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SPECTROSCOPY OF FAINT HALO CARBON STARS

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ABSTRACT

Low-resolution spectra are presented for eleven faint, halo carbon stars, selected from previously published objective-prism candidates at high galactic latitude. Temperature and carbon classes are derived from these spectra. These objects are useful for studies of both the dynamics and chemical evolution of the halo and are observable at remarkably large galactocentric distances.

Key words: carbon stars–stellar spectra–Population II

1. Introduction

In the past few years a growing number of faint, high-latitude carbon (C) stars have been discovered. Although one such object, G77-61, is known to be a dwarf (Dahn *et al.* 1977), it is now recognized to be binary (Dearborn *et al.* 1986), and its C spectral features may well be due to causes other than normal red-giant evolution. It seems likely that many or most of these stars are, in fact, of luminosity comparable to the C giants known in the disk and, thus, are at impressive galactocentric distances, approaching 10^5 pc in the more extreme cases. These stars are thus potentially very valuable probes of the evolution and especially dynamics of the outer halo; their sharp C spectral features lend themselves to accurate velocity determination even using modest spectral resolution.

With this motivation, we are conducting a systematic CCD imaging survey of selected halo regions for faint C stars, and the results of this work, still in progress, will be reported elsewhere. It is already clear from our survey, however, that the surface density of these objects is relatively small, so candidates identified by the more traditional photographic techniques must not be neglected. The small number of currently known objects in this class have chiefly emerged from low-resolution objective-prism surveys conducted on photographic plates (Stephenson 1989 and references therein).

Sanduleak and Pesch (1988) provide a list of late-type stars in the halo with suspected C- or M-type spectra and magnitudes in the $R = 9$–17 range. A handful of their candidates from prepublication lists have been confirmed as C stars with slit spectra by Mould *et al.* (1985). Here we report observations of 15 further C-star candidates in their list, eleven of which prove to be C stars. The newly confirmed objects are scattered over the range $R = 11.5$–15.5. The interlopers, as expected at the dispersion of their objective-prism survey, are all M stars.

2. Observations

In March 1990 we obtained spectra at Kitt Peak with the 2.1-m telescope and Gold Camera CCD spectrometer. A grating with 158 lines mm^{-1} provided coverage of 3700 Å centered at 6750 Å, yielding a spectral resolution of about 14 Å FWHM. The spectra, presented in Figure 1, were flattened, sky subtracted, wavelength calibrated, and sensitivity corrected using IRAF[1]. No attempt has been made to remove telluric lines, since the resulting spectra would be no more informative, and these features actually provide a handy visual benchmark. Poor observing conditions made extraction of photometric data impractical.

At this resolution and spectral coverage, the Swan bands of C_2 at 5165 Å and 5635 Å stand out quite strongly in C stars. For those candidates we verified as C stars, we use the methods detailed in Cohen (1979) on our low-resolution spectra to derive C types as given in the system of Keenan and Morgan (1941). These types are listed for each star in Figure 1 below the star name. The first number provides a temperature classification, the second a carbon richness classification; we estimate an observational uncertainty of ± 1 subclass for the latter.

Four of the C-star candidates (CLS 1, 3, 12, and 35) we find to have unremarkable spectra of type M. These candidates were presumably selected because absorption by Mgb and the MgH band near 5200 Å may, at the resolution of objective-prism spectra, mimic the Swan

