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# CHEMICAL COMPOSITION OF GLOBULAR CLUSTER AND HALO POST-AGB STARS

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RESUMEN

Presentamos resultados del análisis de modelos atmosféricos para dos estrellas de la post-rama gigante asintótica (RGA): ZNG-1, en el cúmulo globular M 10, y la estrella del halo PG 1704+222. El análisis de abundancias diferenciales muestra patrones de abundancia típicos de objetos de la post-RGA, siendo ambas estrellas de bajo contenido metálico y abundancia de Helio aproximadamente solar. Se confirma la gran deficiencia de C, observada en todos los objetos calientes de la post-RGA. Esta deficiencia podría sugerir que las estrellas calientes de la post-RGA evolucionan fuera de la RGA antes de que comience el tercer dragado. Sin embargo, la deficiencia de Fe observada en otras estrellas similares sugiere que el fraccionamiento de gas-polvo en los progenitores de los objetos de la RGA es responsable de la composición química observada en ellos.

ABSTRACT

We present results of model atmosphere analyses of two post-AGB stars, ZNG-1 in the globular cluster M 10 and the halo star PG 1704+222. A differential abundance analysis reveals typical post-AGB abundance patterns, both stars being generally metal poor with approximately solar He. Large C depletions, observed in all hot post-AGB objects, are confirmed. The C deficiency may suggest that hot post-AGB stars evolve off the AGB before the third dredge-up begins. However, Fe depletions observed in other similar stars suggest that gas-dust fractionation in the AGB progenitor is responsible for the observed composition of these objects.

*Key Words:* **STARS: ABUNDANCES — STARS: AGB AND POST-AGB — STARS: EARLY-TYPE — STARS: POPULATION II**

## 1. INTRODUCTION

Due to high spectral resolution observations, it is now believed that many objects previously classified as high latitude late-type supergiants are in fact old, low mass post-AGB stars. This paper reports results from a continuing program (Keenan 1992) to investigate the nature of B-type stars in the halo of the Galaxy. Previously we have used high resolution spectra to identify several hot post-AGB stars which had originally been classified as young Population I objects (Conlon et al. 1991; Conlon et al. 1994; McCausland et al. 1992). Although our stars appear to be hotter analogues of the late-type post-AGBs, their abundance patterns display significant differences, most notably large carbon depletions. To further our understanding of this stellar evolutionary stage we have initiated a high resolution spectroscopic program of known hot post-AGB objects. The aim of our program is to establish typical post-AGB abundance patterns. By observing stars in different globular clusters, we may measure post-AGB chemical composition as a function of both current mass and initial metallicity. These globular cluster observations will then provide a template which will allow the accurate identification of field post-AGB stars and their initial metallicities.

## 2. ZNG-1 IN M10 AND PG 1704+222

We present the results of model atmosphere analyses of Keck spectra of two post-AGB stars, ZNG-1 ($T_{\rm eff}$ = 26 500 K; $\log g$ = 3.6 dex) in the globular cluster M10 and the high Galactic latitude star PG 1704+222 ($T_{\rm eff}$ = 19 500 K; $\log g$ = 3.0 dex). For data reduction and analysis techniques we refer the reader to Mooney et al. (2001).

The adopted atmospheric parameters were used to derive stellar chemical compositions for our program stars. Absolute abundances may contain systematic errors due to uncertainties in the atmospheric parameters and atomic data, or simplifications in the model atmosphere analysis (e.g., the assumption of LTE). To minimize such errors, the program stars may be analyzed with respect to a standard star with normal Population I chemical composition and similar atmospheric parameters. In this

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TABLE 1

DIFFERENTIAL ABUNDANCES

| Species | ZNG-1 | PG 1704+222 |
|---|---|---|
| He I | $-0.16 \pm 0.17$ | $0.01 \pm 0.05$ |
| C II | $< -0.94$ | $-1.0$ |
| C III | $< -1.29$ | $\cdots$ |
| N II | $-0.53 \pm 0.14$ | $-0.46 \pm 0.25$ |
| O II | $-0.83 \pm 0.12$ | $-0.83 \pm 0.19$ |
| Mg II | $-1.19$ | $-1.4$ |
| Si II | $\cdots$ | $-0.95 \pm 0.02$ |
| Si III | $-0.97 \pm 0.06$ | $-1.04 \pm 0.04$ |
| S II | $\cdots$ | $-0.93 \pm 0.05$ |
| S III | $-0.88$ | $-0.86$ |

case, ZNG-1 and PG 1704+222 are analyzed relative to the normal composition B-type stars HR 2387 and HR 5595 respectively. Results of the differential analysis are given in Table 1.

## 3. DISCUSSION

The derived chemical compositions of ZNG-1 and PG 1704+222 provide a unique insight into the post-AGB evolutionary stage. It is evident that both stars are generally metal-poor with a near normal He abundance relative to other B-type stars. Perhaps the most striking feature in both stars is the large C deficiency of $> 1.3$ dex in ZNG-1 and 1.0 dex in PG 1704+222. O and N are also underabundant, but N is enhanced relative to other elements. Such abundance patterns are consistent with results found for most high Galactic latitude field (Conlon et al. 1991; McCausland et al. 1992; Moehler & Heber 1998) and globular cluster (Conlon et al. 1994; Moehler et al. 1998) hot post-AGB stars. Conlon et al. (1994) and McCausland et al. (1992) claimed that the CNO abundance patterns observed in their sample of stars were compatible with the products of hydrogen burning being brought to the stellar surface during the first and second dredge-ups. Also, as cooler post-AGB stars do not exhibit large C deficiencies, then the hotter objects must evolve off the AGB before the third dredge-up begins. However, another possible scenario exists which may explain the observed CNO abundances in post-AGB stars. Metals with a high condensation temperature are inclined to condense into dust grains, whereas lighter elements with lower condensation temperatures will remain in the gas phase. The dust formed in the atmosphere of AGB stars is removed via radiation pressure leaving only the gas in the extended atmosphere. As a result, observed abundances in post-AGB stars should mimic the composition of interstellar gas, i.e., Fe, Ca and C depletions. A recent analysis of the PNe central star BD +33°2642 by Napiwotzki et al. (2000) ruled out the third dredge-up scenario. Although the C and O abundances of this star could have been altered by dredge-up processes, nuclear processing in the low mass progenitor could not account for the observed overabundances of $\alpha$ process elements relative to Fe.

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