In pursuing this project, we have recently observed ζ Oph using the new combination of the long camera and the CCD detector. Although ζ Oph is quite bright, and the column density of CH is quite high the equivalent width of the CH $R_1(1)$ line is expected to be only about 0.005 mA. Using a spectral resolution of 150,000, such a line would require a signal-to-noise in the stellar continuum of 10,000 : 1 for a 2 standard deviation detection. Needless to say, this is a very difficult project and the results will depend critically on the details of CCD performance.

Even if we don't detect the line, we feel confident that we can provide a useful upper limit on T_{CBR} at 0.559 mm that will serve to constrain the models for the thermal history of the Universe.

5. The Future

Future work on determining the CBR temperature using interstellar molecules will focus on reducing the uncertainty at 1.32 mm and on finding other lines of sight where the results at 2.64 mm can be confirmed with equivalent precision. Reducing the uncertainty at 1.32 mm can be achieved either by continuing to work on the CN lines toward HD 154368, or by working on another, as yet, undetermined line of sight. Finding new lines of sight in which to study the CBR temperature has been one of the ESO group's objectives in the last few years. So far, about 20 stars have been surveyed and several good candidates have been identified. Unfortunately, the ideal candidate has yet to be found.

Although cosmological theory assumes that the CBR is ubiquitous, the only direct evidence we have that it does not have a local origin is through molecular temperature determinations. These show that the CBR is similar to what we see locally out to distances of roughly 200 parsecs. A confirmation of the universal nature of the CBR on a much larger scale would provide further confidence in our cosmological models. This, however, is a project for the VLT and an appropriate spectrograph, since the stars required being further away will be considerably fainter than those studied to date.

On a very different front, if all goes according to plan, the NASA sponsored Cosmic Background Explorer satellite (COBE) should be launched by June 1989. This satellite should provide very accurate measurements of the CBR spectrum from 0.1 to 10 mm. Although COBE will very likely provide definitive data on this problem, the most accurate measurements possible by other means will still be needed to confirm the satellite results.

References

Blades, J.C., 1978, *M.N.R.A.S.* **185,** 451.

Crane, P., Hegyi, D.J., Mandolesi, N., and Danks, A.C. 1986, *Ap. J.* **309,** 1.

Crane, P., and Hegyi, D.J., 1988, *Ap. J. (Letters),* **326,** L35.

Matsumoto, T., Hayakawa, S., Matsuo, H., Murakami, H., Sato, S., Lange, A.E., and Richards, P.L., 1988, *Ap. J.* **329,** 567.

Smoot, G.F., Bensadoun, M., Bersanelli, M., De Amici, G., Kogut, A., Levin, S., and Witebsky, C., 1987, *Ap. J. (Letters),* **3137,** L45.

Thaddeus, P. 1972 *Ann. Rev. Astron. and Astrophys.,* **10,** 305.

The Abundance of Manganese in Halo Stars

R. G. GRATTON, Osservatorio Astronomico di Roma, Italy

1. Introduction

The chemical composition of halo stars provides primary data about the nucleosynthesis processes that built up the metals present in young stars and in the interstellar medium. Theoretical information about the basic mechanisms of metal production are rather scarce. We know that only a tiny amount of metals was produced during the Big Bang; and we think that most of the heavy elements presently observed were manufactured in massive stars, or in intermediate-mass binaries, exploding as supernovae. However, the relative role of type I und type II (and/or type IIb) supernovae is quite unknown. Furthermore, we do not know precisely the composition of the ejecta of such supernovae. Therefore, empirical data are still at the basis of an interpretation of the chemical evolution of our Galaxy.

Considerable progress has been made in the last years in establishing clear runs of the ratios among the abundances of different elements with overall metallicity, as it is testified by a number of recent reviews (Spite and Spite, 1985; Sneden, 1985; Lambert, 1987; Gustafsson, 1988). This progress was mainly made thanks to the advent of arrays of linear detectors, which allowed very high S/N at high resolution, even for relatively faint stars. ESO has a leading position in this field, mainly thanks to the CES spectrograph at the CAT, and the CASPEC at the 3.6-m telescope. In particular, the combination CAT and CES was at least for five years the most efficient instrumention worldwide for high resolution (> 50,000) spectroscopy. This is most noteworthy since only a rather small telescope is used.

