(up to 5 hours) of selected objects through the available Hα and S II interference filters which have a useful field of about 2°.

The approximate limiting magnitudes for direct plates are quoted in the table. They depend on the seeing; the numbers given are for medium seeing and deeper plates are obtained under excellent conditions. These values may possibly be further improved after the installation of the new Grid Processing machine in November 1988. At the same time, tests are being made of the new Kodak T-max emulsion, although the sensitization appears to be more difficult than first expected. We shall report in one of the next *Messenger* issues about the initial results.

The ESO Schmidt telescope is equipped with one of the world's largest objective prisms, giving a dispersion of about 450 Å/mm at Hγ. Under good seeing conditions, it is possible to obtain widened spectra which allow MK classification, down to magnitude 14.5–15.0. Unwidened spectra give limiting magnitudes, approximately 2–3 magnitudes fainter. The performance is critically dependent on the seeing, as is the case for all objective prism work. The UBK 7 glass is ultraviolet transparent.

Performance of the ESO 1-m Schmidt Telescope

Emulsion	Sensit.	Filter	Bandpass	Exposure	Lim. mag
IIa-O	no	UG 1	UV	60 min 120 min	~19 ~20
	no	GG 385	B	60 min	~21
IIIa-J	yes	UG 1	UV	60 min 120 min	~20 ~21
	yes	GG 385	B	120 min	~22.5
103a-D	no	GG 495	V	45 min	~19
IIIa-F	yes	RG 630	R	120 min	~21.5
IV-N	yes	RG 715	I	90 min	~19

In the future, the 30 × 30 cm plates will be scanned on the refurbished two-coordinate measuring machine at the ESO Headquarters (formerly the S-3000 machine). With a new CCD head and much improved software and large computer storage space, it will become possible to perform "blinking" of large areas. This will greatly speed up the extraction of data from the photographic plates and may give a new impetus to the use of the ESO Schmidt as a powerful survey instrument.

H.-E. SCHUSTER and R.M. WEST

Monitoring SN 1987A

Since the explosion in late February 1987, more than 130 ESO Schmidt plates have now been obtained of the LMC area in which SN 1987A is seen. They document its slow decrease in brightness as well as the now famous double light echo. It is particularly well visible on red and infrared plates. The supernova magnitude was about 10.5 by mid-November 1988.

Learning About Young Globular Clusters

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1. Introduction

Even after many decades of intensive investigation globular clusters still fascinate astronomers. Galactic globular clusters are "fossils" of the epoch of galaxy formation and samples of a very early, but still reachable stellar generation. The situation is different in the Magellanic Clouds where globular-cluster-like objects with a wide variety of ages can be found. We see globular clusters which, judged by their stellar content, cannot be much older than 10^7 yr. Their integrated light is dominated by a slightly evolved upper main sequence. Therefore, they have often been referred to as "blue globular clusters". the question why such clusters are found in the Magellanic Clouds (and perhaps in some other galaxies like M33 and NGC 2403) and not in the Milky Way is certainly of significance for the general understanding of galaxy evolution (see IAU Symp. 126 for more information).

Young globular clusters are ideal laboratories for determining Initial Mass Functions (IMF's), which describe the number of stars found per mass interval in a star forming region. The IMF is of fundamental importance for the evolution of a galaxy, since it controls the energetic feed-back by massive stars to the interstellar medium and largely determines its chemical evolution. However, the determination of the IMF in stellar systems in the Milky Way faces several difficulties. For instance, stars in the solar neighbourhood do not form a coeval sample; open clusters show poor statistics; in galactic globular clusters, only the small mass interval 0.4–0.8 solar masses is observable and they are so old that the observed mass function may be modified by secular dynamical effects. It is evident from these considerations that young globular clusters provide a unique opportunity to study stellar mass functions with good statistics over a large range of masses. Additionally, there is also hope of uncovering a possible dependence of the IMF on metallicity. A spectroscopic high-resolution study by some of us (Spite et al. 1986) confirmed earlier suggestions that NGC 330, the brightest of the young globular clusters in the SMC, has an abnormally low metallicity of −1.3 dex (Fig. 1). In contrast to this, the overall metallicity of the young SMC population is believed to be around −0.7 dex.

