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PLANETARY NEBULAE IN THE MAGELLANIC CLOUDS

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RESUMEN

Presentamos una muestra amplia y homogenea de observaciones ópticas y UV de nebulosas planetarias (NPs) y derivamos sus abundancias así como las implicaciones para estrellas de masa intermedia y la evolución química de las galaxias. Observamos los efectos de la reacción HBB, deficiencia de oxígeno y/o producción estelar (como carbono) durante el 3er. dragado. Todos los efectos son más eficientes a menor metalicidad. Una fuerte precaución a considerar es que el oxígeno no puede ser usado para derivar la composición química inicial del progenitor, sino que hay que usar elementos como azufre o argón.

ABSTRACT

We present a large and homogeneous sample of optical and UV observations of PNe and derive their abundances and the implications for the Intermediate Mass Stars (IMS) and Galactic chemical evolution. We observe the "hot bottom burning" (HBB) reaction, oxygen depletion (ON cycle) and/or production (likewise carbon) during the third dredge-up. All these effects are more efficient at lower metallicity. A strong warning is that oxygen can not be used to derive the initial composition of the progenitor star, but we have to use other elements like sulfur or argon.

Key Words: **GALAXIES: MAGELLANIC CLOUDS — ISM: ABUNDANCES — ISM: GENERAL — PLANETARY NEBULAE: GENERAL**

1. RESULTS

We use a large sample of PNe (> 150) as tracers to cover a wide spread in initial abundances and to improve our knowledge of IMS evolution and element yields with respect to variations in metallicity.

We present results from an optical spectroscopic survey of LMC and SMC PNe, but also combine these data with all published data in the literature and determine several light element abundances. The Type I PNe cannot easily be distinguished from non-Type I on the basis of N or He abundance alone, as continuity exists in all of the diagrams (see Leisy & Dennefeld 2001). The N/O ratio increases with He/H abundance, proof of the mixing of the second dredge-up products into the envelope.

The CN or ON cycles are also more effective with lower initial metallicities and are always complete for Type I nebulae. The third dredge-up *always* takes place (C+N or C+N+O not constant). We observe huge carbon enrichment in the non-Type I PNe, meanwhile this dredged-up carbon is transformed into nitrogen by HBB, but in a few objects only (the more massive) and not even in all the Type I PNe. This fresh carbon is also transformed into ^{13}C or, further, into ^{16}O.

In studies of Galactic chemical evolution through the analysis of gaseous nebulae, the O is usually taken as reference for the global metallicity and then used as tracer of the evolution, assuming that no processing of the initial O abundance has occurred during the progenitor star life-time. Despite that the *average* O in PNe is not different from the mean abundance in H II regions, in various diagnostic diagrams about half the PNe have O above this average value, some objects with large over-abundances. This fact is present in the data shown by various authors in the past, although never specifically commented on, and the issue is also raised in recent theoretical works (Marigo, Bressan, & Chiosi 1996; 1998; Herwig & Blöcker 2000). More interestingly, during this conference we saw several authors questioning the O production in PNe progenitors.

Indeed, O can be affected in at least 2 ways by processing in the PNe progenitor stellar cores:

1. Oxygen destruction occurs during the ON cycle in the more massive progenitors stars (for Type I) and it is strongly metallicity dependent (stronger for SMC than for LMC, see Fig. 1a). The lower abundance in O cannot be due to a lower initial metallicity, as the Type I nebulae arise from higher mass and younger progenitors (with larger Ar abundance).

2. During the third dredge-up, the nebular abundances C and O are enhanced by mixture with freshly core-processed material, these processes

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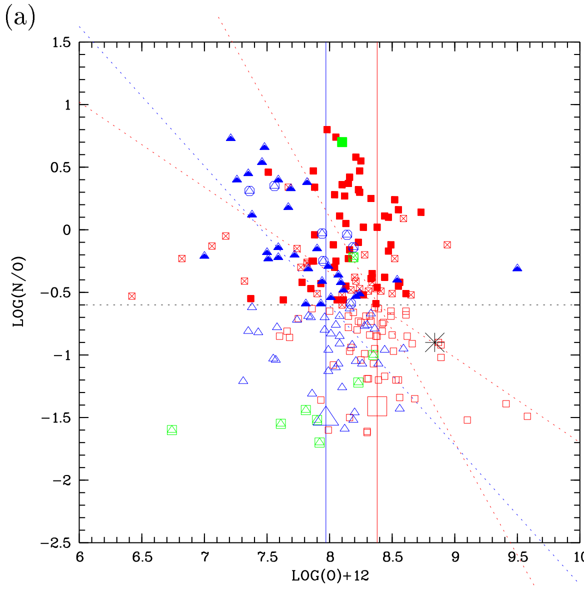
being more efficient for low initial metallicity. During the thermal pulses, fusion of H produces ^{13}C, and O is then also produced from this ^{13}C (but is the reaction rate accurately known?). This reaction is believed to be the strongest source of neutrons, inducing the *s process*: The observed over-abundances of some high atomic weight elements in AGB stars is a direct proof of this reaction. This agrees well with the predictions of semi-analytical models (as Marigo et al. 1996; Herwig & Blöcker 2000). While the O production for solar metallicity seems negligible, large enrichments are predicted for lower metallicity. The explanation of the large observed enrichments lies both in the lower initial metallicities and in the corresponding increase of duration and efficiency of the phase of thermal pulses at the end of the AGB stage.

Therefore one must use elements not affected by transformation during the AGB phase, and whose abundance can easily be determined from optical spectroscopy: argon and sulfur. Unfortunately the emission lines of these elements are usually weak, and not all the ionic stages are observed, especially for S, which requires near IR and IR lines. The abundance determination accuracy for these 2 elements has to increase. In Fig. 1b, only a few objects present an Ar abundance larger than the the one in H II regions (not the case for O). Therefore, if the accuracy increases, Ar and S will allow to trace the chemical evolution of a galaxy.

2. CONCLUSIONS

Low-metallicity galaxies are good targets for studying intermediate mass stars and for tracing the Galactic chemical evolution. The enrichment processes are more efficient in metal-poor galaxies than in our own Galaxy. Oxygen is not a good reference for the initial metallicity, but Ar, S, and maybe Ne have to be used instead.

(a)



(b)

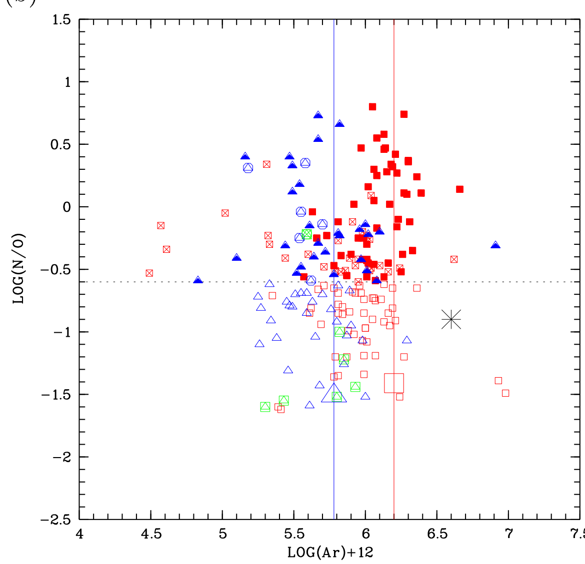


Fig. 1. Measured abundances for PNe in our sample: (a) N/O–O/H (LMC □, SMC △); (b) N/O–Ar/H.

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