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PN-CARBON YIELDS AND THE CHEMICAL EVOLUTION OF THE GALAXY

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RESUMEN

Calculo dos conjuntos de rendimientos estelares observacionales de carbono para estrellas de masa intermedia y baja basados en abundancias derivadas a partir de líneas permitidas y prohibidas de C II y C III (λ 4267 y $\lambda\lambda$ 1906+1909, respectivamente). Comparando los valores de C/O observados en la vecindad solar y en regiones H II Galácticas con aquellos predichos por modelos de evolucion química para la Galaxia que suponen estos rendimientos observacionales, se concluye que las abundancias de C basadas en líneas permitidas son mejores que aquellas derivadas a partir de líneas prohibidas.

ABSTRACT

Two sets of observational carbon stellar yields for low-and-intermediate mass stars are computed from planetary nebulae abundances derived from C II λ 4267 and C III $\lambda\lambda$ 1906 + 1909 lines, respectively. By comparing C/O values observed in stars of the solar vicinity and Galactic H II regions with those predicted by chemical evolution models for the Galaxy, which assume these observational yields, I conclude that the C abundances derived from permitted lines are better than those derived from forbidden lines.

Key Words: **GALAXY: ABUNDANCES — GALAXY: EVOLUTION — PLANETARY NEBULAE: GENERAL**

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1. INTRODUCTION

The $N(\mathrm{C}^{++})/N(\mathrm{H}^+)$ values derived from the permitted line (PL) C II λ4267 are higher, by as much as a factor of 10, than those determined from the forbidden lines (FL) C III $\lambda\lambda$1906+1909. Several explanations to this discrepancy have been presented in the literature, but the problem is still open. Since PNe are important for the C enrichment of the interstellar medium, a successfully chemical evolution model for the solar vicinity and the Galactic disk (Carigi 2000) is used to try to discriminate between the PN-C abundances derived from permitted lines and the PN-C abundances obtained from forbidden lines.

2. PN OBSERVATIONAL YIELDS

Average $(\mathrm{C/H})^{\mathrm{PL}}_{\mathrm{PN}}$ and $(\mathrm{C/H})^{\mathrm{FL}}_{\mathrm{PN}}$ values are computed from 15 type I PNe (PNI), and from 21 type II and III PNe (PNII/III). The $\langle(\mathrm{C/H})^{\mathrm{PL}}_{\mathrm{PNI}}\rangle$ value is calculated from the $N(\mathrm{C}^{++})/N(\mathrm{O}^{++})$ and $N(\mathrm{O})/N(\mathrm{H})$ values given by Peimbert, Luridiana, & Torres-Peimbert (1995a). The $\langle(\mathrm{C/H})^{\mathrm{FL}}_{\mathrm{PNI}}\rangle$ value is obtained from $\langle(\mathrm{C/H})^{\mathrm{PL}}_{\mathrm{PNI}}\rangle$ and the average of $N(\mathrm{C}^{++})/N(\mathrm{H}^+)_{\mathrm{PL}}$, $N(\mathrm{C}^{++})/N(\mathrm{H}^+)_{\mathrm{FL}}$ ratios taken from Peimbert, Torres-Peimbert, & Luridiana (1995b). The $\langle(\mathrm{C/H})^{\mathrm{PL}}_{\mathrm{PNII/III}}\rangle$ and $\langle(\mathrm{C/H})^{\mathrm{FL}}_{\mathrm{PNII/III}}\rangle$ values are computed from the $N(\mathrm{C}^{++})/N(\mathrm{H}^+)$ values given by Peimbert et al. (1995b) and corrected for the contribution of $N(\mathrm{C}^{+})/N(\mathrm{H}^+)$ by adding 0.1 dex.

According to stellar evolution models, the PN I progenitors are stars with initial mass between 2.4 and 8 $M_\odot$ and the PN II/III progenitors are stars with $0.8 < m/M_\odot < 2.4$. The C yields for PN progenitors (C_{PN} yields) are calculated based on $\langle(\mathrm{C/H})_{\mathrm{PN}}\rangle$ values from permitted lines and forbidden lines, neglecting the ejected mass by winds and assuming that the $\langle(\mathrm{C/H})_{\mathrm{PN}}\rangle$ values are independent of the initial metallicity of the progenitors. I assume that the O yields for PN progenitors are null. The mass ejected by PN progenitors are taken from van den Hoek & Groenewegen (1997).

3. MODELS

All models are built to reproduce the observed gas fraction distribution of the Galaxy and the observed O/H Galactic gradient from 4 to 10 kpc. Models adjust the rise of C/O with metallicity in the solar neighborhood shown by dwarf stars, the Sun, and Orion; and the decrease of the C/O abundance with Galactocentric distance derived from the Galactic H II regions M17, M8, and Orion.

The models are very similar to the infall model of Carigi (2000), but in this work there are some differences in the assumptions about stellar yields:

(a) Just one set of metal-dependent stellar yields from massive stars ($8 < m/M_\odot < 120$) is considered: Geneva yields (Maeder 1992). Carigi concluded that only the models with the Geneva yields can reproduce both the increase of C/O with Z in the solar vicinity and the negative C/O gradient.

(b) Four sets of stellar yields for low and intermediate mass stars ($0.8 < m/M_\odot < 8$) are used:

 (i) two metal-dependent-theoretical ones: van den Hoek & Groenewegen (1997, Amsterdam yields), and Marigo , Bressan, & Chiosi (1996; 1998) and Portinari, Chiosi, & Bressan (1998, Padova yields);

 (ii) two metal-independent-observational stellar yields: PN yields from permitted lines and PN yields from forbidden lines.

The C/O value depends on the initial mass function and the C and O yields. Since the initial mass function and the massive-star yields are fixed, the C/O value is used to test the different sets of C and O yields for low and intermediate mass stars

4. RESULTS AND CONCLUSIONS

By comparing observed and theoretical C yields, it can be noted that:

(i) there is very good agreement between the C_{PN}^{PL} yields and those predicted by stellar evolution models with $Z = Z_\odot$ and

(ii) the C_{PN}^{FL} yields are lower, by as much as a factor of 4, than those predicted by stellar evolution models with $Z = Z_\odot$.

From chemical evolution models of the Galaxy, I conclude that:

(a) Models with C_{PN} yields derived from permitted lines match all the observational constraints, in particular they reproduce the C/O absolute values observed in stars of the solar vicinity and in H II regions of the Galactic disk.

(b) Models with C_{PN} yields from forbidden lines fail to reproduce the C/O ratios in: dwarf stars of different ages in the solar vicinity, the Sun, and M17.

(c) Models with C_{PN} yields derived from permitted lines agree with models based on theoretical yields, in particular show better agreement with models based on the Padova yields than with models based on the Amsterdam yields.

(d) The C/O values predicted with C_{PN} yields derived from permitted lines are 0.1 dex higher than those obtained with the Amsterdam yields and 0.05 dex lower than those computed with the Padova yields.

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