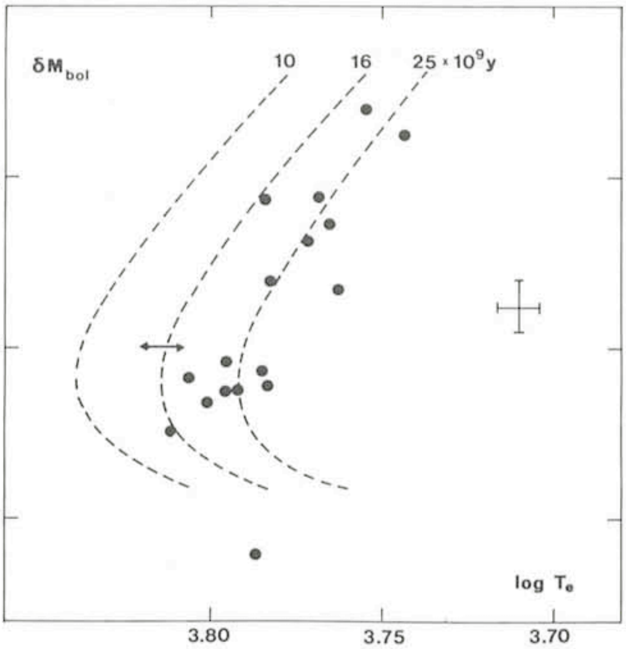

Fig. 5: *The log T_e − δM_{bol} diagram for turnoff stars in NGC 6397. The definition of δM_{bol} is given in the text. Isochrones corresponding to ages of 10, 16 and 25·10^9 years have been computed by Hejlesen (1980). A helium abundance of $Y = 0.20$ and a metal abundance of [Me/H] = −1.6 have been adopted. The log T_e shift of the isochrones corresponding to $\Delta Y = 0.1$ is indicated by the left arrow. The shift corresponding to Δ[Me/H] = 0.2 is given by the right arrow.*

Error bars indicate the errors of log T_e and δM_{bol} inferred from observational errors. Within these errors there is a fairly good fit to the 25·10^9 years isochrone. Systematic errors of the age determination are discussed in the text.

(i) The interstellar reddening may be wrong by $\pm 0^m.02$. This converts to an error of ± 0.01 in log T_e and as seen from Fig. 5 the corresponding error of the age is $\pm 4\cdot10^9$ years.

(ii) The zero point of the b-y calibration could be wrong by up to 0.02 mag. In the present calibration a colour index for the sun, $(b\text{-}y)_\odot = 0.395$, was adopted. Some recent investigations give a value of $(b\text{-}y)_\odot = 0.415$, which would decrease the age determined by about $4\cdot10^9$ years.

(iii) The error of the metal abundance is ±0.2 in [Me/H]. As seen from Fig. 5 the corresponding error of the age is $\pm 2\cdot10^9$ years.

(iv) In the age determination we have assumed the weight fraction of helium to be Y = 0.20. However, it could be as high as Y = 0.30. This would increase the age by about $2\cdot10^9$ years.

Comparison with the Hubble Constant

From the error discussion above we conclude that the age of NGC 6397 lies between 16 and 25·10^9 years. Thus a lower limit for the age of the universe deduced from this particular cluster is 16·10^9 years. Other recent investigations of globular clusters, e.g. Sandage and Tammann (1981), have also resulted in similar high ages. It is therefore of interest to make a comparison with determinations of H_o.

It is a well-known result from Friedman models of the universe, that for a given value of H_o, the age is a function of the present mass density, ϱ_o. In Fig. 6 the age has been plotted as a function of $\Omega = \varrho_o/\varrho_c$, where ϱ_c is the critical density, for various values of the Hubble constant. H_o = 52 km/s/Mpc is the value recently found by Sandage and Tammann (1981) from a study of distances and recession velocities of 16 type-I supernovae. H_o = 95 is the value found by Aaronson et al. (1980) from distances of galaxies derived by the Tully-Fischer method. Both determinations refer to galaxies at distances well beyond the Virgo cluster. The values should therefore represent the *global* value of H_o.