Another cluster for which a high-resolution spectrum hints of a lower metal abundance than is found in the field population, is NGC 1818 in the LMC (Richtler et al. 1988, Fig. 2).

It is of great interest to look into the mass function of these objects to find possible differences to a "normal" IMF.

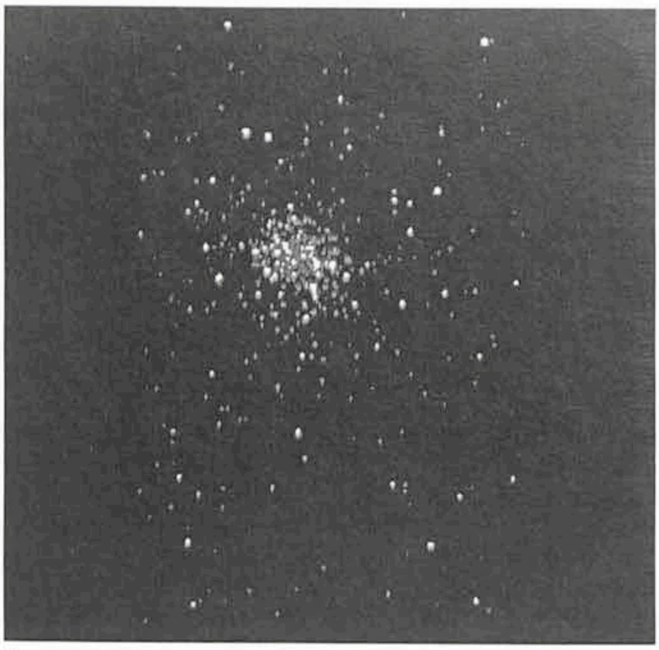

Figure 1: *A 10-sec V exposure of the young SMC globular cluster NGC 330, taken at the 1.54-m Danish telescope. The brightest stars are already saturated.*

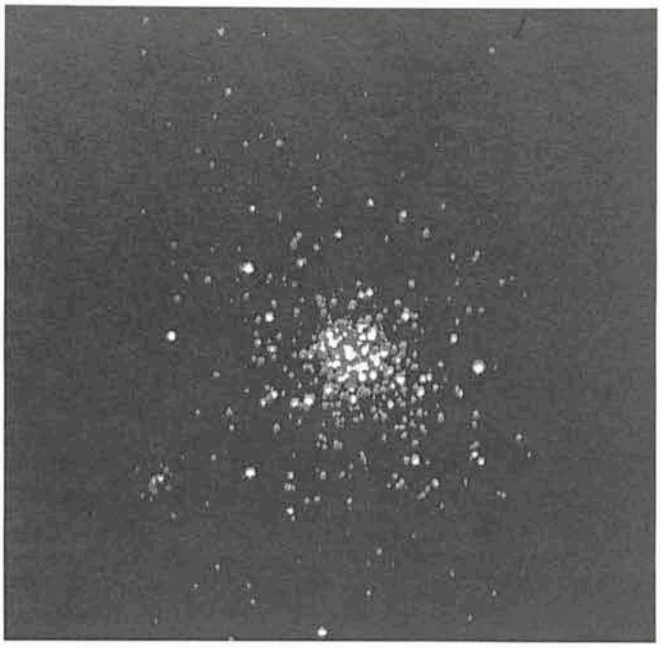

Figure 2: *A 10-sec V exposure of the young LMC globular cluster NGC 1818, taken at the 1.54-m Danish telescope.*

Theoretical considerations indeed point to differences. The concept of opacity-limited fragmentation leads to the prediction that the IMF for massive, zero-metal stars is steeper (Yoshii and Saio, 1986) than a Salpeter mass-function, which characterizes the IMF in the solar neighbourhood.

