corresponds to 25.0 kpc. If we substitute $q_0 = 1/2$, these numbers become 43.44, and 18.1 kpc respectively.

From the knowledge of the projected separation a of the two components and from the (significant) difference in velocity between A and B, it is possible to determine a direct estimation of the total mass of the system, under the hypothesis of orbital motions of the two components around their centre of gravity of the system. Using Kepler's third law, we have:

$$(M_A + M_B)\sin^3 i = 2.89\ 10^5\ \frac{a}{kpc}\ \frac{V^2}{km^2 s^{-2}}\ M_\odot \quad (1)$$

If we take a = 25.0 kpc and V = 250 km/s (mean of the determinations using the complete spectra, i.e. 3200–7000 Å), for $\sin i = 1$, the total mass of the system equals $M_A + M_B = 4.5\ 10^{11}\ M_\odot$ (lower bound).

Concerning absorption lines, it is worth mentioning that, with an angular separation of 17.9 arcmin, the projected distance between the lines of sight to the two quasars Tololo 1037-27 and Tololo 1038-27 is of the order of 4 Mpc. Thus the absorption line systems in these two quasars could give the largest distance over which correlated absorption quasar spectra has been reported to date (Ulrich 1986). In the case of PKS 1145-071 A+B, the absorption feature in the HeII 1640 of the A component only could give the smallest distance (less than 25 kpc) known so far over which differential absorption is observed, the intervening material being only at a very small distance from the concerned object.

Another exciting possibility is that this pair is situated towards a high-redshift galaxy cluster: if quasars are rare events, then two quasars could be suggestive of a high galaxy density. Mere existence of rich clusters at such large redshifts provides an interesting timing constraint for the theories of large-scale structure formation. No such rich environment is visible on our short exposure frames. Studies of "normal" galaxies in this hypothetical cluster (i.e., those *not* selected by their large radio power, or strong line emission) should be extremely valuable for the investigations of galaxy evolution at large look-back times. Deep imaging and spectroscopy are needed to pursue this potentially highly rewarding possibility, an ideal proposal for the VLT!

It is a pleasure to thank T. Courvoisier for extremely stimulating discussions and advice.

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Preliminary Abundances in Three Cool Supergiants of the SMC

M. SPITE and F. SPITE, Observatoire de Paris, Section de Meudon

Introduction

It is quite well known that the objects of the Magellanic Clouds (even the younger objects) have lower abundances of heavy elements than similar objects of our Galaxy (see for example Lequeux, 1983). The whole history of the chemical evolution of the Magellanic Clouds is not yet fully understood. Stellar spectroscopy can contribute to a better knowledge of the abundances in the MC. The pioneering work of Przybylski was begun a long time ago (LMC, 1968, SMC, 1972) using photographic plates at the coudé spectrograph of the 1.88-m (74-inch) telescope at Mount Stromlo. Subsequent work was made by other astronomers, especially by B. Wolf (1972, 1973) using similar techniques at the ESO 1.5-m spectrographic telescope. The use of photographic plates (the only detector available for such a problem at that time) pushed the astronomers towards the observation of blue (hot) stars, since the sensitivity of photographic emulsions is at maximum in the blue part of the spectrum. Foy (1981) and Thevenin and Foy (1986) used the ESO ECHELEC spectrograph and the electronic camera (Baranne, 1976) for the analysis of cooler supergiants.

New Observations and Analysis

As soon as the CASPEC spectrograph with its CCD detector became available (D'Odorico et al., 1983) it appeared that it was perfectly suited for the determination of stellar abundances (D'Odorico et al., 1985; Spite et al., 1985; Spite, 1986). M. Dennefeld called our attention to the subject of the abundances in the Magellanic Clouds, and we decided to try to improve the previous knowledge about the abundances in the Clouds by careful observations and analysis of a few supergiants. Some difficulties in this task are obvious. The determination of the temperature of such stars is affected by uncertainties (the calibration of the colours of the supergiants is not completely reliable, the reddening of the stars is not accurately known and the profiles of the hydrogen lines are not always reliable). Moreover, these stars, even when not known as variable, may still be slightly variable. Finally, the spectral lines could be affected by non-LTE effects.

