THE LARGE-FIELD BRIGHT-STAR HIGH-PRECISION CCD PHOTOMETER OF BAO

Shiyang Jiang

Beijing Astronomical Observatory, Academy of Sciences

1. INTRODUCTION

Time-series high-accuracy photometry is very important for research in stellar variability. For a long time photometry made by a photomultiplier was the only instrument for high precision stellar photometry. To overcome the atmospheric variation and instrumental problems, we must choose at least one stable star as a comparison star and move the telescope quickly between the targets. So the real efficiency is very low and one only can do it on photometric nights. To overcome this limitation, since 1989 we began to cooperate with the team of the STEPHI network. We used the Chevreton four-channel photometer which can observe the variable, two comparison stars and a chosen sky background simultaneously. The multi-channel photometer is much better than normal single channel photometer as we can see from the several STEPHI results. Now the very high quantum efficiency CCD becomes more and more popular, so we are trying to change to use CCDs. Here we give some general description of a large field high accuracy bright star CCD photometer being prepared for the Beijing Astronomical Observatory (BAO).

2. THE PRIME FOCUS OF THE 60-CM REFLECTOR OF THE XINGLONG STATION OF BAO

The 60-cm reflector of the Xinglong Station has a prime focus of F/4. But the original correctors were not good enough, hence we asked Dr. M. L. Yi of Nanjing Astronomical Instruments Research Center to redesign and rebuild a new corrector. It is a four element, K9 glass made, lens system. The largest spread image size is less than $0\overset{''}{.}8$ within a field of view of one degree. Just this August we finished the installation of this new corrector system and got some CCD frames with a SBIG ST6 CCD as a test.

3. THE CCD SYSTEM

The CCD camera we chose is a TC-215 type thermoelectric cooling system made by Dr. Z. W. Zhao at the National Observatory of Japan when he was a visitor there between 1992 to 1993.

For fast photometry and a smaller data base, we will add window readout type software. That means we will make a square box for each object which we want to measure and only read those boxes and save them to the disk. In this way the read out time can be limited to 40 ms and the data base is only 0.1% of the full read of the chip.

A. G. Davis Philip et al. (eds.), New Developments in Array Technology and Applications, 325–326.

4. SOME CALCULATIONS

a) The signal to noise ratio and the limiting magnitude: If D is the diameter of the telescope, t is the light efficiency of the telescope, a is the light transparency of the atmosphere, f is the light efficiency of the filter, c is the quantum efficiency of the CCD, T is the integration time, w is the wave band width, V is the magnitude of the objects, I is photons per angstrom per square cm per second of a zero magnitude star, then we have:

$$\text{Signal} = (\pi/4)\, D^2\, (\text{tafcwI})T \times 2.512^{-V}$$

$$\text{Noise} = \sqrt{\text{Signal} + (\pi^2/4)\, D^2\, (\text{tafcwI})TM^2 \times 2.512^{-22.0} + 64M}.$$

Here M denotes the total pixels in each box. To get a high S/N we defocus the stellar image to about 11" or M = 78. Under this condition, for V = 15, on a moonless night, with T = 100 s we can have a S/N better than 100, so it is the limiting magnitude for high accuracy photometry.

b) The dynamic range: When we defocus the stellar image to 11", we can get about 4.5 magnitudes range for high accuracy photometry. That is to say we can work on V = 5 - 9.5 with T = 1 s or V = 10 - 14.5 with T = 100 s or somewhat in between.

c) How many stars are there in each frame to a limit of V = 15? As we know generally, in the average each square sphere degree on the sky, will have one or two stars in the V band brighter than 8 mag, our CCD on the sky will cover about 0.09 square degrees, so there will be only a 9% chance to find a star brighter than 8. But for finding a star brighter than 12 mag, the chance is larger than 500%. Within the sky area we cover, one can have more than 100 stars in V brighter than 15. So for high accuracy photometry of bright stars, in most situations we can find good comparison stars.

5. RESEARCH PROJECTS

a) δ Scuti stars and asteroseismology research: Due to the low quantum efficiency and short integration time, in most situations, we only work on stars brighter than V = 10. By using a CCD, we can have a two to three magnitude gain. Hence it is very useful if we choose some clusters as a target, so that for variable stars we can not only easily get some frequencies for known variables but also we will have many chances to find new variables.

b) Faint Be star observations: Up to now we have worked only on bright Be stars, for which it is very difficult to find comparison stars within short distances. We can not get a high enough photometric accuracy. Using a CCD, one can work on clusters, and find many new faint Be stars. For these objects we can rather easily find comparison stars in the same field and get photometry of high accuracy

c) Supernova survey: For the supernova survey, the CCD will be used. The two pixel image is 2.14" which matches well with the normal seeing disk of our site. For a 300 s integration, the detected limiting magnitude can be as faint as V = 22. This is very useful for super nova surveys among galaxies.