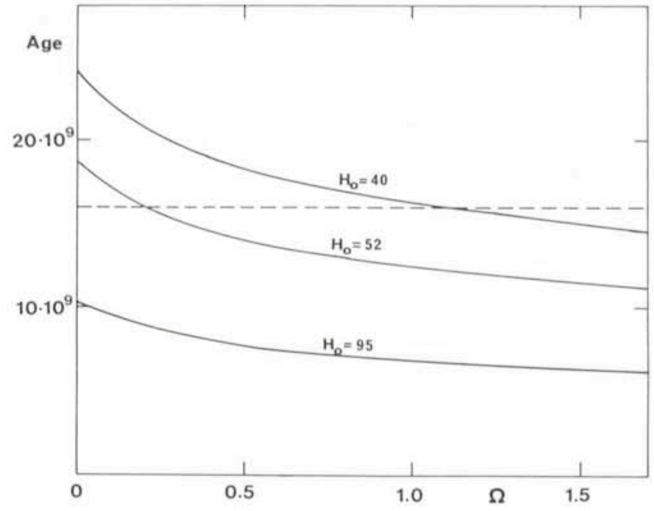

Fig. 6: *The age of the universe in years as a function of the density parameter Ω for various values of the Hubble constant. The horizontal line indicates the lower limit for the age of the universe as derived from the age of NGC 6397.*

It is seen from Fig. 6 that H_0 = 52 is consistent with the age limit of 16·10^9 years if $\Omega < 0.2$, which corresponds to an open universe. On the other hand there is a large discrepancy between the age limit and the value of H_o found by Aaronson et al.

Finally, Fig. 6 shows that a Hubble constant, $H_o \leq 40$ km/s/Mpc, is compatible with a closed universe, i.e. $\Omega \geq 1$. Such a low value of H_o cannot be totally excluded in view of the present uncertainty of the value of H_o.

The discussion above illustrates why it is interesting to determine accurate ages of globular clusters. We think that Strömgren photometry of turnoff stars provides an important method for this purpose, a method which in many respects is more accurate than BV photometry. The final cosmological conclusions should await improvement in the calibration of the photometry and further observations of other globular clusters.

References

Aaronson, M., Mould, J., Huchra, J., Sullivan, W.T., Schommer, R.A., Bothun, G.D.: 1980, *Astrophys. J.* **239,** 12.
Alcaino, G., Liller, W.: 1980, *Astron. J.* **85,** 680.
Carney, B.W.: 1979, *Astrophys. J.* **233,** 211.
Crawford, D.L.: 1975, *Astron. J.* **80,** 955.
Crawford, D.L., Mandwewala, N.: 1976, *P.A.S.P.* **88,** 917.
Hejlesen, P.M.: 1980, *Astron. Astrophys. Suppl.* **39,** 347.
Nissen, P.E.: 1981, *Astron. Astrophys.* **97,** 145.
Sandage, A., Tammann, G.A.: 1981, ESO Sci. Preprint No. 174.

Second ESO Infrared Workshop

About 70 external participants in addition to ESO staff met from 20th–23rd April 1982 to discuss a variety of topics ranging from the infrared work going on at major ground-based observatories to proposals for future space missions. Although mainly devoted to technical aspects, the rapid progress in instrumentation and facilities made in recent years was best demonstrated by the sample of astronomical results obtained at Calar Alto, CFHT, ESO, TIRGO, UKIRT and with aircraft and balloon-borne telescopes which were reviewed by some of the invited speakers. The major trend in future instrumentation was evident from the large number of presentations on array detectors and their application in infrared imaging, spectroscopy and speckle interferometry. An impressive illustration that these devices are already beginning to revolutionize observational possibilities came in the form of 2D "photographs" at 10 μm shown of such old infrared favourites as the BN/KL complex in the Orion Nebula and NGC 7027.

The main theme of the Workshop, explored during several discussion sessions, was the future relationship between ground-based, air-borne and space observations. Of immediate general interest in this area was the question of how best to provide the follow-up observations necessary to fully exploit the IRAS all-sky satellite survey due to start later this year. Although heated at times, this discussion unfortunately only served to confirm that any coordinated approach on the ground during the survey itself is likely to prove extremely difficult for a number of reasons. It also became clear, however, that much of the desired follow-up will in any case have to await the even higher sensitivities promised by other cold space telescopes such as GIRL and, hopefully, ISO and SIRTF. These facilities offer unparalleled opportunities for a wide range of infrared observations.

