# Morphological Classification of Veiled CEMP Stars

Devin D. Whitten[1,2], Jinmi Yoon[1,2], Timothy C. Beers[1,2], Vinicius M. Placco[1,2], and Young Sun Lee[3]

1 - Department of Physics, University of Notre Dame, Notre Dame, Indiana, 46556, USA
2 - JINA-CEE, University of Notre Dame, Notre Dame, Indiana, 46556, USA
3 - Department of Astronomy and Space Science, Chungnam National University, Daejeon 34134, South Korea

## Abstract

We present a novel method for the classification of cool ($T_{eff}$ < 5000 K) Carbon-enhanced Metal-Poor (CEMP; [C/Fe]≥+0.7) stars, for which parameter determinations were previously elusive. We explore the extent of carbon-veiling in medium-resolution (R~2,000) spectra and present a continuum normalization routine, GISIC, specifically designed for heavy molecular-band absorption. This routine was applied to a library of synthetic spectra, with which a classification procedure based on the Yoon-Beers diagram was developed. This procedure was applied to SDSS J1327+3335, which we identified as the first Group III CEMP star in the Canes Venatici I dwarf galaxy.

## Carbon-veiling

The determination of an adequate continuum in medium-resolution spectra of cool ($T_{eff}$ < 5000 K) carbon-enhanced stars presents difficulties due to the depression of the flux level by strong carbon molecular bands. This "veiling" affects the entire wavelength range of interest for stellar atmospheric parameter determination, including the Ca II H&K lines which are crucial for estimates of metallicity. Carbon stars are also challenging for automated normalization techniques which are typically sensitive to large absorption features.
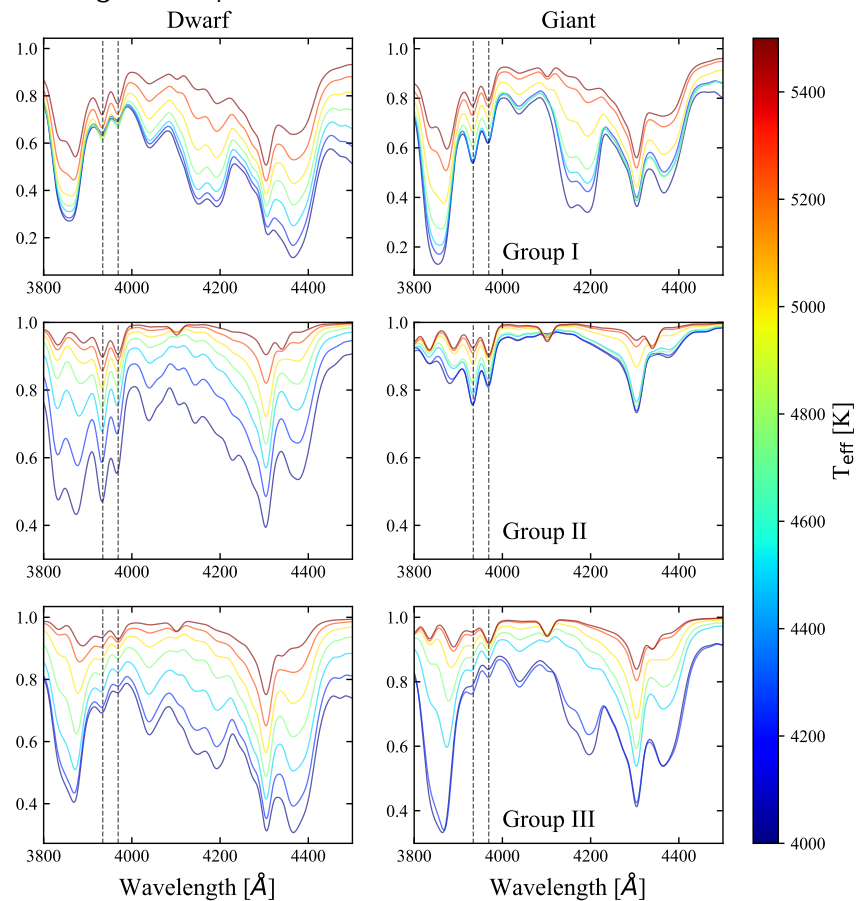