These ideas are to some degree supported by observational work: strong variations of the IMF in time and space are known to exist in open clusters (Tarrab, 1982). The mass function of galactic globular clusters has been recently investigated (McClure et al. 1986), and a significant dependence on metallicity was found, in the sense that a low metallicity seems to occur with a larger slope. On the other hand, indirect evidence was presented by Melnick (1987) that the IMF of massive stars exciting H II regions is metallicity dependent, but this time in the opposite way. These results are not necessarily in contradiction because the authors address quite different parts of the IMF (15 to 40 $M_\odot$ for Melnick, 0.2–0.8 $M_\odot$ for McClure et al.). To confuse this issue further, Eggen (1987) finds a luminosity function of the field metal-poor population in our Galaxy nearly identical to that of the solar neighbourhood.

During the course of the present work, two papers appeared, dealing with luminosity functions (LF) of young Magellanic Cloud clusters. Elson, Fall and Freeman (1988) investigated the LF's of their objects by visual star counts, while Mateo (1988) employed CCD-techniques to determine LF's of Magellanic Cloud clusters of a large range in age.

These investigations do not arrive at a common conclusion. Mateo finds that the LF's of the clusters he investigated are (within the given uncertainty) similar to each other and also cannot be distinguished from a Salpeter function. Elson et al. find their LF's flatter than a Salpeter function and also differences from cluster to cluster. In a nutshell, this is what we know (or not know) and probably most astronomers agree that further investigations are of importance.

2. Observations

Our data come from two different telescopes. In November 1987, we observed with the 2.2-m telescope in re-

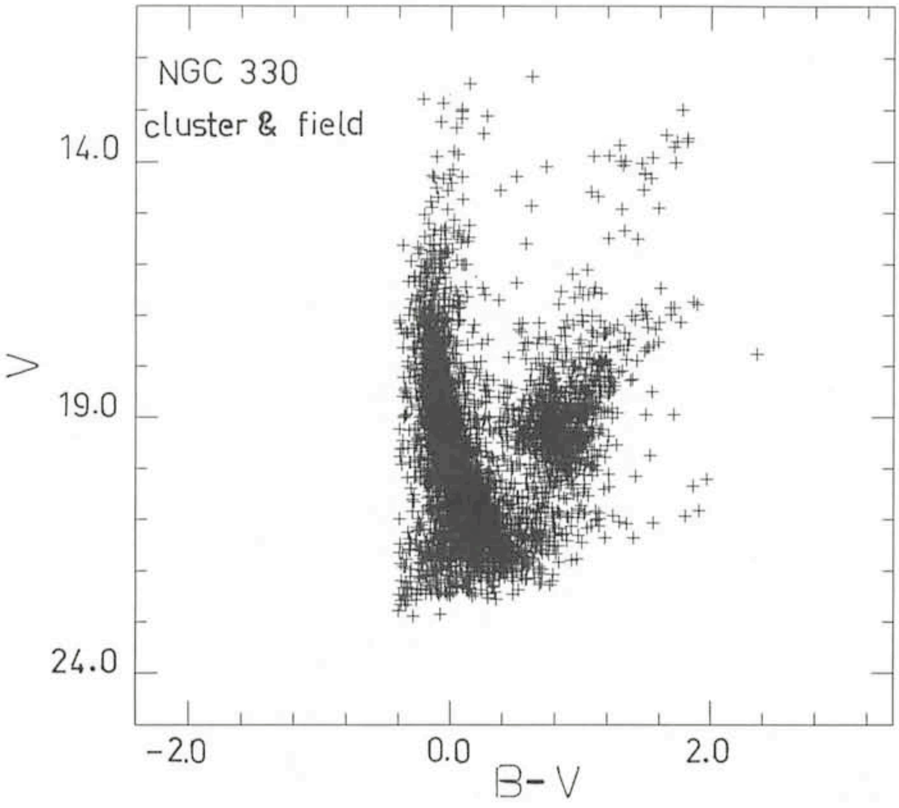

Figure 3: *This is a colour-magnitude diagram of all stars measured in the field of NGC 330. Note that most of the faintest stars are probably field stars, since the deep 2.2-m frames have been taken with the cluster near one edge.*

mote control to take deep B and V frames in the fields of NGC 330 and NGC 1818. The CCD camera No. 5 was attached to the Cassegrain focus. Pixel size was 30 μm leading to a scale of 0″.36 pixel. The exposure times were as long as 40 minutes in B and 30 minutes in V. The 1.54-m Danish telescope had been employed a few nights earlier to take frames of shorter exposure time. Here the CCD-camera operated in binned mode (30 × 30 μm^2) with a scale of 0″.47/pix. Exposure times ranged from 10 s to 1200 s. In both cases, the seeing was of medium quality of about 1″.6, so optimistic astronomers can say that in spite of binning the stellar images were well sampled.