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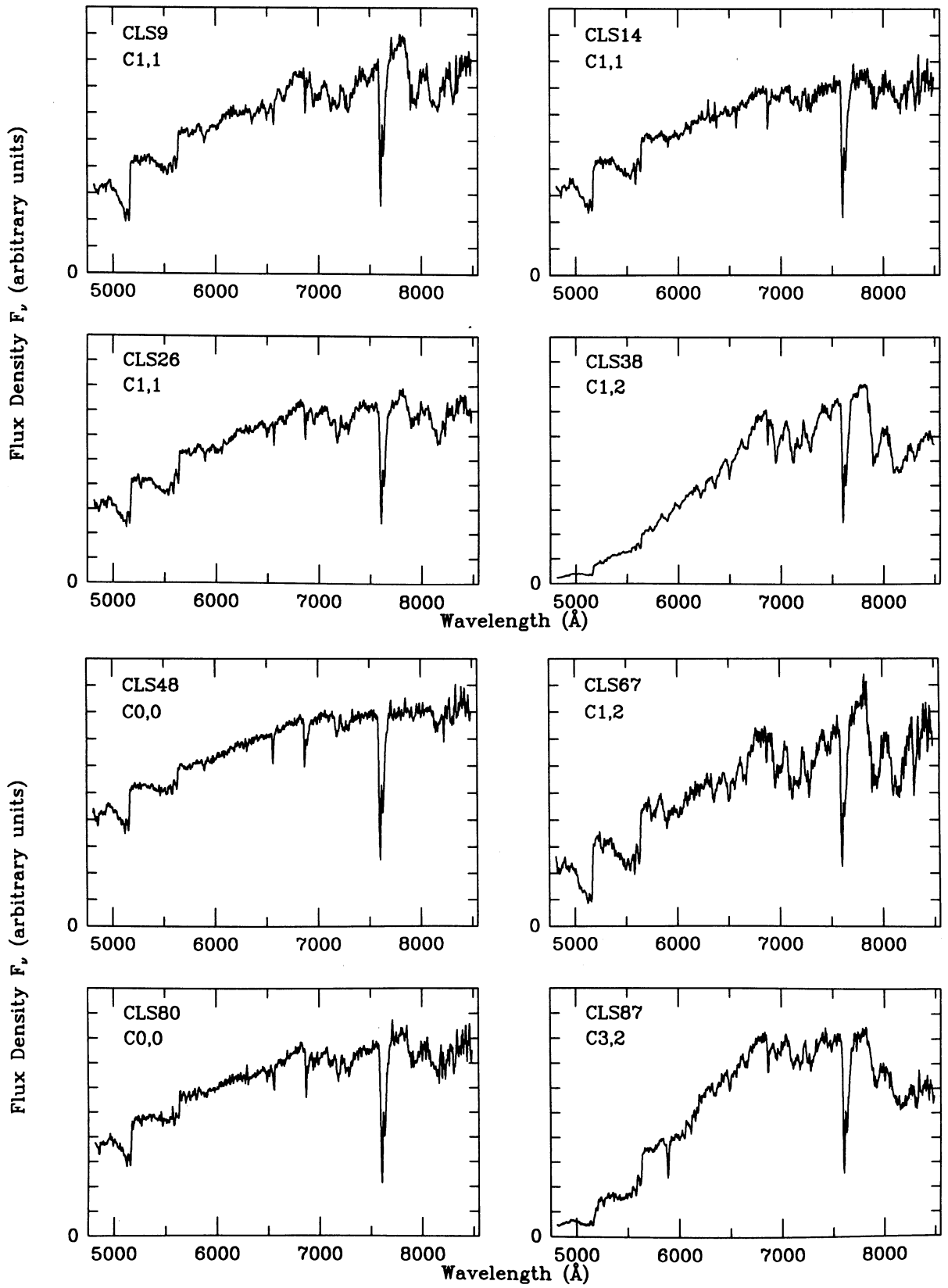
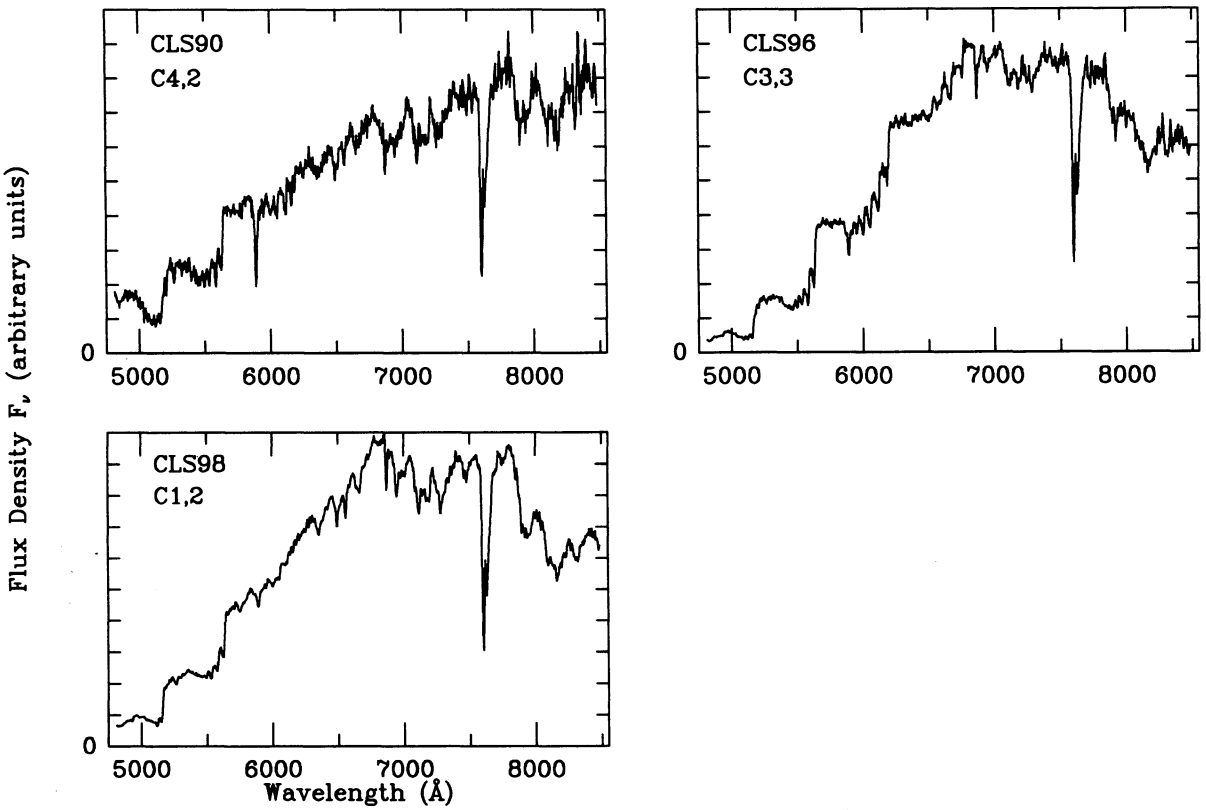


