CARBON AND NITROGEN IN HALO STARS

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ABSTRACT: A new study of carbon and nitrogen abundances has been carried out for a sample of halo dwarf stars. This sample was limited to relatively bright high velocity stars with substantial metal deficiencies ($-0.65 \geq [Fe/H] \geq -2.00$). Synthesis of CH molecular bands for nine program stars indicates that $[C/Fe] = -0.1 \pm 0.2$ in halo stars. Preliminary results of the NH synthesis in two stars shows discrepant results: a moderate velocity star has $[N/Fe] \lesssim -1.0$ while a very high velocity star has $[N/Fe] \simeq +0.0$. Implications of these abundances for galactic chemical evolution are discussed.

A. INTRODUCTION

Carbon and nitrogen are important elements for the study of the chemical history of our galaxy. They are abundant elements and as such materially affect the evolution of a star. Additionally they are made in different nucleosynthesis processes than are the iron-peak elements (see Audouze et al. 1975). Knowledge of [C/Fe] and [N/Fe] as functions of [Fe/H] may therefore help set constraints on the types of nucleosynthesis sites, and hence the mass function of stars which existed at early epochs in the galaxy. Previous studies have concentrated on deriving carbon and nitrogen abundances in high velocity stars of moderate metal deficiency (Clegg 1975) or stars of low velocity and large metal deficiency (Sneden 1974). The present work sought to obtain these abundances in high velocity dwarf stars with a wide range in metallicity. We have employed high resolution echelle spectra to analyse the chemical contents of these rather faint ($m_v \sim 9.5$) stars. We report below the complete carbon abundance survey and preliminary results for nitrogen.

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B. OBSERVATIONS AND ANALYSIS

Echelle spectra of most program stars were obtained with the Mt. Hopkins 60-inch telescope, and coudé spectra of ν Indi were obtained with the 60-inch telescope at Cerro Tololo Interamerican Observatory. Description of the echelle observations, plate tracing procedure and stellar model atmosphere analysis are given by Peterson (1977). This analysis yielded values of T_{eff}, log g, microturbulent velocity, and [Fe/H] for each star except ν Indi, for which the Bell (1970) atmosphere parameters have been adopted. Synthetic spectra of the CH 4300 Å G-band and the NH 3360 Å bands were then computed and compared with the stellar spectra tracings to derive values of [C/H] and [N/H]. Further details of the molecular band analysis are given in Peterson and Sneden (1978).

C. THE CARBON TO IRON RATIO

Figure 1 shows [C/Fe] plotted versus [Fe/H] for our program stars. The data indicate that the [C/Fe] ratio is constant throughout the metallicity range, and we derive [C/Fe] = -0.1±0.2 for the present sample of halo dwarf stars. This result is consistent with the earlier work of Clegg (1975), who obtained [C/Fe]≃-0.18 and with that of Sneden (1974), who found [C/Fe]≃+0.1. This result, in conjunction with the previous studies seems clearly to indicate that there is little deviation from the solar carbon to iron ratio in metal-poor dwarfs.

The constancy of this ratio argues that the relative contribution of different stellar masses to the enrichment of the interstellar medium from early in the galaxy's history to the present has undergone no significant change. If carbon is returned to the interstellar medium in supernova explosions, any change in the mass function should show up in varying [C/Fe] ratios, for the amount of carbon which survives such an event is a sensitive function of supernova mass. This result may help set constraints on the theoretical mass functions employed in studies of early galactic evolution.

Two other points are worth noting. Theoretical stellar evolution models have usually assumed [C/Fe] = [N/Fe] = [O/Fe] = +0.0, for lack of contrary data from metal-poor stars. This work and the previous studies have shown that at least the carbon to iron constancy is a valid assumption. Also, the peculiar carbon overabundances seen in the CH stars and some planetary nebulae (Torres-Peimbert and Peimbert 1977), as well as the underabundances found in weak G-band stars are the result of the internal evolutions of those stars involved. No dwarf appears to share these peculiarities.

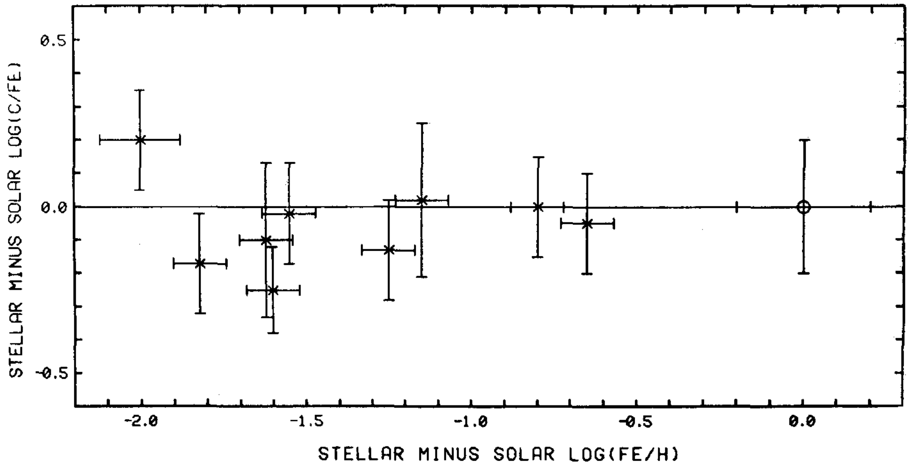

Figure 1: The derived [C/Fe] ratios plotted versus the [Fe/H] ratios. The solar abundance is denoted by an open circle.

D. THE NITROGEN TO IRON RATIO

Clegg (1975) has shown that, with large scatter, [N/Fe] α V, where V is the component of stellar velocity in the direction of galactic rotation. Our synthesis of the NH bands in ν Indi (V=-92 km sec^{-1}) indicates that [N/Fe]$\lesssim$ -1.0. This result is somewhat lower than Clegg's relation would suggest but in line with the trends of his data. However, HD 64090 (V=-249 km sec^{-1}) exhibits [N/Fe]$\lesssim$+0.0 in the present analysis. This result is puzzling and provides added weight to Pagel's (1971) suggestion that there may be large scatter in the [N/Fe] relationship for metal-poor stars.

This scatter in [N/Fe], if confirmed in more stars, shows that nitrogen can be built up to its solar ratio in stars which began their lives with little or no carbon. The scatter also indicates that the mixing of nucleosynthesis products into the interstellar medium has not been a completely homogeneous process, or that the timescale for galactic enrichment of nitrogen has been quite different from that of iron. The nitrogen anomalies may represent the first indication that the interstellar medium is not chemically well mixed. It is therefore vital to obtain more data on the [N/Fe] ratios in metal-poor stars.

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