PANEL DISCUSSION ON STAR CLUSTERS

Given below are the texts of the introductory statements by panelists J.E. Hesser, P.W. Hodge, A. Renzini, L. Searle and S. van den Bergh. The transcription of their remarks was prepared from a very low-quality tape recording. The Editors wish to apologize for any misinterpretations that may have been made of the speaker's actual remarks.

J.E. Hesser
Dominion Astrophysical Observatory

After listening to the talks this morning, I should like to reiterate Searle's point concerning the deliterious effects of stochastical background fluctuations on both the corrected integrated colors and spectra of Magellanic Cloud clusters and the dominance that a few very blue and/or red stars may have on the observed integrated cluster properties. At the same time I feel that we should not lose sight of the fact - as I think we tended to do today - that the Cloud clusters are incredibly valuable probes of stellar evolution: Rich cloud clusters contain stars in unusual regions of the HR diagram which are very difficult to sample by studying less populous Galactic star clusters. I feel that this whole field is going to change very much in the near future with the advent of CCD detectors and the application of the profile fitting techniques which have been developed for stellar magnitude determination. These new techniques are going to constrain theories of stellar evolution very powerfully through much higher quality data on the Magellanic Cloud star clusters. Many more color magnitude diagrams will be required to take full advantage of these improved techniques.

Leonard Searle made another good point about the importance of the Magellanic Cloud star clusters for understanding light from composite systems. The Clouds are the only other galaxies in which one can observe the individual stars and synthesize system properties (in integrated light) for comparison with observed integrated cluster properties. I really think that this is terribly important: We will not be able to understand the integrated light of galaxies if we can't understand the composite light of Cloud star clusters. I am again very optimistic. The CCD technology in particular will make it possible to obtain extremely good color-magnitude diagrams of Cloud clusters (even with ground-based telescopes and certainly with Space Telescope) to extremely faint absolute magnitudes. But I think we should not lose

S. van den Bergh and K. S. de Boer (eds.), Structure and Evolution of the Magellanic Clouds, 63–66.

sight of the fact that the CCDs may reveal that we are not in very good control of the Galactic globulars as comparison objects. I would not be surprised if we find that an awful lot of color-magnitude diagrams that have been constructed in the past 10 years or so turn out to be rather "ropey" at the faint end. We're going to find a lot of new, exciting results after we tighten up their color-magnitude diagrams with data of 1 or 2% precision, and much will be learned about stellar evolution. At the same time we will be in a position to predict the luminosity functions much better, and hence to model synthetic spectra and colors for integrated systems.

From an observational viewpoint, I am, concerned about the application of CCDs to C - M diagram determinations. When I think back to the photoelectric UBV photometry that I used to do, I wouldn't have considered a night to have been well calibrated if I had only 8, 9 or 10 standard star observations without any idea of extinction. I am very concerned that we observers may not be thinking enough about how we are going to set the zero points in all this magnificent new CCD photometry. We can only make correct deductions when we compare objects in the Galaxy with those in the Magellanic Clouds, or compare our observations with theory, if we get the zero-points right. To take advantage of the magnificent evolutionary tracks that Don VandenBerg, among others, has been calculating will require great observational care in this matter.

Finally I would like to emphasize the point that John Graham just made on Ken Freeman's talk. I think the RR Lyrae stars offer an enormous potential to understand more about the halo of the Magellanic Clouds. I am perhaps not quite as confident as he is that we know the age-range of the RR Lyrae's that well, but there is certainly no doubt that they are a probe of the oldest component. Those people who are attempting to study RR Lyrae stars in clusters ought not to concentrate their efforts entirely on the clusters, but should also look at the fields around them - they might turn out to be as interesting as the clusters themselves.

P.W. Hodge
University of Washington

Firstly I think the importance of the discrepant ages arrived at by different means shouldn't be ignored and I hope very much that a solution to this discrepancy will be found in the next year or so. Additionally, I am concerned about 2 clusters; NGC 1978, which is very old by spectroscopic techniques, perhaps not quite as old by some people's preliminary CCD techniques, and rather young by other people's photometric results. Similarly, NGC 2021 is a key cluster to re-examine to see why it gives such different results. A second area where there is a lot of disagreement in detail, and some disagreement in the general picture, is that of stellar metallicities. The first thing there is not to argue about the question of whether metallicities correlate with age but to argue about how you define metallicity indi-

ces since different definitions yield different results. Thirdly the question of age distributions is a very important one. The problem of the age distribution for open clusters and of very massive clusters is a question that hasn't been resolved. In that general connection I feel very puzzled by the lack of large numbers of old NGC 1866's and other such intermediate-age clusters. And then finally I mention the age-chemical composition relation because we have heard a lot about this today. It is an extremely difficult question; people get different results using different calibrations. It is perhaps something for 20 to 50 years from now.