After basic processing (flat-fielding, etc.) the photometric information has been extracted with the DAOPHOT package (Stetson, 1988).

The transformation of instrumental to standard magnitudes was performed via photoelectric standard stars in the field of NGC 330 measured by Alcaíno and Alvarado (1988). For the photometry of NGC 1818 we used the same colour terms, but with the zero-points from the photometry of Robertson (1974). These last data have to be considered as preliminary until an accurate calibration becomes possible.

3. Colour Magnitude Diagrams

Figure 3 shows the CMD of all stars measured in the field of NGC 330. A large fraction of these stars are probably field stars since the deepest frames have been taken with the cluster located at the edge of the frame in order to minimize saturation effects. Very conspicuous is the bulk of stars belonging to an older population. The comparison of Figure 4a and 4b demonstrates the dominance of the field population. Figure 4a plots stars closer than 50″ to the cluster (1.54-m data). Figure 4b shows all stars more distant from the cluster centre than 100″. NGC 330 is embedded in a field population which has a component almost as young as the cluster itself.

A very remarkable feature in the cluster CMD is the gap visible between 13.2 and 14.4 mag. The stars above the gap are with high probability cluster members, since such stars are completely missing in the field diagram. Carney et al. (1985) already noted this gap and presumed that these stars were He-burning supergiants, i.e. stars which are at the blue end of their supergiant evolutionary loop (e.g. Maeder and Meynet, 1988). The number statistics of such stars may be of great importance for testing stellar evolution theories since the respective lifetimes of blue and red He-burning supergiants are sensitive to properties of evolutionary models as effects of overshooting and/or metallicity. Presently, a comparison with theory seems impossible since a suitable grid of massive, metal-poor stellar models is still lacking. Furthermore, these models should be given in observable parameters, i.e. colour-magnitude diagrams. We recall that the slope δ BC/δ (B-V) is larger than 10 for supergiants bluer than B-V = 0 (the same is true for supergiants redder than B-V = 1.6), so transforming observed colours and magnitudes into the $M_{BOL} - T_{eff}$ plane enlarges error bars more than 10 times.

One of the most obvious difficulties connected with observations of Magellanic Clouds clusters is the severe crowding. The density of the field population near NGC 330 is 350 stars/square arcmin down to 23 mag and 100 stars down to 20 mag. Even in a good seeing with a FWHM of 1″, the stellar profile extends from the photometrist point of view to a diameter of at least 4″, which means that the sky is 1.2 times overcrowded with stars as faint as 22.5 mag.

The cluster itself exhibits a further tremendous enhancement in star density over this background field. If we assume the cluster radius to be 50″, we expect 760 background stars down to 22.5 mag within this area. In Figure 4b, 270 stars are fainter than 17 m and 140 of them are statistically field stars. When going to fainter magnitudes, this fraction favours even more the field contribution: of all stars fainter than 18 mag, 60 % are field stars. The reason for this is the growing incompleteness of the photometry in the cluster region.

With NGC 1818, the situation looks much better. Figure 5a shows all stars within 50″ of the cluster and Figure 5b is the field population outside 100″. As a young cluster, NGC 1818 is projected on a field population of intermediate age, which with 35 stars/square arcmin