Even these facilities cannot fully exploit the astronomical potential of the entire infrared waveband, however, and there appears good reason to believe that other projects such as the VLT (probably an array of 8–10 m diameter telescopes) being studied by ESO, the European Astroplane, the Large Deployable Reflector being studied by NASA and even possibly the Space Telescope promise equally exciting prospects for Infrared Astronomy in the future.

It is intended to publish the Proceedings of the Workshop which will hopefully be available in September/October 1982.

A.F.M.M

Study of the Large Magellanic Cloud with the Fehrenbach Objectiv-Prism

Ch. Fehrenbach, M. Duflot, R. Burnage and the radial velocities staff of the Marseille and Haute-Provence Observatories

The 40 cm Objective-Prism (GPO or Grand Prism Objectif in French), now at La Silla, had first been used in the Southern Hemisphere, at Zeekoegat, in South Africa. ESO, then looking for a site for its observatory, had accepted its installation on one of the tested sites.

It is Ch. Fehrenbach who, as early as in 1958, thought that the detection of the members of the Large Magellanic Cloud (LMC) from their radial velocity (RV) would be well suited to the GPO then operating at the Haute-Provence Observatory. Indeed, because of its velocity relative to the Galaxy and of its galactic longitude of about 280°, the stars of the LMC have a RV of the order of 250 km s^{-1}, well outside the range of RV of the galactic stars.

The Fehrenbach's POs are mainly built for the measurement of radial velocities. With the GPO it is possible to measure the RV of all stars brighter than magnitude 13 in a 2 × 2° field; so the LMC supergiants are measurable. Sixteen fields are needed for a proper coverage of the LMC.

The first plates, obtained in 1961, showed the efficiency of the method. A first list of 102 stars, probable members of the LMC, was published in 1964 (Duflot et al.) and about one hundred were added in 1965 (Fehrenbach et al.). At the present time, one last catalogue (in press) of stars known to be members of the LMC from their RV, contains 711 stars.

During this study, we have discovered a group of LMC stars having abnormal spectral characteristics of a type unknown in our Galaxy. These stars have abnormally strong hydrogen lines (Fehrenbach and Duflot, 1972). Similar stars have since been found by other astronomers in the Small Magellanic Cloud.

On the other hand, we have been surprised to find in the direction of the LMC a large number of galactic stars with a large radial velocity, in the 100–350 km s^{-1} range (same reference).

Our work was not limited to the detection of the LMC stars; we have also measured the RV of all the stars appearing on our plates, either in the LMC or galactic. To achieve this, it has been necessary to get a large number of plates: 6 to 9 for each field. Many of these plates have been obtained in Chile after the move of the GPO from Zeekoegat to La Silla where it is now, being taken care of by ESO.

The measurements made at the Marseille Observatory with a spectrocomparator (Compelec) do not have the same accuracy as the one obtained by the Haute-Provence Observatory group; there, the plates are measured by a correlation method (Mesucor). However, the density of stars and nebulae on the LMC plates is very large and the Mesucor is not suited to this work. Only an experienced eye can detect the lines in spectra which are generally blended with other spectra, blurred in nebulae or at the limit of detection; stars called CON in the HD catalogue. In a paper in press, the accuracy is estimated to be 11.5 km s^{-1} for the Compelec measurements, which is good enough for a statistical study.

We have now at our disposal radial velocities for 418 stars in the LMC and for 2,560 galactic stars in the direction of the LMC.

We have made the following observations:

1. For two regions of the LMC, the velocity dispersion is significantly different:

   Region I: the densest part is at about 5^h32^m, –67°10′ and the velocity dispersion is about 18 km s^{-1}.

   Region II: The densest part is at about 4^h55^m, –69°40′ and the velocity dispersion is about 48 km s^{-1}.

   These two regions are about symmetrically placed with respect to the centre of the LMC and could correspond to the neutral points of the de Vaucouleurs and Freeman (1972) theory: region I stable, region II unstable.

2. The histograms of the distribution of the galactic RV (Fig. 1) show maxima in agreement with the velocity of the Sun toward its apex. In the west of the LMC and even more in the south-west, another strong maximum appears at about 45 km s^{-1}. Is it a group of more distant stars?

Let us note that the systematic study of the plates has allowed us to build