Notes on the Use of DAOPHOT

DAOPHOT is one of the best programmes in the world for stellar photometry in crowded fields. Many people use it, and it can also be run within MIDAS at ESO. A detailed DAOPHOT User's Manual by P.B. Stetson is stored on-line (and is also available from F. Murtagh). He recently added some supplements (P.A.S.P., **99,** 191, 1987). Our aim was to do low-amplitude variable star photometry with an accuracy of 0.01 mag or better. While we have been successful in running DAOPHOT at ESO, the following notes may be useful for other DAOPHOT users. These notes refer to the "old" version of DAOPHOT at ESO.

(1) The shape of the Point Spread Function (PSF) may not be unique within the whole frame. The CCD we used belongs to those which have variable PSF across the frame. For isolated bright stars, the systematic error caused by using the PSF from the lower part of the frame in the upper part is less than 0.02 mag (not including the extreme corners). But for differential photometry, the Δm between the comparison and the variable star is less influenced by this kind of error.

(2) When the zenith distance was larger than 65°, even 60 seconds exposure was not long enough for 13^m stars to well establish the statistical properties of the seeing, and even stars located within a small area, say, 50 × 50 pixels, may have different shapes (PSF). This of course depends on the instrumentation used and also the seeing. Using different "CUTS" (one value to indicate the halo of the stars and the other to indicate the core) one can clearly see the difference of the shapes on the DeAnza screen.

(3) For poorly guided frames, the star images are irregular and the use of an inaccurate PSF may lead to disaster. We have encountered the case where after subtracting the bright stars from the original frame and then running the "FIND" routine again, the residuals of some bright stars were detected as *false* faint stars together with the *real* faint stars buried in the profiles of bright stars (sometimes the real faint stars were omitted). If these false faint stars were not deleted manually from the list when running the "NSTAR" routine, decidedly wrong results would be obtained. Checking the CHI value was no use at all in this case, because it was not worse than that of the nearby real faint stars. Somebody who is not familiar with his star field must be very careful.

(4) Even at the step of "GROUP", strong interactive operation is necessary. This automatic routine divides the star list for a given frame into optimal subgroups in order to reduce the CPU time and to describe the sky brightness with fewer parameters. For the version we used, the criterion to divide stars into subgroups is a critical separation, which is the sum of the brightest star image radius and the fitting radius. For the version used at DAO, the critical separation is a function of apparent magnitude. The stars within one subgroup are close enough so that the light of one will influence the profile-fitting of another and they should be reduced together. For the version of DAOPHOT now released, the maximum number of stars run by the "NSTAR" routine is 60.

The problems we have met in practice are:

(a) In our frames sometimes the stars in one subgroup form a long, thin and curved string over a large area. We do not think it is suitable to consider the stars of this long string as one unit which have the same PSF. It is also not good to break them into smaller subgroups by using a smaller critical separation value. We prefer to load the star list given by the "GROUP" routine onto the DeAnza screen and "EDIT" the stars manually, i.e. to find some star(s) on the string where it is relatively sparse, break the string over at this point and so group the stars in this way.

(b) Sometimes it happened that the stars which belong to one group are really located within a compact region and should be reduced as a unit, but the number is a little larger than 60. According to DAOPHOT, the "SELECT" routine must be used to select a slightly smaller critical separation value and break this group into several smaller subgroups. Unfortunately, it often happened that among these subgroups many stars were divided into one star per subgroup. For these "single" stars, the "NSTAR" routine became the "PEAK" routine, i.e. the multiple simultaneous profile-fitting advantage was lost. In this case, we simply edited the group file and took away some stars at the edge of the group on the screen, considering them as another small subgroup and sacrificing their accuracy. Now the original group contained less than 60 stars and could be run with "NSTAR".

(5) One must be very careful while running the "PSF" routine in a crowded field. In the DAOPHOT Users' Manual, Stetson vividly describes the process as an art, not a science. Obtaining a good PSF in a crowded field is a delicate business; do not expect to do it quickly, plan on spending a couple of hours for this endeavour.

The author of this article will be happy to directly inform interested persons about his experience with DAOPHOT in greater detail than is possible here.

classical viewpoint: are there any variables outside the strip with amplitudes larger than 0.02 mag.?

Observations

An RCA thinned back-illuminated 320 × 512 pixel CCD (pixel size 30 × 30 μm) mounted at the 1-metre reflector (f/13.5) of the Yunnan Observatory in Kunming, P.R. China, was used to observe M4 during 8 nights in March and May of 1986. A series of successive frames was obtained during each night with a typical exposure time of 5 minutes through the V filter and each star was nearly fixed at the same position of the frame. As mentioned above, the zenith distance of M4 is always large for northern observers.

The data reduced at ESO were obtained on May 11, 1986 and consist of

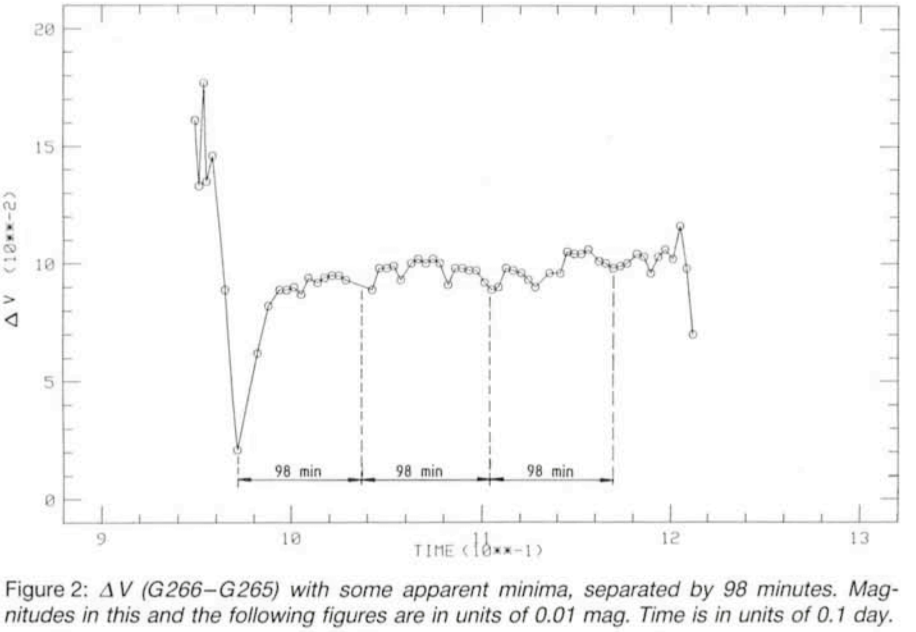

Figure 2: *Δ V (G266–G265) with some apparent minima, separated by 98 minutes. Magnitudes in this and the following figures are in units of 0.01 mag. Time is in units of 0.1 day.*