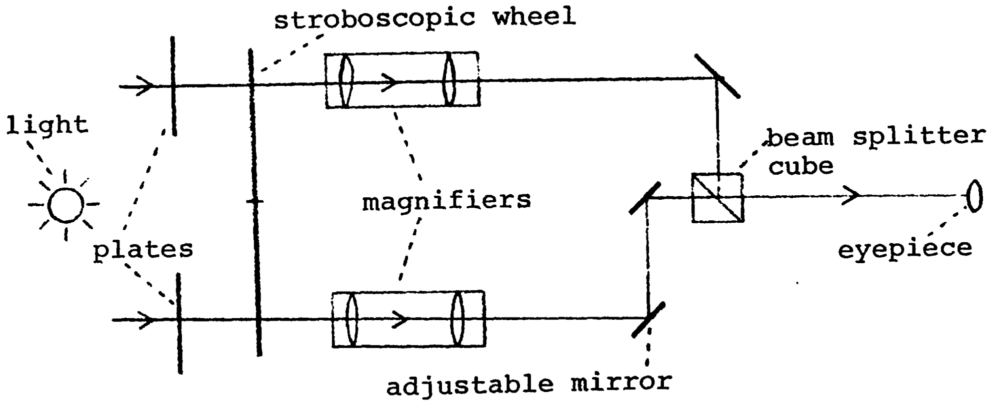

Figure 1. Optical design of the Rodman Blink Microscope.

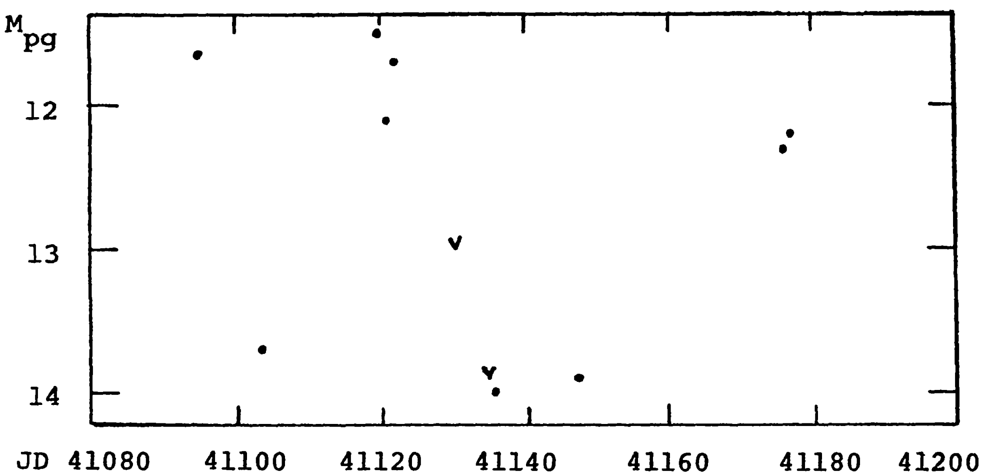

Figure 2. New Variable: Observations between JD 41080 and 41200. (v = fainter than)

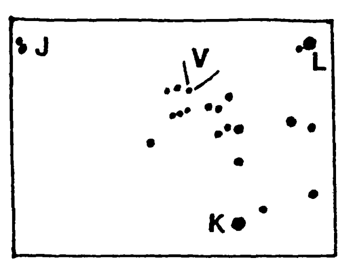

Figure 3. Finder Chart for New Variable (V) at
$\alpha = 18^h\ 19^m\ 36^s.4$, $\delta = -29°\ 28'.8$ (1900)
The stars marked J, K, and L are, respectively:
CoD -29° 14900-1, 14939 and 14952.
Chart approximately 45' x 25', south up.