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STRONGLY METAL DEFICIENT PLANETARY NEBULAE

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ABSTRACT: We study a group of planetary nebulae of type II with extremely low abundances of heavy elements. It is concluded that their central stars have masses lower than expected from most stellar evolution calculations.

RESUMO: Estudamos um grupo de nebulosas planetárias de tipo II com abundâncias de metais extremamente baixas. Concluimos que as estrelas centrais destes objetos têm massas abaixo dos valores estimados pelos modelos de evolução estelar.

Key words: ABUNDANCES — NEBULAE-PLANETARY

. INTRODUCTION

In the framework of the classification scheme of planetary nebulae (PN) originally roposed by Peimbert (1978), these objects can be classified in four types, namely, types I, I, III and IV. A further subdivision of type II into subtypes IIa and IIb has been proposed y Faúndez-Abans and Maciel (1987a), and the PN of the galactic centre have been considered s of type V by Maciel (1989). As recently shown by Maciel and Faúndez-Abans (1985) and aúndez-Abans and Maciel (1986), PN of type II display electron temperature and chemical omposition radial gradients, in the same sense as presented by H II regions. However, it has lready been pointed out in these papers that some nebulae show a strong heavy element eficiency, even if the abundance variations with galactocentric distance are accounted for. his is especially true for the objects IC 4593, IC 4634, IC 4776, BD 30°3639, Hu 2-1, SwSt-1, 1-26 and Cn 3-1, where we have included other objects studied by Freitas Pacheco and Veliz 1987a,b). The proposed subdivision of type II nebulae is not sufficient to explain the bserved deficiency, although it seems significant that all these objects are of type IIb, hat is, they are N-poor.

I. METAL-POOR TYPE II PN

We have adopted distances estimated by Maciel (1984), Freitas Pacheco and Veliz 1987a,b) and Daub (1982). The abundances are referenced in Faúndez-Abans and Maciel (1986; 987b), and have been supplemented by new observations obtained at the "Laboratório Nacional e Astrofísica - LNA" (Freitas Pacheco and Veliz, 1987a,b; Freitas Pacheco et al., 1989). dopting the radial gradients determined by Faúndez-Abans and Maciel (1986, 1987b), at a given alactocentric distance R the abundances could in principle be estimated from the abundance radients within a standard deviation. However, as can be seen in Table 1, where the eviations in the observed abundances relative to H are given in terms of the standard eviations, the derived differences are usually much higher than predicted. It should be bserved that the abundances relative to oxygen are essentially normal, as expected for PN f low mass progenitors.

III. POSITION OF THE CENTRAL STARS ON THE HR DIAGRAM

In order to provide a link between the observed nebular abundances and the properties of the central stars, we proceeded to determine their positions on the HR diagram. We have used published stellar temperatures, especially H I Zanstra or blackbody temperatures and luminosities (Cerruti-Sola and Perinotto, 1989; Freitas Pacheco et al., 1986; Sabbadin, 1986; Shaw and Kaler, 1985; 1989; Amnuel et al., 1985; Pottasch, 1984; Pilyugin and Khromov, 1979; Martin, 1981; Preite-Martinez and Pottasch, 1983; Freitas Pacheco and Veliz, 1987a,b; Flower et al., 1984). The luminosities have also been calculated using three different methods: (i) H beta fluxes (Pottasch, 1984; 1989), (ii) bolometric corrections and magnitudes (Cahn, 1984) and (iii) stellar radii and temperatures.

IV. RESULTS AND DISCUSSION

Figure 1 shows the obtained positions on the HR diagram for the objects listed in Table 1, along with evolutionary tracks of stars in the appropriate mass range (Shaw and Kaler, 1989). It is seen that the observed positions are consistent with central stars of very low masses, that is, their core masses are of the order of 0.5 M⊙ or lower. As already pointed out by Pottasch (1984, 1989; Zijlstra and Pottasch, 1989) this poses a problem for stellar evolution theory, as most theoretical models stop at higher masses, due to the large

