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Research Note

An insipid CH star in the Sculptor dwarf spheroidal galaxy*

Matthew D. Shetrone[1], **Michael Briley**[2], **and James P. Brewer**[1]

[1] European Southern Observatory, Casilla 19001, Santiago 19, Chile
[2] Department of Physics and Astronomy, University of Wisconsin, Oshkosh, WI 54901, USA

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Abstract. A strong CN star in the Sculptor dwarf spheroidal galaxy discovered by Smith & Dopita (1983) has been found to be an insipid CH star. This star, Sculptor 314, exhibits both strong CN bands and strong CH bands ruling out any similarity with CN strong stars found in most globular clusters. No C_2 bands are found in its spectra. Based on the derived abundances, when Sculptor 314 evolves further up the giant branch it will **not** develop strong C_2 and will **not** appear similar to those CH stars which have been found by previous searches.

Key words: stars: carbon – galaxies: Sculptor dwarf spheroidal – galaxies: stellar content

1. Introduction

In the only blue CN survey of the Sculptor dwarf spheroidal galaxy (henceforth Sculptor), Smith & Dopita (1983) found several stars with strong blue CN bands compared to their Ca strengths. Because the study by Smith & Dopita was conducted with narrow band photometry and not spectroscopy they could not further investigate the nature of these strong CN stars. Three possible explanations for the nature of these strong CN stars are: (1) they could be CH stars missed by other surveys; (2) they could be mild or insipid CH stars; or (3) they could be similar to the CN strong stars that have been found by many authors in globular clusters.

The existence of CH stars in Sculptor has been explored by Westerlund (1979), Frogel et al. (1982), Richer & Westerlund (1983), Azzopardi et al. (1985), and Azzopardi et al. (1986). These surveys have employed prism surveys in either the near-infrared or in the near-blue to identify spectra with strong CN and/or C_2 bands which characterize most CH stars. These CH star surveys are nearly "complete" in that they recover the CH stars found by the other investigators and only added a few new CH stars. However these types of surveys would not detect mild or insipid CH stars such as IV-59 in M5 (Smith et al. 1997), L2406 in M55 (Briley et al. 1993) or III-106 in M22 (Vanture & Wallerstein 1992). These globular cluster CH stars do not exhibit strong C_2 bands but have both strong CN **and** CH bands compared to the other stars within the cluster. The CN strong stars found in globular clusters are completely different than CH stars. CN strong stars are associated with enhancements of N and depletions of C (and sometimes O). The CN bands of both CN strong stars and the cluster CH stars can be stronger than the CN bands in "normal" CN weak stars by up to a factor of three, thus to differentiate between the two types of stars one must look at both the CN and CH bands. In this paper we investigate the nature of one of the strong CN band stars in Sculptor.

* Based on observations carried out at the European Southern Observatory (La Silla, Chile)

2. Observations and analysis

The observations were made on September 10 1997 with the DFOSC on the Danish 1.54m telescope. The setup of the spectrograph allowed us to obtain a spectrum from 3850Å to 6840Å. The slit was aligned to obtain simultaneous spectra of two giants, 314 and 340 (notation of Kunkel & Demers 1977). Three exposures of 5400 seconds each were taken. Despite the very long exposures the spectra have low S/N, at 4200Å S/N = 18/pixel and at 3900Å S/N = 9/pixel. The spectra were reduced using standard IRAF long slit packages. A single flux standard, LTT 7987, was taken at the beginning of the night and was used to flux calibrate both stars.

Photometry, reddening (a value of E(B–V) = 0.045 was used), and numbering notation for the Sculptor stars were taken from Kunkel & Demers (1977). Initial estimates of the surface gravity, effective temperature and microturbulent velocity were made by comparing $(B-V)_0$ of the program stars with high resolution analyses. Using analyses of Keck Hires spectra of the globular clusters M15 ([Fe/H] = –2.3, Sneden et al. 1997) and M13 ([Fe/H] = –1.6 Kraft et al. 1997) correlations between the spectroscopic parameters and $(B-V)_0$ were created. The scatter in the given correlations at a given color was adopted as the error in the model parameter. A linear interpolation was done for metallicities between these two clusters.