Most of the investigations on the composition of metal poor stars concentrated on the interesting light elements, and on the heavier ones, like Barium and the rare earths. However, Fe-group elements merit a particular inspection, since the presence of an enhanced odd-even effect was first reported by Helfer et al. (1959). The investigation of this enhanced odd-even effect was for a long time hampered by the poor knowledge of the hyperfine structure of lines of elements like Vanadium, Manganese, Cobalt and Copper, which have appreciable nuclear magnetic momenta. However, two papers from the Oxford group (Booth et al., 1983, 1984) provided detailed hyperfine structure and oscillator strengths for quite a large number of Manganese lines. This allowed a preliminary investigation of the abundance of Manganese in 13 metal-poor stars (mainly giants) using blue CASPEC spectra (Gratton, 1988). This investigation showed that Manganese is indeed deficient in metal-poor stars, as originally proposed by Helfer et al. However, the use of the resonance lines, which are located in a crowded spectral region, required a careful consideration of synthetic spectra and of (uncertain) damping parameters. Furthermore,

Erratum

Dust in Early-Type Galaxies. M.P. Véron-Cetty and P. Véron. *The Messenger,* No. 52, June 1988, p. 41.

In Figure 1, the names of two galaxies have been interchanged; the picture of NGC 4526 is labelled NGC 4696, while the picture of NGC 4696 is labelled NGC 4526.

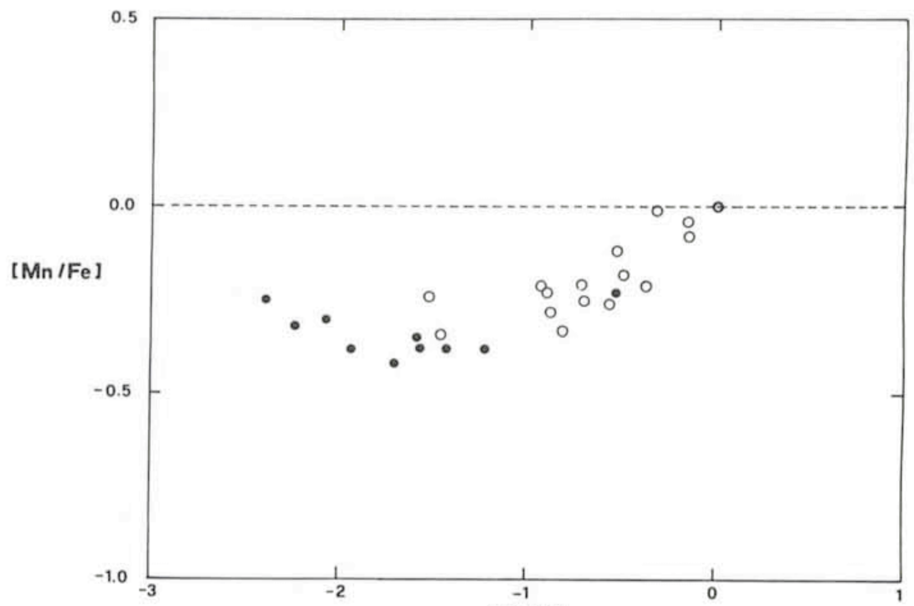

Figure 1: *[Fe/H] vs [Mn/Fe] for field halo stars. Dots are giants, circles are dwarfs. The Sun is also shown.*

there is concern for deviations from LTE for these lines, which form in the very outer layers of the atmospheres of these stars.

I therefore decided to use the best available instrumentation (the short camera at the CES, equipped with a high resolution RCA CCD), to investigate higher excitation transitions of Manganese, which are likely to be less affected by deviations from LTE, and are located in the visual spectral region, where crowding is not a problem at a resolution of 50,000.

2. Observations and Analysis

A very good observing run was made in the second half of October, 1987. I obtained high S/N (> 200), high resolution (~ 60,000) spectra in six spectral regions for 25 metal-poor field stars, most of them fainter than V = 8. The instrument proved easy to use, efficient and reliable: no time was lost due to instrumental failures. Furthermore, the availability of on-line IHAP facilities allowed a complete reduction of the spectra during the same observing nights. Practically, I came back to Rome ten days after my departure with the final list of the equivalent widths on my hands! By mid-November, I had the final abundances.

Details of the abundance analysis are presented in a paper currently in press in *Astronomy and Astrophysics.* They are typical of the investigations of the composition of metal-poor stars. Consideration of the hyperfine structure of Manganese lines is made by means of detailed synthetic spectra. About ten lines due to Manganese were observed in each star; typically, standard deviations of abundances derived from individual lines are less than 0.10 dex.

3. Results

The results are summarized in Figure 1, which displays the run of the abundance ratio between Manganese and Iron, against the Iron abundance, which is a measure of the overall metal abundance. The presence of an enhanced odd-even effect in metal-poor stars is confirmed by the general underabundance of Manganese. Observations suggest that the ratio between Manganese and Iron is constant in the halo ([Fe/H] < −1), at a value of [Mn/Fe] = −0.34 ± 0.06. It then increases for larger metal abundances, up to zero for solar abundances. In the disk, the present results merge with those obtained some years ago by Beynon (1978).