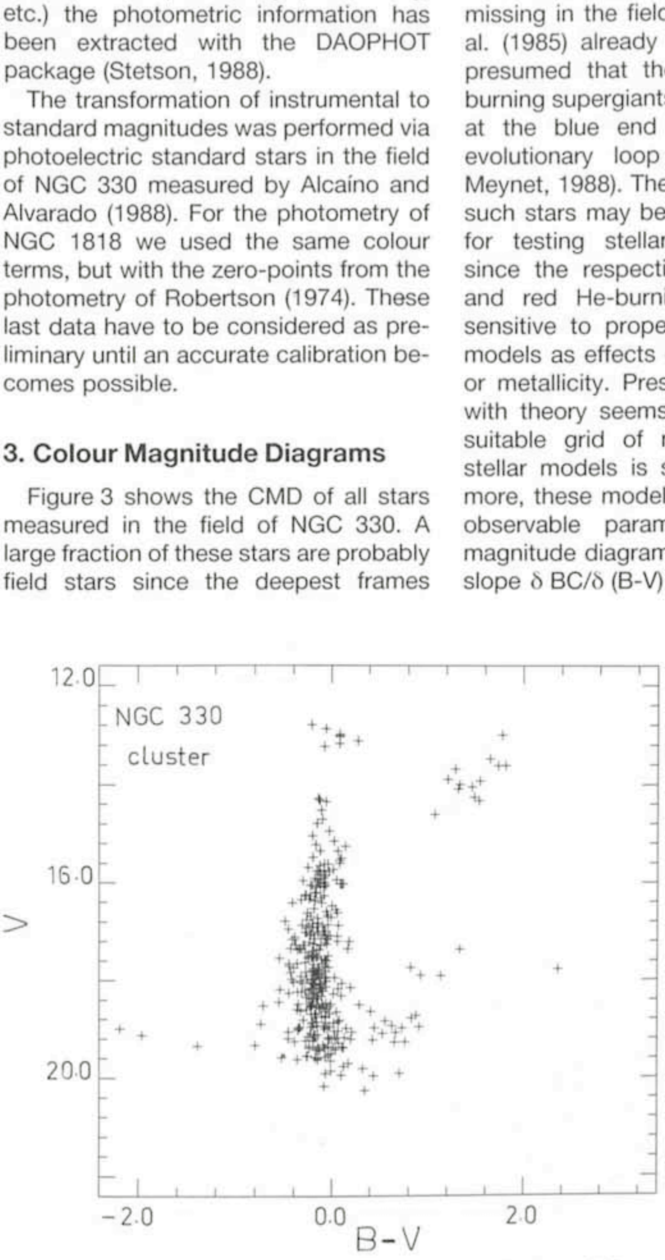

Figure 4a: *This is a colour-magnitude-diagram for all stars within a distance of 50″ from the centre of NGC 330. Note the disappearance of the conspicuous bulk of red stars at V = 19 mag. in Figure 4b. It is also striking that the group of blue supergiants above the gap in the "blue sequence" are only visible for the cluster, thus arguing strongly that these stars are cluster members.*