The SSG program described by Bell & Gustafsson (1978, 1989) and Gustafsson & Bell (1979) was used to calculate synthetic spectra for each model atmosphere. The atomic and molecular data used with SSG have been discussed by Bell, Paltoglou, & Tripicco (1994), and Tripicco & Bell (1995). Emer-

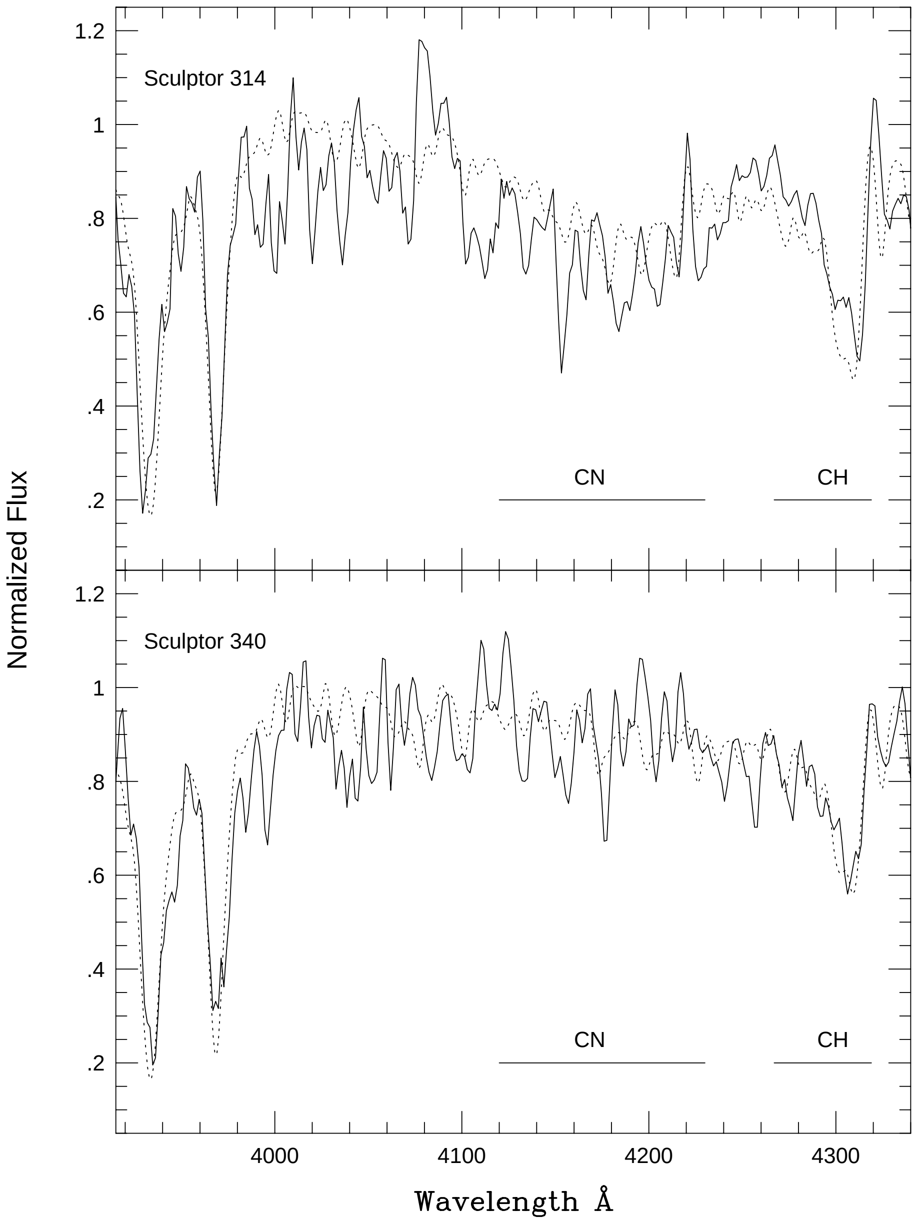

Fig. 1. Comparison of the synthetic spectra with the observed spectra. The solid lines are the data and the dashed lines are the synthetic spectra. All of the spectra have been smoothed with a 3 pixel boxcar and normalized by an arbitrary spline fit to a pseudo continuum.

gent fluxes were computed at a wavelength spacing of 0.02Å, and the resultant spectra were then smoothed to a Gaussian of FWHM=4.5Å to simulate the resolution of the smoothed DFOSC spectra. The carbon isotope ratio ($^{12}C/^{13}C$) was set to 4 for all models. Initial metallicity estimates were made using the Ca index - metallicity relation derived by Suntzeff (1980). Subsequent iterations of the metallicity were made by visual comparison of the Ca H and K lines and in the region 5000Å - 5400Å which is dominated by metallic lines.

The final adopted parameters for the strong CN band star, Sculptor 314, are T_{eff}=4500, log g = 0.95, v_t = 1.8, and [M/H] = –2.2. The final adopted parameters for the comparison star, Sculptor 340, are T_{eff}=4500, log g = 1.00, v_t = 1.8, and [M/H] = –1.9. Fig. 1 exhibits the spectra with the final synthetic spectra models. The solid lines are the data and the dashed lines are the synthetic spectra. All of the spectra have been smoothed by a 3 pixel boxcar and normalized by an arbitrary spline fit to a pseudo continuum for display purposes only.