The run of the Manganese to Iron ratio is symmetrical to the run of the Oxygen to Iron ratio (Barbuy, 1988); and to the runs found for even light elements (see e.g. Magain, 1987; and François, 1988). Observations for Oxygen and other even light elements are usually explained as due to the interplay between the time-scale for star formation, and the evolution of the progenitors of type II (massive stars) and type I (intermediate mass binaries) supernovae (see e.g. Matteucci, 1988). Within this framework, it is possible to attribute the observed run of the Manganese to Iron ratio to a smaller neutron excess in the region of Si-burning in type-II supernovae, with respect to the neutron excess in analogous regions in type-I supernovae.

4. Globular Clusters

My observations are based on a sample of field halo stars in the solar neighbourhood. Is the run of Figure 1 representative of the entire halo population? Are the conclusions valid also for e.g. globular cluster stars?

To investigate this point, I reexamined a group of about eighty high-dispersion spectra of forty-one globular cluster stars, taken during several observing runs from October 1984 to May 1987, with the CASPEC spectrograph at the

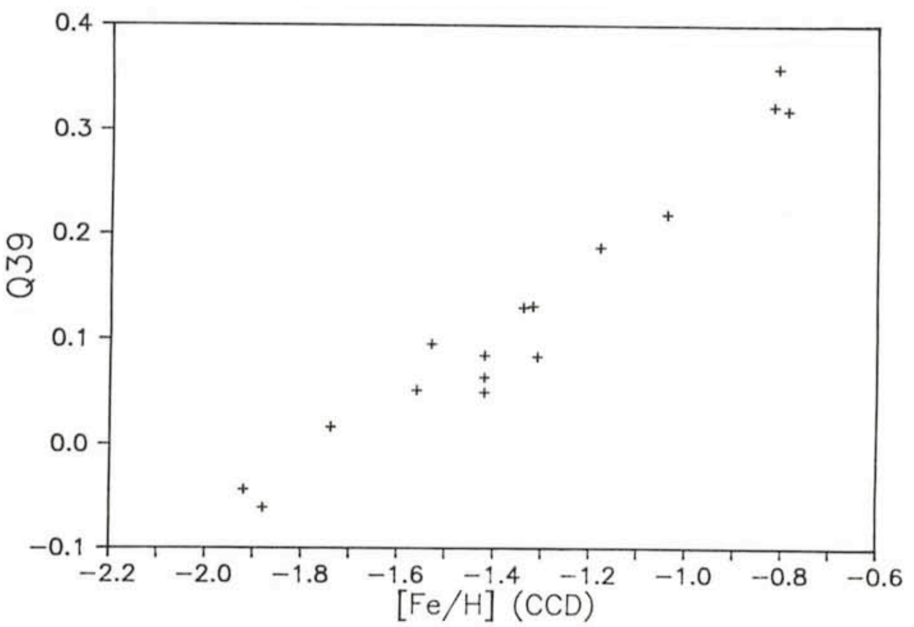

Figure 2: *Comparison between mean Fe abundances obtained from high dispersion CCD spectra and the integrated Q_{39} index (Zinn and West, 1984).*

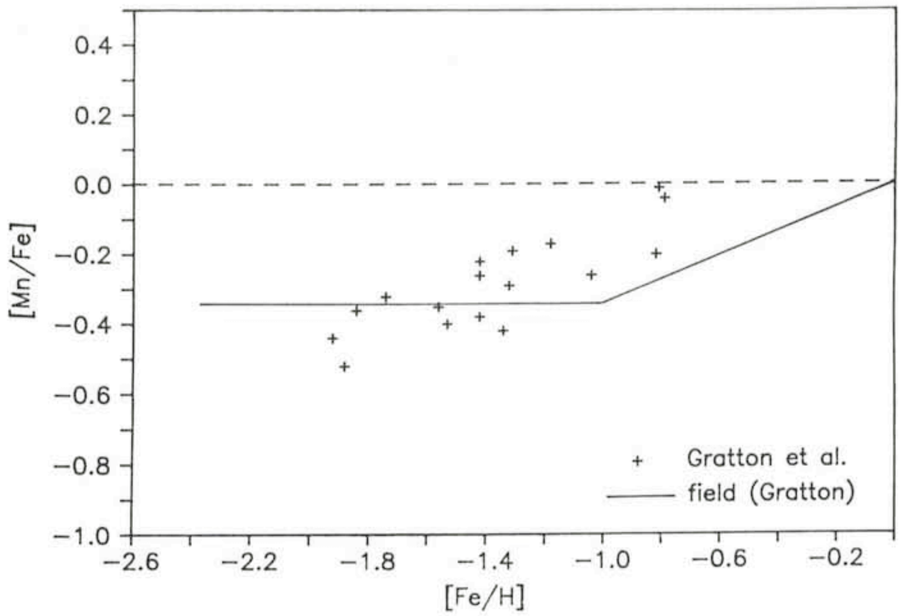

Figure 3: *[Fe/H] vs [Mn/Fe] for globular clusters. The solid line is representative for field halo stars.*

3.6-m telescope on La Silla. These spectra were used to obtain metal abundances which allowed the derivation of a highly accurate metallicity scale for globular clusters. The good correlation existing between metal abundances obtained from these spectra and photometric indices like Q_{39} (Zinn and West, 1984) is shown in Figure 2.