FIG. 1–Optical spectra of eleven verified carbon stars from the list of candidates of Sanduleak and Pesch (1988), where coordinates, approximate magnitudes, and finding charts are provided. Spectral resolution is ~14 Å FWHM. Each spectrum is labeled by the Case Low-Dispersion Survey (CLS) star number, and underneath, the Keenan-Morgan carbon star classification is listed, as determined here from our spectra.



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band of C_2 at 5165 Å. All four of these stars were, in fact, typed as questionable by Sanduleak and Pesch (1988), and all but one of the eleven verified C stars were typed as high-confidence candidates, lending further credence to selection of C stars from the Case material.

3. Discussion

High-galactic-latitude C stars are likely to be Population II, and the spectra we have obtained appear indeed to correspond to earlier (warmer) C types. Our spectral coverage was determined in large part by considerations of the overall survey observing program. Some fraction of the objects discussed here are likely to be CH stars, but no reliable spectral diagnosis is possible within our spectral range, since the G band of CH (4300 Å) falls too far to the blue. For C stars as warm as these it is difficult to assign a ^{13}C index using low-resolution data. Derivation of actual abundance ratios is problematic, due to the difficulty of estimating the true continuum level and the absence of reliable model atmospheres for C stars in general. A great range of distances, from the solar neighborhood out to at least 50 kpc, is spanned by halo C stars, so we expect further study of their abundances to provide valuable clues to the collapse and subsequent evolution of the halo itself. Although our spectral resolution is currently insufficient to provide interesting radial-velocity constraints on the dynamics of the halo, the objects reported here are sufficiently bright that this task should be straightforward.

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