BD +03°740: a New Extreme Metal-poor Dwarf

P. MAGAIN, ESO

The analysis of the halo stars is an important tool, not only for tracing the chemical evolution of the Galaxy, but also for the understanding of the processes of star and galaxy formation. Although the models are able to explain a number of observed features, some basic problems remain. One of these problems is the absence of Population III stars, i.e. stars of the first generation, which would have formed out of the Big Bang matter (basically H and He) and would not contain any heavy elements (that is with atomic number $Z \geq 6$) in their atmospheres. Recent models (Cayrel, 1986; Jones, 1985) seem able to explain the absence of these stars, basically by showing that massive short-lived stars are likely to form first and pollute the interstellar gas before the formation of the long-lived lower mass stars that can be observed now. However, although these models are very attractive, they do not, for example, explain the presence of s elements (e.g. Sr, Y or Ba) in the atmospheres of the most metal-poor stars. These elements should be seen only in the atmospheres of the dwarfs of the third and subsequent generations: a first stellar generation is required to synthesize the "primary" elements (e.g. C, O, Fe, . . .) from H and He, while the stars of the second generation, containing these primary elements, would be able to produce the "secondary" elements and, in particular, the s elements, which would thus appear in the atmospheres of the dwarfs of the third generation. (It should be pointed out that this problem is not particular to the new models mentioned here, but is common to most models of galactic evolution).

From the observational point of view, it is well known since the work of Spite and Spite (1978) that these s elements are overdeficient in the atmospheres of the most metal-poor stars. However, although low, their abundances are not zero, and this is the problem. Where would be the stars of the second generation?

In an attempt to clarify this problem, as well as other problems related to the early galactic evolution, I have observed a sample of extreme metal-poor dwarfs and subgiants during 4 nights (2 in May and 2 in October 1986) with the CASPEC at the 3.6-m telescope. These stars were selected mainly on the basis of their Strömgren colours indicating very low metal abundance. Some 25 stars were observed in two spectral regions, centred at 4300 and 5500 Å. A rapid inspection of the spectra immediately showed that one of these stars, namely BD +03°740, had extremely weak lines and should be one of the most metal-poor stars discovered so far. I would like to present here some results of a preliminary analysis of that star, based on the blue spectrum. This spectrum was obtained on the night 13/14 October, with an exposure time of 40 minutes, which gave a good S/N ratio for that 9.8-mag star. It was reduced using the MIDAS and IHAP facilities at La Silla. A portion of the spectrum of BD +03°740 is shown in Figure 1, while Figure 2 shows for comparison the same region in the spectrum of the classical extreme metal-poor star HD 140283. The extreme weakness of the metal lines in the spectrum of BD +03°740 is immediately obvious.

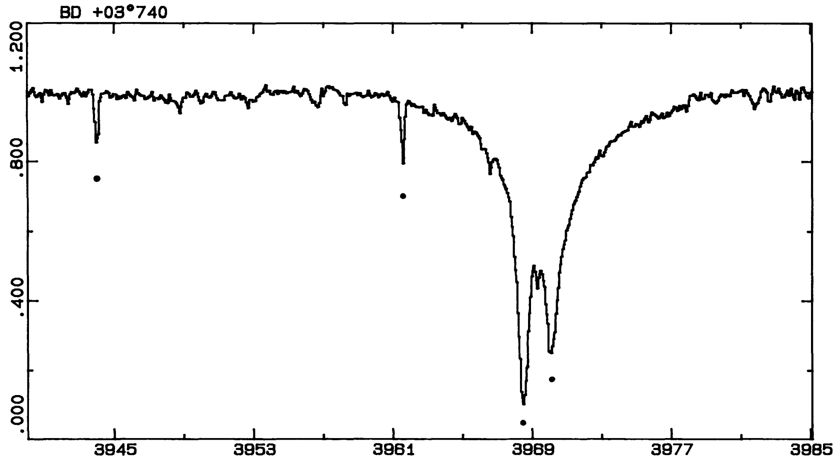

Figure 1: *Portion of the CASPEC spectrum of BD +03°740. The dots indicate the two resonance lines of Al I, as well as the H line of Ca II and H_ε.*

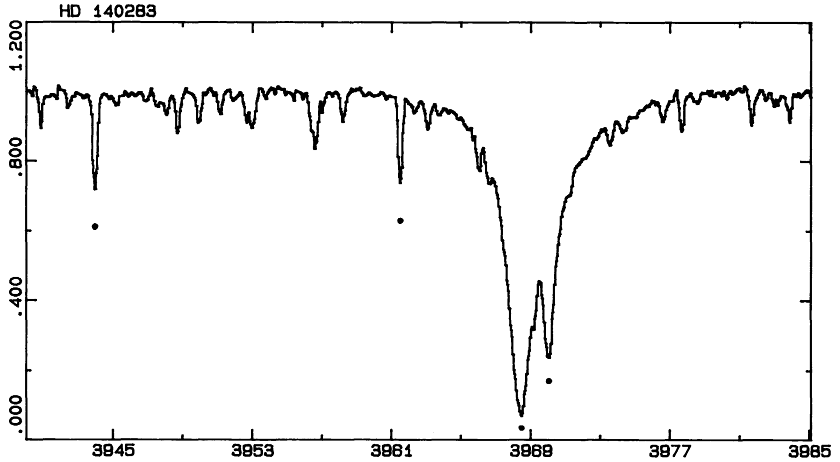

Figure 2: *Same as Figure 1 for HD 140283.*

The analysis was carried out using the empirical models of Magain (1985). The effective temperature was deduced from the V-K colour index, indicating T_{eff} = 6,050 K. The surface gravity was determined by forcing the Fe I and Fe II lines to give the same abundance, which led to log g = 3.25. The microturbulent velocity was found equal to 1.5 km/s using the method of Magain (1984). The abundances were determined from a detailed line-by-line analysis, assuming, as usual, local thermodynamic equilibrium (LTE). The main results are shown in Table 1. As far as I know, only two stars are known with lower metal abundance, namely the giant CD −38°245 (Bessel and Norris,

