A SEARCH FOR VARIABLES AT GOETHE LINK OBSERVATORY

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Presented at the 85th AAVSO Spring Meeting, April 13, 1996

Abstract

The 25-cm Cooke astrograph and blink comparator at Indiana University's Goethe Link Observatory are being used to conduct a successful photographic search for new variable stars. Some difficulties in recognizing stellar variability from photographic images are discussed.

1. Introduction

A systematic search for new variable stars entails four requirements: a suitable optical instrument, a means to record or measure stellar images at two or more epochs, a means to compare these images or their derived magnitudes to detect changes in brightness, and a means to check the identity of detected variables in order to confirm that they are new. CCD detectors are the latest development in this field of endeavor. CCDs are highly effective in detecting variables in certain specialized situations (e.g., small-amplitude variables and variables in restricted fields such as star clusters). However, the classic combination of photographic plates or films, wide-field optics, and a blink microscope is still a potent method to search large areas for previously unrecognized variable stars.

It might be supposed that many previous searches during the past century have exhausted the supply of undiscovered variables with significant amplitude. However, current search programs by Dan Kaiser in the United States (MacRobert 1988, Liller 1992) and Mike Collins in England (Ridpath 1991), using 35-mm cameras with 135-mm telephoto lenses, have produced dozens of new variables, some as bright as 7th and 8th magnitude. Lennart Dahlmark in France (Dahlmark 1993, 1994), using larger-format cameras of 300-mm focus for a deeper search, has found more than 200 new variables between 11th and 14th magnitude in such previously well-searched regions as Cygnus and Cassiopeia.

2. The search for variables at Link Observatory

In recent years, I have enjoyed regular access to Indiana University's Goethe Link Observatory. The 25-cm photographic refractor (f/6.3 Cooke triplet) and blink microscope at this observatory have been little used since the conclusion of the major asteroid program for which these instruments were installed. In order to take advantage of this old but still useful equipment, I am photographing selected fields and comparing pairs of these photos in the blink microscope to discover new variables. The blue-corrected astrograph records a field of 6.4 x 8.0 degrees on 20 x 25-cm Kodak SB-5 x-ray film and reaches a limiting magnitude of 15.0 B in a 30-minute exposure.

Before the advent of computers, the identification of newly-detected variables was a time-consuming process, requiring measurement of the star's position and a tedious search of the variable star catalogues for a known variable at (or near) that position. Today, I am fortunate to be able to identify known variables using the "Guide" CD-ROM computer program (Project Pluto, Ridge Road, Box 1607, Bowdoinham, ME 04008). The Guide program indicates and labels all stars from the *General Catalogue* *of Variable Stars* and the *New Catalogue of Suspected Variable Stars* in fields plotted from the *Guide Star Catalogue* (STScI 1989). The latest versions of the program are updated to include all the additional variables that have been officially recognized since the catalogues were published.

Photographs of the target fields have been accumulated during the past several years. Some of the fields were initially photographed for other purposes, and additional photos have been taken to provide suitable pairs for blinking. But two fields in Sextans and Leo Minor were chosen specifically for the search program because they contain very few known variables.

The search fields are photographed on sheet film, but the blink comparator is designed for glass photographic plates. I therefore placed clear glass in the plate carriages to support the film. It has proved impossible to keep the large-format film free from dust, especially during the many hours of blinking. Most foreign particles can be recognized by inspection, thanks to the high magnification of the blink microscope. But some particles are very stellar in appearance, and the film must be brushed on both sides to test the validity of any blinking image.

Another class of false alarms involves real images of stellar-like objects, including airplanes, satellites, and asteroids. The strobe lights on distant aircraft produced perfect 12th-magnitude stellar-like images on two of my photographs. The aircraft running lights were too red or too faint to leave a trail. The true nature of these images was revealed only when continued blinking found additional images, identical in brightness and equally spaced across the field. Specular flashes from satellites could produce the same kind of image. I have tried to avoid the nuisance of asteroids by selecting search fields outside the ecliptic zone, and only one asteroid has been detected on the first seven pairs of photos. If an asteroid is found, the Guide program can plot all known asteroids in the field if the program is set for the time of the photo.

3. Results

I began systematic blinking on the last weekend of 1994. During the first year, I managed to complete the comparison of seven pairs of films in 97 hours of blinking. Detecting stellar variability with a blink microscope is an acquired skill. The first pair of photos that I blinked, a Milky Way field in Puppis that includes the open clusters M46 and M47, required 38 hours to complete. Each of the approximately 50,000 stars was examined critically, and many small-amplitude (0.5 magnitude or less) suspects were marked.

However, I was unable to confirm a sampling of these suspects on additional photos at Link or on Harvard patrol plates. No doubt, some of these stars are really variable. However, most of them appear slightly variable because of their color and differences in focus and effective exposure between pairs of photos.

Ideally, photos suitable for blinking should be identical in quality. However, no two photos are really identical, and all stars appear to be slightly variable when blinked. Atmospheric seeing, transparency, altitude of the field during exposure, and quality of guiding introduce a myriad of subtle differences in the stellar images. In addition, the 25-cm astrograph's focus must be adjusted according to the temperature during each observing session. A difference of 20 degrees Celsius changes the telescope's focus setting by 1 mm. The telescope's finely divided vernier scale is difficult to read in dim light, and if the focus happens to be set closer to "best focus" on one photo than on the second, blue stars will differ little on the two films, but red stars will be slightly enlarged on the less-well-focused film. These red suspects identify themselves as doubtful variables because the apparently brighter image is always on the same film of the pair.

The "best focus" setting itself is dependent on a star's brightness and color. Ross (1926) published an interesting note on how slight differences in focus can change the relative size of stellar images depending on each star's magnitude. He attributed this phenomenon to the higher-order complexity of the distribution of light in the focal image, due to the multiplicity of refracting surfaces in a high-speed anastigmat lens. The same effect applies to stars of different color (Belserene 1986).

After the long process of blinking the first pair and my failure to confirm the variability of the many small-amplitude suspects, I decided to ignore stars that appear to vary by less than about 0.5 magnitude. As a result, I have been able to speed up the blinking process, and subsequent photo pairs of the same Milky Way field in Puppis were completed in about 15 hours. Fields at higher galactic latitudes require only 5 or 6 hours. Only stars that are grossly variable (more than 0.5 magnitude) are marked for further checking.

By this relaxed criterion, I found seven previously unreported variables on the seven pairs of films during 1995. The first new variable found and confirmed was GSC 5409:1201 in Puppis, about 1 degree west of the open cluster M47. It appeared as a well-exposed stellar image of 12.8 B magnitude on one film and was completely invisible, fainter than 15.0 B on the second film. Observations of this star on more than 500 Harvard patrol plates reveal that it is an Algol-type eclipsing binary with a period of 10.98 days. The remaining new variables are awaiting similar confirmation and classification on the Harvard plates. Positions, types, periods, and finding charts will be published in the IAU *Information Bulletin on Variable Stars* as observation and analysis are completed.

4. Acknowledgements

I am grateful to the Indiana University Astronomy Department for use of the Link Observatory facilities under the auspices of the Indiana Astronomical Society, and to Dr. Martha Hazen for the use of the Harvard plate collection. Dan Kaiser also helped greatly by providing printouts of search fields from the Guide program before it became available at the observatory.

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