A. Renzini
University of Bologna

The Magellanic Cloud globulars are, in a broad sense, of interest to the theory of stellar evolution for several reasons, and I will just single out a couple of them. In the first place, to study advanced stages of stellar evolution, one needs a large assemblage of stars in order to find one star in an advanced stage of stellar evolution. This is particularly true for the so called asymptotic-branch stars, which are in the double shell burning stage. One needs a total of something like 10^5 stars to have one star in such a state. (These figures will change a little bit with the age of the system). The problem with even the richest Galactic clusters is that they contain only something like 1,000 stars. I would also like to draw the attention of observers to the very bright stars that exist in the Magellanic Cloud clusters. It would be important to get reliable bolometric magnitudes and high dispersion spectra of these objects that could become K-type giants or supergiants. Not only do these stars contribute substantially to the models of stars, but they also provide a variety of interesting elements - not only carbon, nitrogen and oxygen. Finally, my impression is that all the evolutionary population synthesis models attempted so far are wrong in the sense that they have forgotten important evolutionary phases.

L. Searle
Mount Wilson and Las Campanas Observatory

I have no ability to prognosticate the future and I have no idea what the direction of research will be a year or a few years from now. I can't even predict my own research on a six-month time scale. So I will confine my remarks to things that struck me during today's presentations. And I should like to emphasize the point that Paul Hodge made. I think that we saw a very clear confrontation between different techniques for estimating the ages of clusters. And some striking disagreements. I think that this represents a remarkable opportunity for future research because it is very clear that these discrepancies must be resolved. And in the direction of resolving them I think that it is not just a matter of more work of the same kind but it is of upgrading the entire level of instrumental and intellectual effort that is put into these problems. In the poster session in the work of Rich,

Mould and Da Costa one sees a whole new level of the work on color-magnitude arrays of globular clusters which gives us some idea of what will be coming along in the next few years.

One other point that I would like to make is on the absence of something that was not talked about today. It seems to me that while it is important to age-date clusters accurately, it is also important to understand the chemical evolution of galaxies and also to determine abundances with accuracy. It was a strange thing that there was no review at this symposium concerning spectroscopic determinations of abundances from studies of individual stars in globular clusters. It is clear that Judy Cohen made a remarkable and important start on that problem. It just scratches the surface and there is a tremendous opportunity for individual spectroscopic studies of stars belonging to these clusters. A comparative study, for example, of the clusters in the Large and Small Magellanic Clouds. And if I were to select a field that is opportune for advancing our knowledge of the evolution of galaxies I think that following Judy Cohen's lead would be such a field.

S. van den Bergh
Dominion Astrophysical Observatory

I think there are perhaps still a number of things which could be mentioned that have not been discussed by previous panelists. One of the important clues, I think, to cluster formation is the fact that the Magellanic Clouds contain significant numbers of populous clusters - whereas such objects appear to be rare or absent in giant spirals such as the Galaxy and M31. It would be interesting to hear from theoreticians what suggestions they might have to account for this observation. Many of the rich clusters which we see now must, in the past, have been even more spectacular objects than they are at present; objects comparable to (or more luminous than) the cluster presently located in the center of the Tarantula Nebula. And it seems quite likely that populous intermediate-age clusters also contained objects that were once similar to R136 near their centers. One can ask one's self to which extent the evolution of such clusters might have been affected by such massive objects in their centers. Finally, I think that after hearing the papers this morning, one perhaps worries about the fact that there appears to be considerable evidence from observations of stars for a burst of star formation that took place two or three billion years ago. It is puzzling (but possibly not significant) that the evidence from clusters for such a burst of star formation is, at best, much weaker. I think that this is a situation which we really should try to straighten out with observational techniques that are already available. One would certainly like to think that bursts of star formation go hand in hand with a high rate of cluster formation. Although this need not, of course, be the case as is shown by the example of the dwarf galaxy NGC 1613 which is presently forming stars quite vigorously but (according to Baade) does not contain a single star cluster.