Table 1: *Relative abundances*

[Fe/H]	= −3.13
[Mg/Fe]	= +0.59
[Al/Fe]	= −0.82
[Si/Fe]	= +0.50
[Ca/Fe]	= +0.50
[Ti/Fe]	= +0.38
[Cr/Fe]	= −0.18
[Sr/Fe]	= −0.22
[Ba/Fe]	= −0.62

1981) with [Fe/H] = −4.5 and the turnoff star G 64−12 (Carney and Peterson, 1981) for which [Fe/H] = −3.5. Incidentally, BD +03°740 is also probably a star near the turnoff. The relative abundances confirm the general picture outlined in Magain (1985, 1987) and other papers, namely:

– overabundance of the "α elements" Mg, Si, Ca and Ti by some 0.5 dex,

– overdeficiency of the s elements Sr and Ba,

– large overdeficiency of Al relative to Mg: [Al/Mg] = −1.4.

The behaviour of Al relative to Mg is subject to some controversy, some authors (e.g. François, 1986) suggesting that [Al/Mg] is constant in the halo, at roughly −0.5, while others (e.g. Arpigny and Magain, 1983; Magain, 1987) argue in favour of an increasing Al overdeficiency with decreasing metal abundance. The present analysis supports this last interpretation, as is shown in Figure 3, where the representative point of BD +03°740 is added to the [Al/Mg] versus [Mg/H] plot of Magain (1987). It should be pointed out, however, that the Al abundance in the most extreme metal-poor stars is determined from the single resonance line at 3961 Å, and would be in error if the latter was affected by departures from LTE.

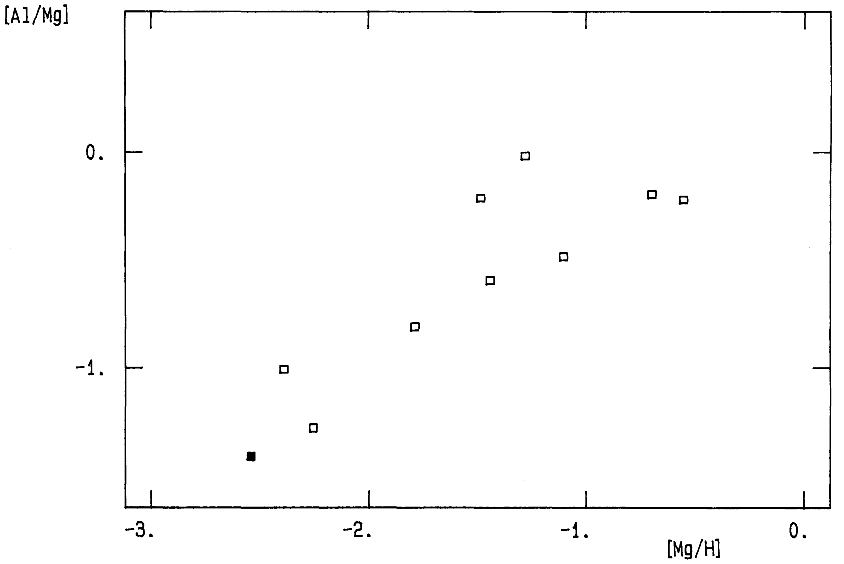

Figure 3: *Plot of [Al/Mg] versus [Mg/H] for the stars of Magain (1987, open squares) and for BD +03°740 (full square).*

Finally, the analysis of BD +03°740, which is the most metal-poor dwarf in which s element abundances have been determined, confirms the presence of these secondary elements in the atmospheres of the extreme halo dwarfs, in contradiction with the classical models of nucleosynthesis and galactic evolution.

Acknowledgements

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BD Pavonis, a New Double Lined Eclipsing Cataclysmic Binary

H. BARWIG and R. SCHOEMBS, Universitäts-Sternwarte München

Cataclysmic binaries are double stars consisting of a compact primary and a cool secondary component. They are so close that the surface of the secondary fills its so-called Roche limit and transfers matter towards the primary in a stream. Due to the system's orbital motion, however, the stream does not impact on the primary but forms an accretion disk around it. Where the overflowing mass hits the rotating gas, a hot bright spot is produced. The momentum of the disk material has to be separated before it can be accreted onto the primary. Magnetic fields can influence the structure of the disk, in some cases no disk exists at all and matter is forced to flow along the magnetic field lines producing extremely hot X-ray emitting spots above the magnetic poles.

Novae, dwarf novae, several X-ray sources like AM Her stars, intermediate polars, DQ Her stars and X-ray bursters are examples for the large group of CVs, and the variety of classes demonstrates their complex behaviour.

A unique member of this group, BD Pav, had been discovered by Boyd (1939) on star plates taken in 1934. The object, never seen before, suddenly had brightened to 12.4 mag. After 20 days the star faded below detection limit (16.5 mag) again. This led to the classification as a classical nova, which was doubted already by Payne Gaposchkin (1977) because of consequences of the decay time scale on the absolute magnitude.

We observed BD Pav with the ESO 1.5-m telescope in June 1980 during a spectroscopic survey programme searching for cataclysmic systems with