I performed an analysis similar to that made for the field halo stars on these spectra. There are three good Manganese lines, near 6000 Å, in these spectra. Mean abundances for seventeen globular clusters were thus obtained. The results are displayed in Figure 3, which is analogous to Figure 1; each point represents a globular cluster. The mean results for field halo stars are also displayed here. Like field halo stars, also globular cluster stars exhibit an enhanced odd-even effect with respect to population-I stars, approximately by the same amount (~0.3 dex) as field halo stars. However, the results suggest that Manganese is more and more deficient as metallicity drops in globular clusters. If confirmed by more extensive results, this fact suggests a systematic difference in the nucleosynthesis processes in globular clusters and field halo stars.

References

Barbuy, B.: 1988. *Astron. Astrophys.* **191,** 121.

Beynon, T.G.R.: 1978. *Astron. Astrophys.* **64,** 145.

Booth, A.J., Shallis, M.J., Wells, M.: 1983. *Monthly Not. Roy. Astron. Soc.* **205,** 191.

Booth, A.J., Blackwell, D.E., Petford, A.D., Shallis, M.J.: 1984. *Monthly Not. Roy. Astron. Soc.* **208,** 147.

François, P.: 1988. *Astron. Astrophys.* **195,** 226.

Gratton, R.G.: 1988. In *Stellar Evolution and Dynamics of the Galactic Halo,* M. Azzopardi and F. Matteucci eds., ESO, Garching, 153.

Gustafsson, B.: 1988. In *Stellar Evolution and Dynamics of the Galactic Halo,* M. Azzopardi and F. Matteucci eds., ESO, Garching, 33.

Helfer, H.L., Wallerstein, G., Greenstein, J.L.: 1959. *Astrophys. J.* **129,** 700.

Lambert, D.: 1987. *J. Astrophys. Astron.* **2,** 103.

Magain, P.: 1987. *Astron. Astrophys.* **179,** 176.

Matteucci, F.: 1988. In *Stellar Evolution and Dynamics of the Galactic Halo,* M. Azzopardi and F. Matteucci eds., ESO, Garching, 609.

Sneden, C.: 1985. In *Production and Distribution of C, N and O Elements,* J. Danziger, F. Matteucci and K. Kjär eds., ESO, Garching, 1.

Spite, M., Spite, F.: 1985. *Ann. Rev. Astron. Astrophys.* **23,** 225.

Zinn, R., West, M.J.: 1984. *Astrophys. J. Suppl.* **55,** 45.

Chemistry at High Galactic Latitudes: CH, CH^+ and CN Absorption Lines

E.F. VAN DISHOECK, California Institute of Technology Pasadena, USA, and
C.P. DE VRIES, Laboratory for Space Research, Leiden, the Netherlands

Introduction

The molecular clouds detected at high galactic latitudes by Magnani, Blitz and Mundy (1985) through CO line emission at 2.6 millimetre have attracted a lot of attention. They are particularly interesting because most of them appear to lie within the hot, local ($d \leq 150$ pc) interstellar medium, where they may be condensing out of loops and filaments of atomic hydrogen (Blitz 1988). The clouds can also be characterized by their optical obscuration, and by their emission at 100 μm as seen by IRAS (de Vries and Le Poole 1985; Désert, Bazell and Boulanger 1988).

Although a considerable amount of data has been gathered over the past few years on the global properties and morphology of the clouds, still little is known about the physical and chemical state of individual clouds. Because the high latitude clouds are embedded in a different environment, it is intriguing to ask to what extent they differ from the "classical" diffuse clouds (such as the ζ Oph or ζ Per clouds), or the "classical" dark clouds (such as the Taurus molecular cloud TMC1 or L134N). For example, the high latitude clouds have low visual extinctions, $A_v \approx 1–2$ mag, similar to those of the diffuse clouds that have been studied extensively by optical absorption line observations; yet their strong CO millimetre emission is much more characteristic of that found in dark clouds. Are the abundances of other simple molecules also enhanced in high latitude clouds compared with diffuse clouds? If so, what process is causing this enhancement?

Observations and Results

In order to investigate this question, we proposed to search for molecular absorption lines in Southern high latitude clouds using the Coudé Echelle