ELECTRONOGRAPHIC PHOTOMETRY OF STAR CLUSTERS IN THE MAGELLANIC CLOUDS

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The high quantum efficiency, linear response, large dynamic range and large number of picture elements make the electronographic camera the most suitable of the presently available detector systems for the study of the colors and magnitudes of stars in the clusters associated with the Magellanic Clouds. Owing to the remoteness of these objects and the consequent small angular separation of the stars within them, the best method of determining electronographic magnitudes of the cluster stars is still that of measuring the star image profiles on one-dimensional scans made using a Joyce Loebl microdensitometer. While this technique does not utilize all of the information contained in the star image, it provides better correction for overlapping star images and variable background than is achieved with two dimensional methods that simulate observation through a focal-plane diaphragm. By this method, it has been possible to measure a star of B =23.8 on a 180 min exposure in 2.0 arcsec seeing taken with a Spectracon image converter on the 1.5 m Tololo reflector. The probable error of this measurement is ±0.12 mag, while the error due to photon statistics is ±0.06 mag. Thus, using electronographic cameras on larger telescopes and in good seeing, it should be possible to study the stellar content of the Magellanic Cloud clusters down to about the luminosity of the Sun. Further, current studies indicate that if a sufficient number of electronographic magnitudes are determined in a cluster, these can then be used to set up calibration curves as a function of radial distance from the cluster center, permitting photographic photometry of a large number of stars to be carried out, free of the usual limitations imposed by the effects of the unresolved background light of the cluster on the photographic measures. Using this technique, cluster observations can be carried out effectively using a small-field electronographic camera such as the Spectracon, which may be much smaller and less expensive than the large-field electronographic cameras, and thus more practical to use at distant observing sites.

James E. Hesser (ed.), Star Clusters, 365–367.

To date, color-magnitude diagrams have been determined for eight Magellanic Cloud clusters from observations with a Spectracon on the Tololo 1.5 m reflector. These clusters include: NGC 339, 419 and Kron 3 in the SMC and NGC 1866, 2209, 2231, 2257 and Hodge 11 in the LMC. The diagrams extend to V = 20.9 - 23.2, depending upon the seeing and length of exposures. References to the published diagrams and to the instrumentation and reduction and calibration procedures used are given in Walker (1979). Of particular interest are NGC 2209, 2231 and Hodge 11 which have ages of 8 x 10^8, 1.3 x 10^9 and 6 x 10^8 y and [Fe/H] of -0.5, -0.9 and -2.4, respectively, indicating that as recently as 6 x 10^8 y ago at least some stars in the LMC were being formed from material having nearly the primordial chemical composition. In the SMC, the clusters NGC 339 and Kron 3 appear to be similar, but it is not yet clear if these objects are "metal rich globular" clusters, or objects with a metal content like that of M 13. The present studies demonstrate that electronographic photometry provides us with a very important technique for the study of the evolutionary history of the Magellanic Clouds. Observations of additional clusters will permit us to trace the rate of star cluster formation, and the change in chemical composition as a function of time in the Clouds, and to study intermediate age clusters of low metal content not found in our own galaxy.

REFERENCES

Walker, M.F.: 1979, *Mon. Not. Roy. Astron. Soc.* 186, 767.

DISCUSSION

BOK: How do you rate the technical performance of the CCD beside the electronographic camera?

WALKER: For an individual start there's no question that you're going to get higher formal accuracy of measurement from the CCD device. The problem with it is that at the present time you can only get a small number of pixels. So you get a very good magnitude of something in some little area on the sky around some star but we know, of course, . . .

BOK: But they're already making them 3 x 3 arcmin, or 4 x 4 arcmin.

WALKER: O.K., but how many stars do you need, you see, in order to do this job? The point is you need a lot of them if you really want to realize the advantage of doing it the CCD way, rather than accepting the accuracy that you would get in this method, which is down by a factor of, let's say, 2 from what you would get

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out of pure photon statistics. The point is to realize that not to be limited by the real problem, which is the occurrence of all these faint field stars, you have to have really quite a large number of these standard stars. To do that, then, you require practically the whole field of the cluster to get enough objects.

KING: Two questions. How big is your field in so many pixels by so many? And the other question, are you describing private equipment or public equipment that you're urging everyone to use?

WALKER: Those are both difficult questions. The cluster observations which I have discussed here were all obtained in 1968 - 1969 with a Spectracon image converter attached to the Tololo 1.5 m reflector. Production of the Spectracon for "outside" users was terminated at Imperial College, London, upon the retirement of Professor McGee some years ago. Commercial production of these tubes was undertaken by a small firm in England, Instrument Technology, Ltd. (ITL). While I did not myself succeed in obtaining a satisfactory tube from them, some other observers apparently did. Production of these tubes has now been taken over by a new firm, Photon Tubes, Ltd., formed by personnel from ITL, and it should be possible to order tubes from them. With regard to other electronographic cameras, the classical Lallemand cameras are still being produced at the Paris Observatory and could presumably be ordered from that source. The Kron camera is no longer being made commercially, but cameras of this type are in operation at the US Naval Observatory, Flagstaff, and at the Mount Hopkins Observatory of the Smithsonian Institution (the latter, I believe, for spectroscopic observations only). The McMullan camera, developed at RGO, is no longer available from RGO, but negotiations are under way to have this device produced for commercial sale by ITL. McMullan cameras are currently in use for direct observations at: RGO, the Sutherland Observatory in South Africa, the Anglo-Australian Observatory, the Wise Observatory in Israel, and at ESO in Chile. While I can of course not speak for any of the Observatories where electronographic cameras are in use for direct observations, I would expect that observers might be able to arrange to use the cameras at some of these institutions.

FEAST: Just to answer Ivan, perhaps I could say that at the Cape, and at one or two other places, the McMullan camera has been in routine operation for general use by anyone with any reasonable amount of competence. (Laughter).

GASCOIGNE: I would just like to emphasize that the stars that Merle has measured the magnitudes and colors of remain by far the faintest available at this time, and they were done using the 1.5-m Tololo reflector when it was not in best adjustment at all.