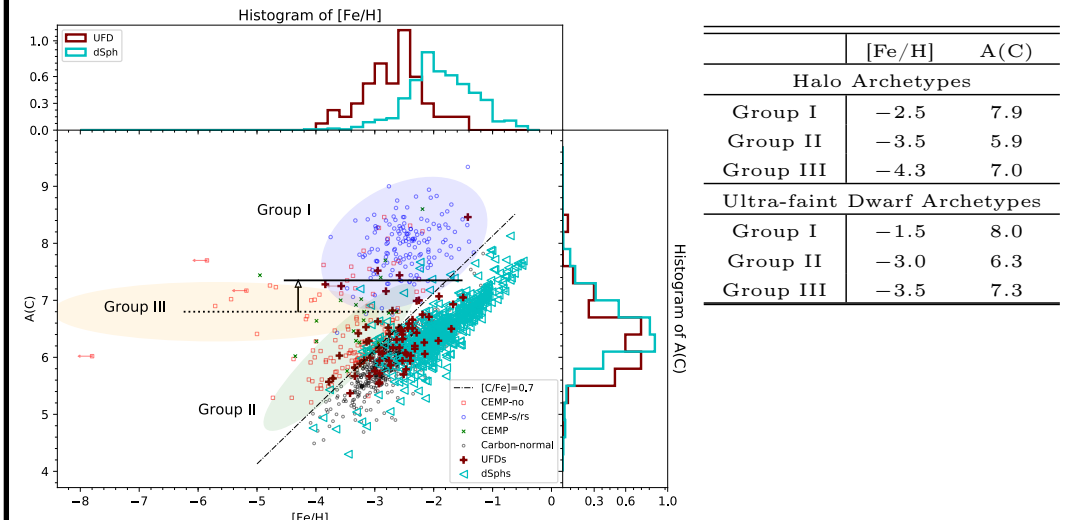## Gradient-based normalization with GISIC

We present the Gaussian Inflection Spline Interpolation Continuum (GISIC). GISIC is specifically designed for continuum normalization of spectra with heavy absorption regions, based on the determination of continuum points from the 2nd-order gradient of the spectrum after Gaussian smoothing. This routine enables the automated normalization of synthetic models of carbon stars.

**https://pypi.org/project/GISIC/**
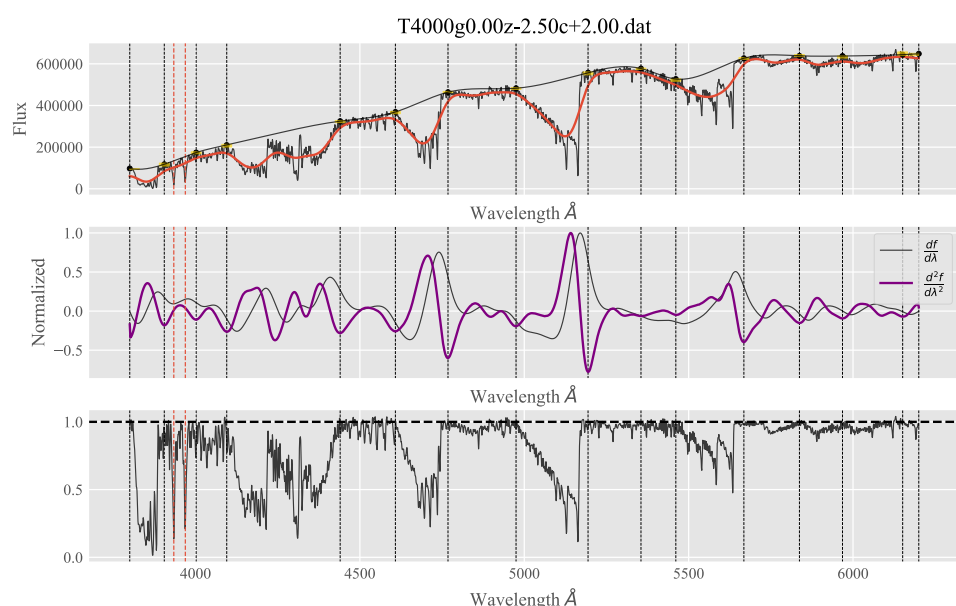


## Group Archetypes

**Table 1.** CEMP Group Archetype Parameters for the Halo and UFDs



|  | [Fe/H] | A(C) |
|---|---|---|
| Halo Archetypes | | |
| Group I | −2.5 | 7.9 |
| Group II | −3.5 | 5.9 |
| Group III | −4.3 | 7.0 |
| Ultra-faint Dwarf Archetypes | | |
| Group I | −1.5 | 8.0 |
| Group II | −3.0 | 6.3 |
| Group III | −3.5 | 7.3 |