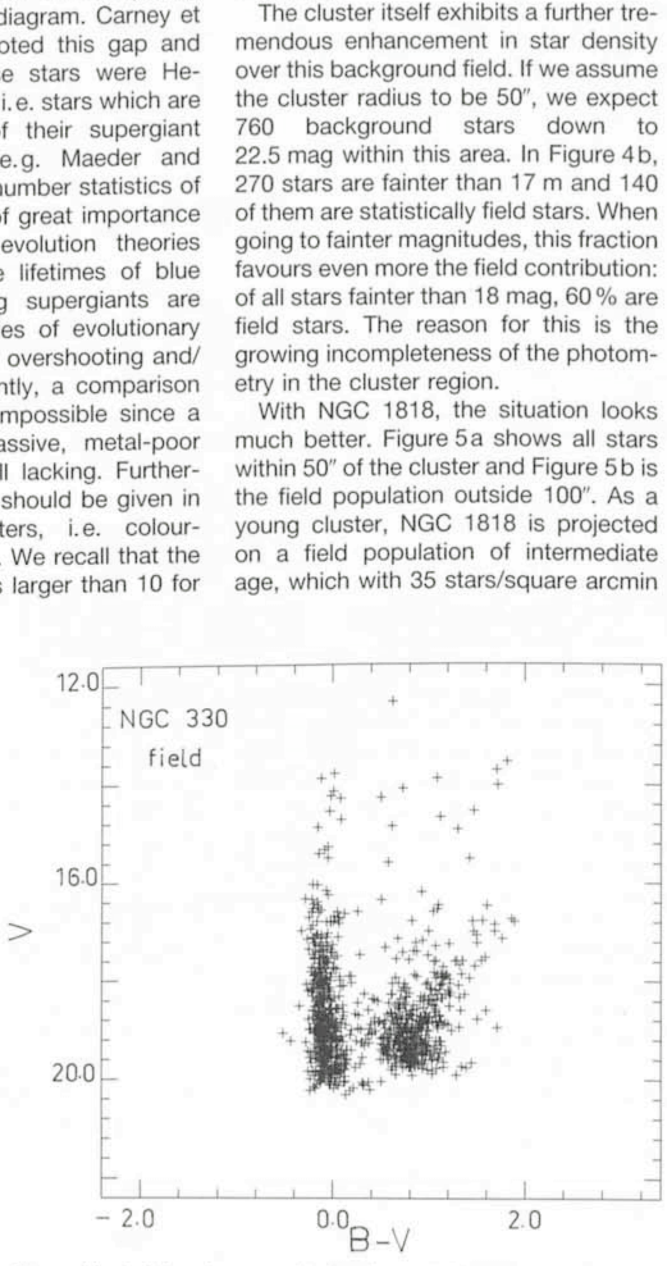

Figure 4b: *In this colour-magnitude-diagram all stars more than 100″ from NGC 330 are plotted. The youngest stars in the field population have ages larger than those in the cluster.*

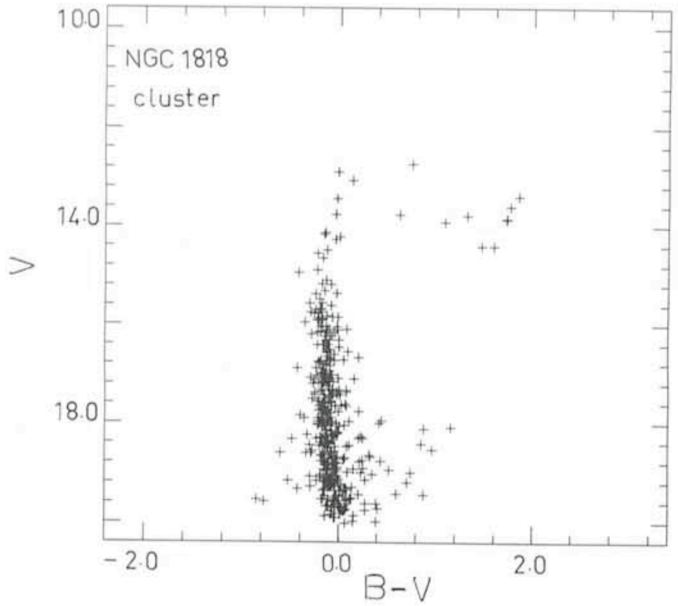

Figure 5a: *A colour-magnitude diagram for stars nearer than 50″ to the centre of NGC 1818. Comparison with Figure 5b reveals that the field population is much less dominant than in the case of NGC 330.*

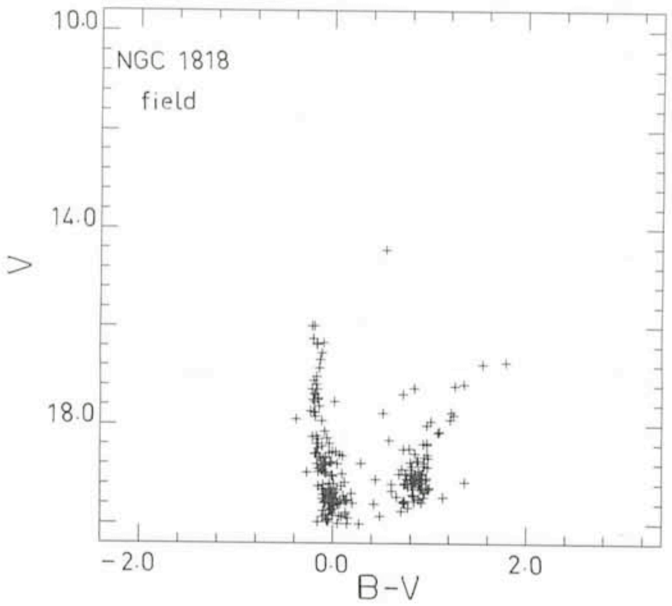

Figure 5b: *A colour-magnitude diagram for stars farther than 100″ from the centre of NGC 1818.*

down to 20 mag is also 3 times less dense than in the case of NGC 330.