The best way to tackle this problem was to select rather cool supergiants for observation. The spectra of cool stars display numerous absorption lines: faint and strong lines, lines originating from low and high excitation levels, lines of various elements. From the accurate measurements of these lines, a number of constraints are found for the model atmosphere, so that, by iteration, a model can be adjusted, from which reliable abundances can be derived. The best accuracy of the measurements of the equivalent widths of lines is achieved when using the red part of the spectrum, where the continuum is more easily determined, and this is made possible by the good sensitivity of the CCD detector in the red.

Observations of supergiants were begun at the ESO 3.6-m telescope with the CASPEC spectrograph, but the programme was severely disturbed by

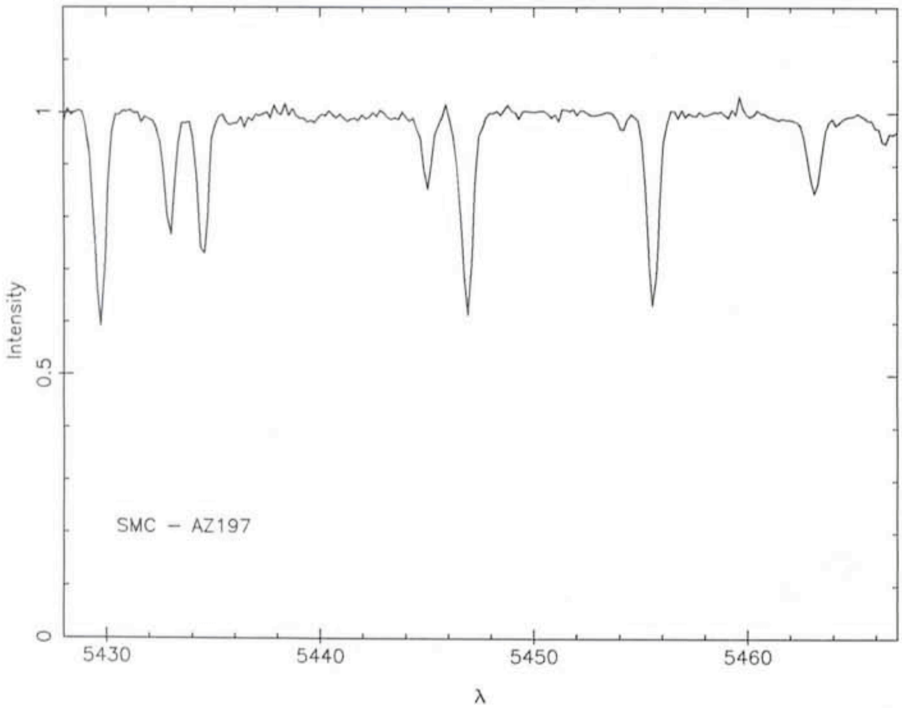

Figure 1: *A (small) part of the spectrum of a supergiant field star of the Small Magellanic Cloud, obtained at the ESO 3.6-m telescope, using the CASPEC spectrograph.*

cloudy weather. A few good spectra of stars in the LMC and SMC were obtained, as well as one spectrum of a star in a young globular cluster of the SMC (Spite et al., 1986). An example of one of the spectra obtained in the SMC is shown (Fig. 1). Preliminary results are now available for the three field stars observed in the SMC. The curve of growth of iron of the star AZVI 197 is shown in Figure 2. The curve and the abscissae were computed by using the models of Gustafsson et al. (1975). The scatter of the measured lines is rather small and, more importantly, there is no apparent stratification of the lines originating from low or high excitation levels: this is an evidence that the choice of the model temperature was correct.