As a check of our adopted parameters, V and B–V values were also computed from the synthetic spectra using the B and V filter profiles, and the IRCONV program (see Tripicco & Bell 1991). Assuming a mass of 0.6 $M_\odot$, the observed luminosities and colors were matched by models with surface gravities of 1.25 and 1.15 dex, and effective temperatures of 4600 and 4450 K, for Sculptor 314 and 340 respectively. These temperatures and surface gravities are within the expected uncertainties and within the S/N of the spectra. Adopting these models in the analysis below did not change the derived abundances.

3. Abundances

Inspection of the spectrum of Sculptor 314 reveals no C_2 bands and no red CN bands. The CH G-band is clearly strong, slightly stronger than in Sculptor 340. Both Sculptor stars are weak lined but Sculptor 340 has slightly stronger lines in the region from 5000Å - 5400Å indicating it probably has a higher metal abundance than Sculptor 314.

Because the carbon and nitrogen abundances are somewhat sensitive to the assumed oxygen abundance and because no information about the oxygen abundances has been published on these two stars, some degree of assumption is required. For the comparison star, Sculptor 340, an oxygen abundance of [O/Fe]= 0.3 is assumed and for the strong CN star, Sculptor 314, an oxygen abundance of [O/Fe] = 0.0 is assumed. The positive oxygen to iron ratio for the comparison star is consistent with oxygen abundances found for Galactic population II stars. The lower oxygen abundance for the strong CN star is consistent with the abundances found in CN strong stars found in many globular clusters (e.g. Smith et al. 1996, Smith et al. 1997), the upper limit found for the oxygen abundance in the CH star in M22 (Vanture & Wallerstein 1992), and the abundances found in field CH stars by Vanture (1992). A change in the [O/Fe] ratio from 0.0 dex to 0.5 dex requires an increase in [C/Fe] of approximately 0.15 dex to maintain the good agreement between the synthetic spectra and the real spectra at the CH and CN bands.

The fits to the CN and CH bands in both broad band fluxes and by visual inspection yield abundances which agree to 0.2 dex. Fig. 1 displays the best spectral fit to the data for both the strong CN star and the normal Sculptor giant. The spectra in Fig. 1 have been normalized by a spline for display purposes only. The abundances that we derive for the comparison Sculptor giant are [C/Fe] = –0.4, [N/Fe]= 0.4, and [Ca/Fe] = 0.1 dex. The abundances derived for the strong CN Sculptor giant are [C/Fe] = 0.15, [N/Fe] = 1.65 and [Ca/Fe] = 0.4 dex. The errors on the [C/Fe] and [N/Fe] abundances we estimate to be about 0.35 dex based on uncertainties in temperature, and S/N. The uncertainty in the [C/Fe] and [N/Fe] abundances based on the [O/Fe] abundance is small due to the overall low metallic abundance of these stars. The [Ca/H] ratios have an error of about 0.25 dex associated with them.

4. Discussion

The abundances of C and N in the comparison giant are consistent with the carbon and nitrogen abundances found among metal-poor field stars and some CN weak globular cluster giants (e.g. Carbon et al. 1982 and Kraft et al. 1982). Our spectrum does not have enough S/N, in addition to the uncertainties in the O abundance, to comment on the enhanced carbon abundances with respect to globular cluster giants other investigators have reported on in several dwarf spheroidals (e.g. Smith 1984).

We can confirm that the star Sculptor 314 does have strong CN bands as reported by Smith & Dopita (1983). Sculptor 314 has a CH band that is slightly stronger than the comparison giant Sculptor 340. From this fact we can conclude that this strong CN giant is not similar to the CN strong stars found in globular clusters. This does not rule out the possibility that some of the other strong CN giants in Sculptor may be globular cluster like CN strong stars. If we take the abundances we derive for 314 and then apply them to a giant near the tip of the giant branch (T_{eff} = 4000, log g = 0.10) and compute a synthetic spectra for this giant we do not get a classical CH star. The red CN bands in this synthetic spectra are quite strong but the C_2 bands are barely noticeable. Thus, we conclude that when 314 evolves up the giant branch it will not appear like the other CH stars that have been found in Sculptor unless significant internal mixing occurs. The closest relative to the strong CN giant, Sculptor 314, is probably the insipid CH stars found in some globular clusters (e.g. M5: Smith et al. 1997, M55: Briley et al. 1993).

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