4. Derivation of LF's

Once the photometry of the stars is established, it should in principle be easy to derive a luminosity function by simply selecting the main sequence stars and counting the stars in defined magnitude bins. However, during the reduction procedure, we became aware that counting stars can be a very difficult task.

The photometry performed with DAOPHOT is a complex interaction between the routines and the charge distribution on the chip, which especially for the long-exposure frames exhibits a complicated structure due to charge overflow of the bright stars. The star finding routines do not find all stars, in particular not the fainter ones. DAOPHOT offers a comfortable possibility to determine quantitatively "incompleteness factors". One can create randomly artificial stars (the point spread function, PSF, is known) in a selected magnitude range. Then these stars can be searched for by the normal DAOPHOT procedure. A comparison of the original artificial star list with the list of all stars found by DAOPHOT gives directly the required incompleteness factors (see Mateo 1988 for a deeper discussion). Since the data sample is built up from frame pairs (B, V) of different exposure levels, we had to calculate incompleteness factors separately for each frame pair. To achieve statistical reliability we added a large number of artificial stars, about 1,000 stars for each frame. Reducing them means a huge amount of computing time which actually is the limiting factor. It turned out that in the cluster field the completeness quickly becomes uncomfortably low at fainter magnitudes. To be on a safe side, one has to consider, at least in a first stage, counts only down to magnitude 18.0 or 18.5 to avoid completeness factors too different from 1.0.

Having made counts both in the cluster area and outside, each with their own completeness corrections, we subtracted the field counts from the (cluster + field) counts. As we have a colour-luminosity diagram, the counts have been restricted to the main sequence, the evolved phases (blue and red supergiants) being taken out.

The derived luminosity function is shown in Figure 6. The number of stars roughly doubles per magnitude interval.

5. Initial Mass Function

In case of a zero-age main sequence, it would be relatively easy to convert our luminosity function into an IMF. We would have first to convert our δM_V bins into δM_{BOL} bins, and then use the zero-age mass luminosity relationship ($L \sim m^{\alpha}$ with $\alpha \simeq 3.0$ to 3.5) to transform it in stars per δ logm bins. Actually we observe an evolved main sequence, so evolution renders the mass-luminosity relation unusable and the number of stars initially in a logm bin ends up in an evolved M'_{BOL}, M''_{BOL} interval, different from the one on the ZAMS. It is then necessary to use evolutionary tracks in order to obtain the relevant (M'_{BOL}, M''_{BOL}) bin corresponding to the initial logm bin. For that procedure the age of the cluster must be known. We can use the luminosity of red supergiants to estimate the age of the cluster. Using evolutionary tracks of the appropriate metallicity kindly provided before publication by Castellani and Chieffi, we have found that the gap between magnitude 14.4 and 13.2 is well explained if the magnitude 14.4 represents the end of the main sequence at an age of 12 Myr, whereas the stars at mag 13.0 are blue supergiants in their He-burning phase with masses near 18 $M_{\odot}$). Assuming that age, we find that δM_V bins transform into fairly unequal δ logm bins at V = 15 and V = 18. Our computations lead to an IMF index x near 1.2 (we remind

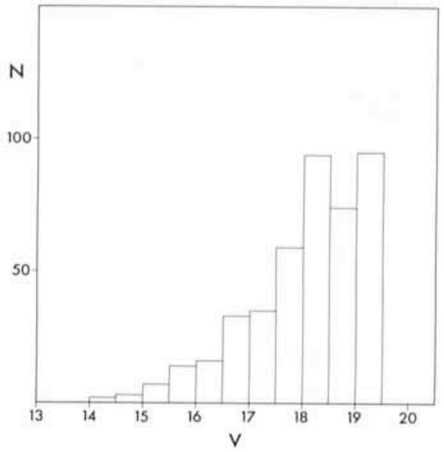

Figure 6: *Luminosity function of NGC 330. The contribution of the field has been estimated and subtracted. Fluctuations on the bright side are due to Poisson statistics. Crowding is the factor limiting the accuracy on the faint side.*

that x = 1.35 for Salpeter law). Although this value is in good agreement with the result of Mateo, we feel that more elaborate work, particularly under outstanding seeing conditions, has to be carried out before we can state that the mass function slope of a metal-poor population is different or not from the value found for normal metallicity Pop I objects currently ≃2.0 (e.g. Tarrab, 1982, Lequeux 1979) for the *upper* main sequence.