Global Metallicity

Let us recall that the iron abundance may be considered as a determination of the global metallicity of the star (we will come back later to refinements such as the variations in the relative abundances of the elements), as well as the oxygen abundance may be considered as a determination of the global "metallicity" (heavy element content) of the gaseous objects such as H II regions and planetary nebulae. Let us also recall that the metallicity of the Sun is representative of the metallicity of the (young) Population I of the Galaxy and is universally adopted as the standard for intercomparisons of metallicities. Table 1 provides: (1) the iron abundances relative to the Sun (i.e. iron deficiencies) found for the three supergiants (they are remarkably similar), (2) the mean of these deficiencies, (3) the mean oxygen deficiencies proposed by Dufour (1983) and by Peimbert (1983) for the SMC and LMC. Taking into account the error bars, the mean metallicity of the SMC supergiants and the "metallicity" of the SMC gaseous objects may be considered as being in fair agreement.

Relative Abundances of the Metals

If we concentrate now on the pattern of the relative abundances of the elements, it appears that the light metals are less deficient than iron: this is what is normally found in the metal-deficient stars of the Galaxy. However, some exceptions are to be noted: (1) magnesium (essentially ^{24}Mg), which is less deficient than iron in the Galaxy, seems to be as deficient as iron in the three supergiants. (2) Sodium (essentially ^{23}Na), which has the same deficiency as iron in the Galaxy, has a smaller deficiency than iron in the three supergiants. In other words, magnesium and sodium have, in the three SMC stars, a behaviour which is the opposite of their behaviour in the Galaxy. (3) Yttrium and barium (^{89}Y and ^{138}Ba) seem to be less deficient than iron. These peculiarities have, of course, to be checked, in order to find if they are real abundance effects or artefacts introduced by the imperfections of the model and/or imperfections in the adjustment of the model.

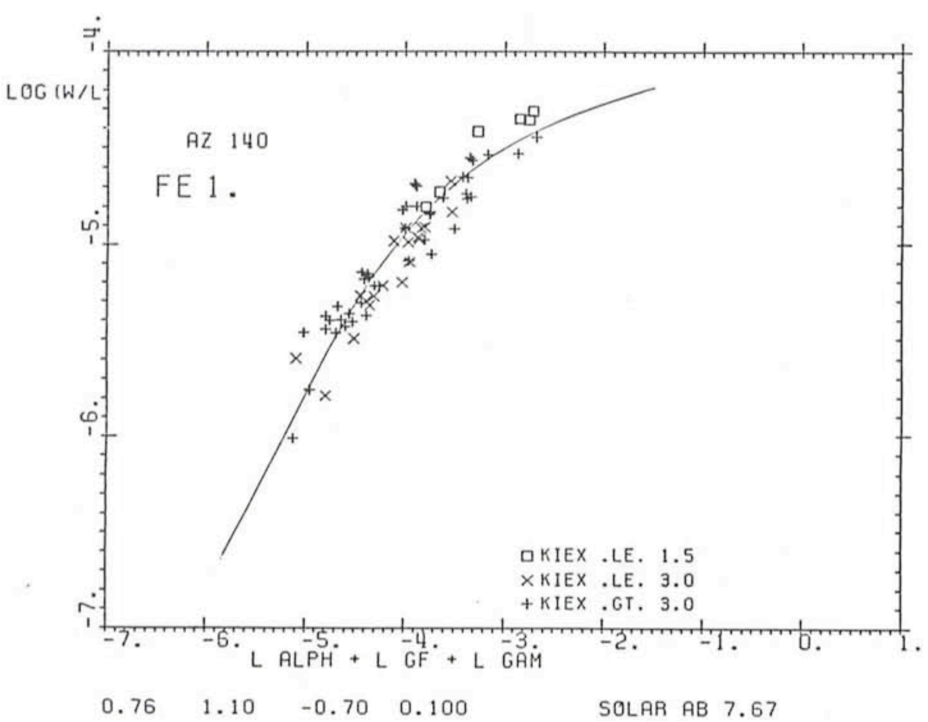

Figure 2: *Curve of growth of neutral iron lines in the star AZVI 140 (a supergiant of the SMC). The abscissa is an auxiliary quantity, computed from the model and from atomic data. The ordinate is the logarithm of the measured quantity W/λ the experimental values are represented by symbols related to the lower level of the corresponding atomic transition. No stratification of the symbols is observed, at variance with the stratifications clearly observed when the effective temperature of the model is not correctly adjusted.*

Conclusion

It is hard to derive a firm conclusion from preliminary results. However, let us note that the cool supergiants analysed here are not very different from the luminous giants of globular clusters, which we have analysed previously, and for which we found abundances similar to the ones found by other authors. Przybylski and Foy have already argued that the abundances found in the supergiants of the Magellanic Clouds should be reliable.