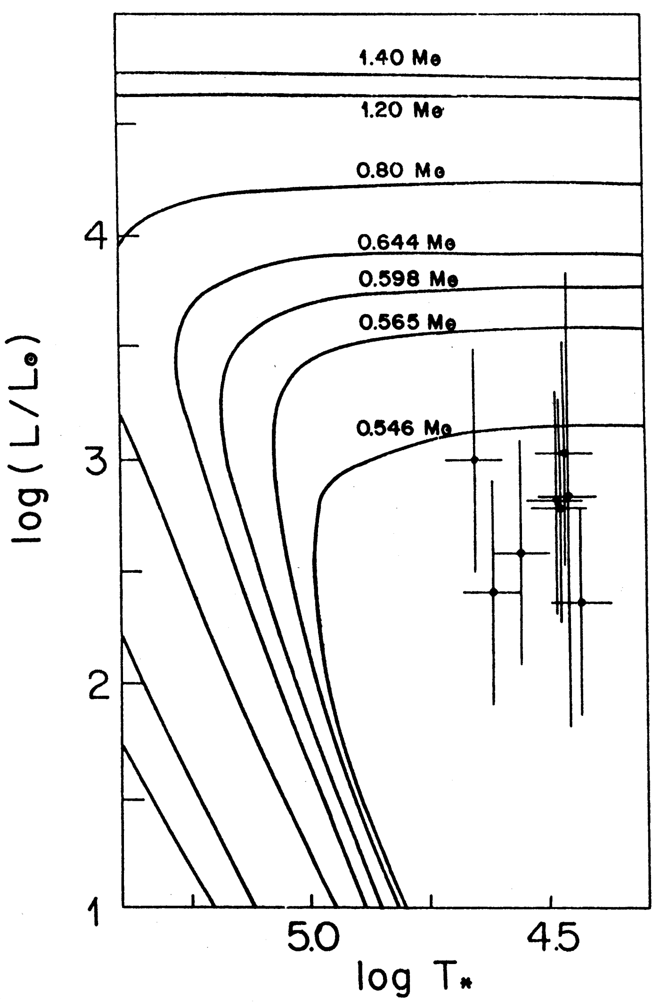

Figure 1 - Position of the central stars on the HR diagram

[able 1 - Deviations from the expected abundances relative to H in terms of standard deviations

name	O	N	S	C	Ne	Ar	Cl
IC 4593	5σ	4σ	2σ	+1σ	3σ	3σ	
IC 4634	3σ	5σ	3σ	5σ	1σ	3σ	1σ
IC 4776	1σ	2σ	1σ		1σ	2σ	1σ
BD+30°3639	3σ	1σ	1σ	1σ			
Hu 2-1	2σ	2σ	4σ	1σ	4σ	3σ	2σ
SwSt-1	2σ	2σ	4σ	4σ			+1σ
M1-26	6σ	2σ	2σ				1σ
Cn 3-1	6σ	3σ	4σ	1σ	2σ		1σ

:imescales of objects in the low mass range. The fact that these objects have low metal ıbundances can therefore be explained by assuming that the PN central stars evolved from low ıass stars formed out of metal poor protostellar clouds. The space distribution and kinematics ›f the objects in the present sample seem to agree with such conclusion, as 4 nebulae have .arge heights from the galactic plane and almost all show large discrepancies relative to the ·otation curve (Dutra and Maciel, 1989). Therefore, these objects do not seem to be of type II ›ut of an intermediate type. As a rough estimate of their evolution, we can assume that, from :he observed relation between the core mass and the progenitor mass (see for example)sterbrock, 1989), a 1 M⊙ star on the main sequence could produce a progenitor of 0.7 M⊙ after ı mass loss of 10^{-6} M⊙ yr^{-1} during about 3 10^5 yr. The low mass core would then be the ·emnant of a strong "superwind" process, where about 10^{-4} M⊙ yr^{-1} would be lost in a :imescale of about 2 10^3 yr. This seems to be supported by strong *present* winds, as all ıebulae in our sample are dense and young, and most display WR spectra, with massive winds.)f course, this poses another problem, as the low luminosities of the central stars would ıake the generally adopted mechanism of radiation pressure less efficient in the process of ıass loss. This remains as another open question, which perhaps could be solved by :onsidering in detail the properties of both planetary nebulae and their central stars.

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