A large potential lies in the many still unstudied young Magellanic Cloud clusters in understanding the morphology of the IMF and the evolution of massive metal poor stars. However, very careful observations, reductions and the availability of evolutionary tracks for a wide range of parameters are necessary to use it. If these conditions are fulfilled, then ground-based observations of the upper mass function will not be superseded by the HST whose resolving power is definitely necessary for fainter magnitudes.

Also other clusters should be studied, because NGC 330 is not one of the easiest objects to work with, although being often presented as the prototype of young blue populous globular clusters in the SMC.

6. Conclusions

The study of the young globular clusters in the Magellanic Clouds is rich in hopes, because it is the most direct check available for the theory of stellar evolution of massive stars with non standard metallicities. In particular, it gives some evidence on what could have been the early evolution of galactic globular clusters. However, the distance of over 60 kpc of these clusters make quantitative work difficult, in particular because of the confusion of stellar images at this distance. In the future, other corrections are to be applied to the photometry than a simple "completeness" factor. Stars which are "lost" are probably affecting the luminosity of other stars of the field, and most visual binaries, when observed in the solar neighbourhood, are seen as single stars in the SMC or LMC. The Hubble Space Telescope will drastically change the prospects in a few years, but this is not an excuse for doing nothing in the meantime.

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The Nebular Stage of Nova GQ Muscae: Physical Parameters from Spectroscopic Observations

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Nova GQ Muscae 1983, a classical nova which had its maximum in January 1983, might already be familiar to the readers of the *Messenger,* since it was already twice the subject of articles in this journal. E. Oliva and A. Moorwood (1983, *The Messenger* **33,** 30) reported on infrared CVF spectrophotometry carried out within the first four weeks after maximum. J. Krautter, K. Beuermann, and H. Ögelman (1985, *The Messenger* **39,** 25) described the results which were obtained from coordinated observations from X-rays to the infrared regime carried out in 1983 and 1984. Apparently, these authors had some foreboding, since they closed their article with the words ". . . This, *at present,* concludes the story of Nova Muscae 1983." In fact, that was not the end of the story of Nova GQ Muscae: since then, exciting results of new observations of GQ Muscae have been obtained which provide the justification to again write an article about this nova for the *Messenger.*

Before we discuss our new observations, we want to shortly summarize the most important results from the early phases. GQ Muscae, which had a visual brightness V ≈ 7.0 mag at maximum, is a moderately fast classical nova: t_3, the time for a decrease by 3 magnitudes from maximum brightness, was about 40 days. The outburst amplitude was more than 14 mag, one of the largest outburst amplitudes ever observed for novae. The lightcurve was somewhat unusual for a fast nova, since the visual magnitude remained nearly constant at a level of 3.5 mag below maximum brightness for a period of about 11 months (April 83 to March 84). It should be mentioned that no indication for dust formation, which quite often happens in novae of this type, was found.

The spectroscopic observations during the early phases showed a pronounced overabundance of nitrogen relative to carbon and oxygen, and there was an indication of a He/H overabundance. However, no abundance of any metal relative to H or He could be determined. The line profiles were very complex; during the early phases the usual P Cygni absorption systems (principal, diffuse enhanced, and Orion system) with velocities of the absorption components up to −2000 km/sec were found as well as up to 4 emission components. The distance was found to be D = 4.8 ± 1 kpc. This allowed a lower limit for the luminosity around maximum of about one Eddington luminosity to be derived, assuming a 1 $M_\odot$ white dwarf.

Of special interest were the X-ray observations carried out with EXOSAT, since GQ Muscae was the first classical nova from which X-ray radiation was observed during the outburst or decline from outburst. Since no spectral energy distribution could be determined, two