OBJECT	Fraction of solar metallicity	[Fe/H]	[O/H]
star AZVI 140	0.19	−0.72	
star AZVI 197	0.22	−0.66	
star AZVI 369	0.18	−0.74	
Mean (SMC stars)	0.2	−0.7	
SMC HII (Dufour)	0.16		−0.8
SMC HII (Peimbert)	0.10		−1.0
SMC PN (Peimbert)	0.16		−0.8
LMC HII (Dufour)	0.40		−0.4
LMC HII (Peimbert)	0.32		−0.5
LMC PN (Peimbert)	0.25		−0.6
Let us recall the classical notation: $[X] = \log X_* - \log X_\odot$			

Therefore, if it is accepted to have (provisionally) a very optimistic and naive view of the results here presented, it could be admitted that the metallicity of all the young supergiants in the SMC agree, within determination errors, with the „metallicity" (i.e. oxygen abundance) of young gaseous objects such as HII regions and planetary nebulae. With some further optimism, it could be guessed that the agreement found for the SMC holds also for the LMC, and that therefore the global metallicity of young stars in the LMC will be the one found for oxygen in the gaseous objects. As a consequence, the best choice for the progenitor of the supernova 1987A would be the metallicity found for the gaseous objects in the LMC, i.e. about ⅓ of the solar metallicity (see Table 1).