## Classification of SDSSJ1327+3335

We assessed the likelihood of the CEMP Group classifications based on synthetic archetypes, for which assumed parameters are listed in Table 1. By ruling out otherwise degenerate groups, we determined $T_{eff}$, [Fe/H], and A(C) based on $\chi^2$-minimization techniques within the region of the Ca II H&K lines and the CH G-band, assuming the [Fe/H] - A(C) region determined by the classification.
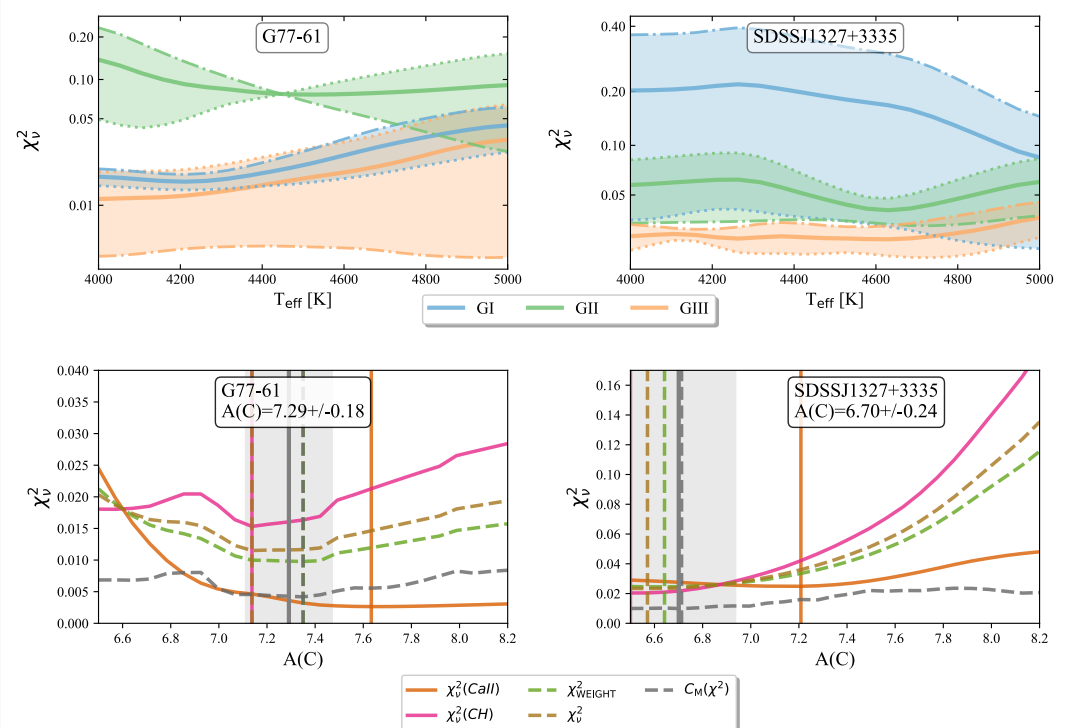


This procedure was first validated with G77-61, a canonical dwarf carbon star, before parameter estimation of SDSS J1327+3335. Final parameter estimates of $T_{eff}$=4200K, log(g)=0.2, [Fe/H]=-3.25, and A(C)=+6.7 reveal this star to be the first Group III CEMP star discovered in the Canes Venatici I dwarf galaxy.
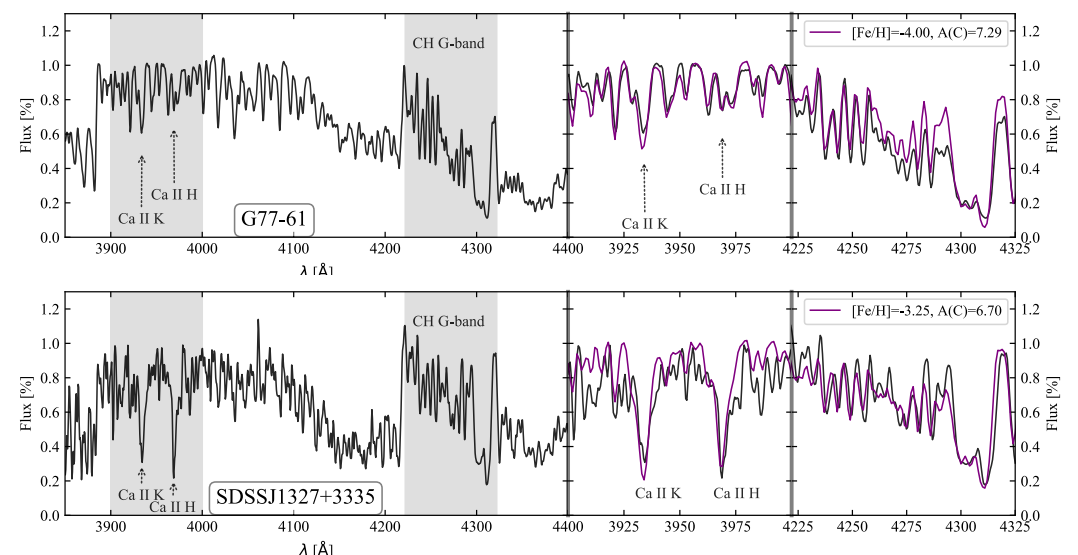


## References

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