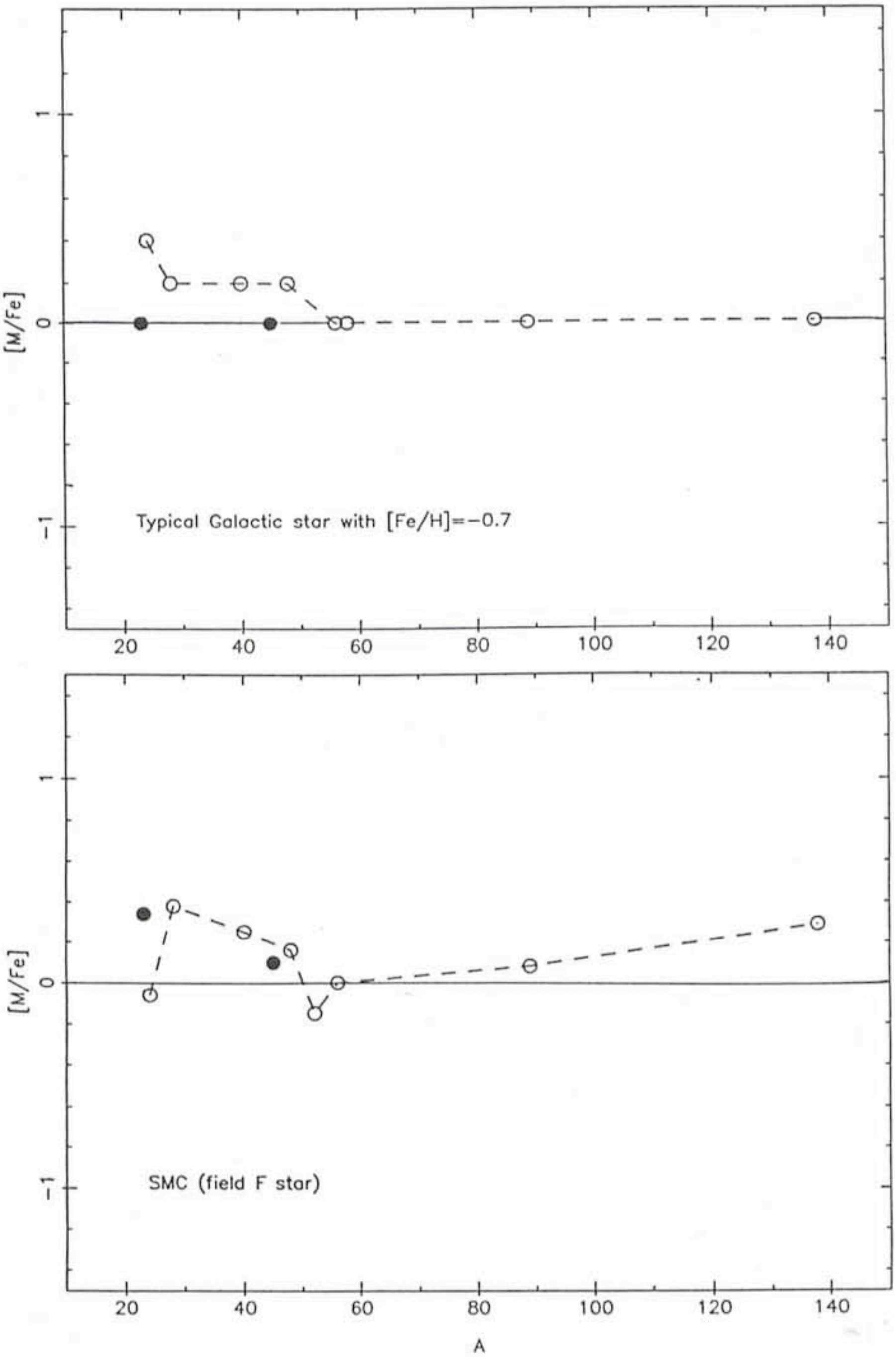

Figure 3: *Patterns of elemental abundances in Galactic dwarfs (upper part) and in SMC supergiants (lower part). The abscissa is the atomic number, the ordinate is the (logarithmic) ratio of the abundance of the element relative to iron. In both cases, a smaller deficiency of the light metals is apparent, but the two metals Sodium ^{23}Na (filled circles) and Magnesium ^{24}Mg (open circles) have opposite behaviours.*

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Distant Clusters of Galaxies

A. CAPPI[1], G. CHINCARINI[2,3], P. CONCONI[3], I. MANOUSSOYANAKI[4], and G. VETTOLANI[5]
[1]Bologna; [2]Università degli Studi di Milano; [3]Osservatorio Astronomico di Brera, Milano; [4]Istituto di Fisica Cosmica e Technologie Relative, CNR, Milano; [5]Istituto di Radioastronomia del CNR, Bologna

The information we receive from astronomical objects is, thanks to the finite speed of the electromagnetic radiation, related to their past status. Such differentiation between past and present becomes meaningful only on a large scale or, equivalently, over long times. The clock and time unit are set by the stellar evolution and by the dynamical time.

A glance at Figure 1 shows indeed that at z = 0.5 the look back time for Ω_o = 1.0 and H_o = 50 km sec^{-1} Mpc^{-1} is about $6 \cdot 10^9$ years, a time which is long enough to allow the evolution off the main sequence of some stars and comparable to the free-fall time of large and massive clouds of gas. The collapse time of a cluster of galaxies (Gunn and Gott, *Ap.J.* **176,** 1, 1972) is of the same order of magnitude, however, it is independent of the particular cosmological model. It is striking, indeed, to consider what Figures 1 and 2 tell us. At z ⩾ 0.5 and depending on the values of q_o and H_o we may look at the Universe before cluster formation, or we may look only at extremely rich clusters of galaxies (since these have a much shorter collapse time). To us seem fundamental not only the fact that the observations of distant clusters of galaxies give information on the evolution of galaxies but also the awareness that searches and statistics on distant clusters may give constraints on the geometry of the Universe in a simple and straightforward way. This observational work must be allowed and must be done since it is within the state of the art of modern observations.

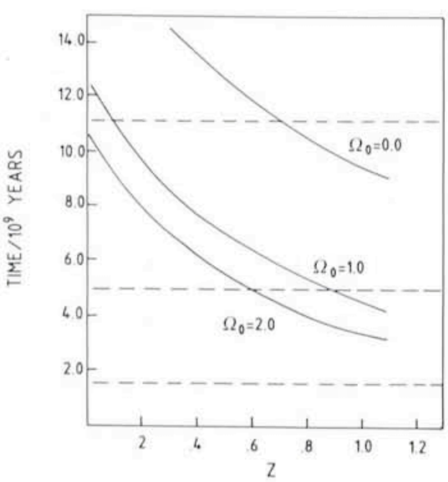

Figure 1: *Cosmic time as a function of redshift for H_o = 50 km sec^{-1} Mpc^{-1} and values of Ω_o as marked (continuous line). The dashed lines mark the cluster collapse time for a cluster which is 5 times less dense than Coma (t_c ≃ 11.2 10^9 years, top line), as dense as Coma (t_c ≃ 5 10^9 years, central line) and 10 times denser than Coma (t_c ≃ 1.6 10^9 years, bottom dashed lines).*

The geometry of space, indeed, remains one of the fundamental tasks of observational cosmology. The classical tests: magnitude-redshift and angular diameter-redshift, need to be investigated up to z = 0.9/1.0 and the evolution effects must be understood before any conclusion can be drawn.

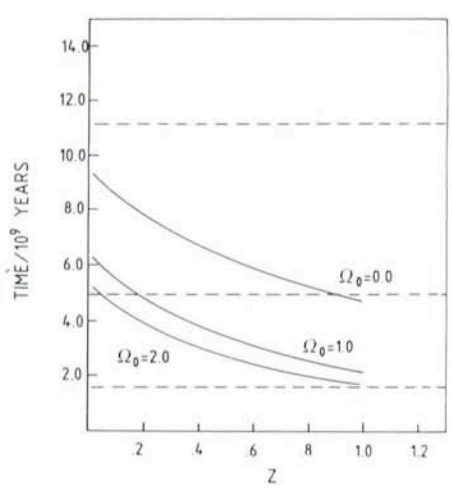

Figure 2: *Same as Figure 1 for H_o = 100 km sec^{-1} Mpc^{-1}. For Ω_o = 0.0 a cluster like Coma would form at about z = 0.9.*

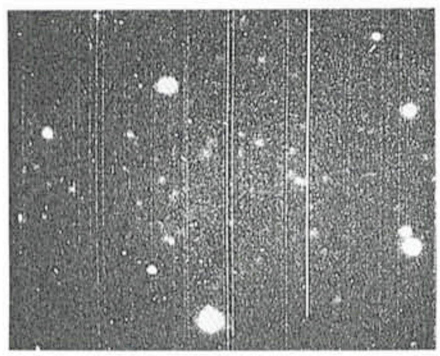

Figure 3: *CCD image (3.6 m telescope + EFOSC) of a cluster at z = 0.69.*

The standard candle for these tests is generally taken to be the first ranked cluster galaxy. This is, however, the one galaxy that is most affected by statistical fluctuations and luminosity and/or dynamical evolution. Often it is a radio source and it is unclear yet to what extent we are dealing with a well defined and low intrinsic dispersion standard candle. As stressed also by Tammann, the use of the 5th brightest galaxy is a better choice, and we must try to measure more, and fainter, magnitudes.

The deep knowledge we have today on stellar evolution and the present and planned instrumentation allows a realistic approach to the fundamental and fascinating field of cosmic evolution. Signs of detection can be found in the early work by Butcher and Oemler (*Ap.J.* **219,** 18, 1978) and by Dressler and Gunn (*Ap.J.* **270,** 7, 1983). Such signs are however inconclusive and only mark the beginning of a set of new observations which can now be done in a systematic way.

To detect evolution means to evaluate the differences between the same object at two different epochs. The astronomical equivalent is to observe what we believe to be the realization of the same object (or even better the realiza-