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PLANETARY NEBULAE IN THE MAGELLANIC CLOUDS

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RESUMEN

Presentamos observaciones ópticas y UV de PNe y derivamos sus abundancias y las implicaciones para la evolución química. Observamos la reacción HBB y el decremento del oxígeno en las estrellas más masivas por la reación ON, así como una producción de oxígeno (así como carbono) durante el 3^{er} *dragado* (el efecto es más eficiente a bajas metalicidades). El oxígeno no puede ser usado para inferir la composición inicial de la estrella progenitora, debemos usar otros elementos como azufre o argón.

ABSTRACT

We present optical and UV observations of PNe and derive their abundances and the implications for chemical evolution. We observe the HBB reaction and also an oxygen depletion via the ON reaction in the more massive stars, and an oxygen production (like carbon) during the 3^{rd} *dredge-up* (the effect is efficient at lower metallicity). Oxygen cannot be used to derive the initial composition of the progenitor star, we have to use other elements like sulfur or argon.

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

1. INTRODUCTION

We use a large sample of PNe as tracers to improve: *(i)* the spatial distribution to obtain a uniform galactic coverage, *(ii)* the time sampling to cover a wider initial abundances domain, and *(iii)* the knowledge of the intermediate mass star evolution and the yields with respect to metallicity changes.

We present results from our optical spectroscopic survey of LMC and SMC PNe, and also combine these data with all published data in the literature in order to re-analyze a complete and homogeneous sample and determine light element abundances, and also to discuss the LMC-SMC chemical evolution.

2. INTERPRETATIONS

Only preliminary results can be derived because we do not know the initial mass. Nevertheless, some trend can already be defined because: *(i)* the PNe abundance distribution is inhomogeneous contrary to the H II region distribution, and *(ii)* the Type I PNe are not correlated with the LMC and SMC star forming regions. Therefore, the star formation rate was not constant neither in time nor in space, and the PNe distribution traces the different star formation epochs and confirms that the last billion years were "tumultuous". With these large homogeneous abundance determinations we put more constraints on the stellar evolution of intermediate mass stars ($M_i < 8\ M_\odot$).

The Type I PNe cannot easily be distinguished from non-Type I on the basis of N or He abundance alone, since continuity exists in all of the diagrams (Fig. 1 or see Leisy & Dennefeld 1996). The N/O ratio increases

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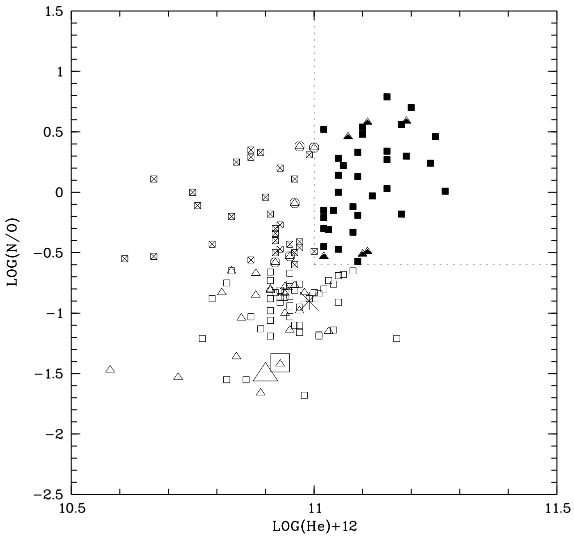

Fig. 1. He/H – N/O (LMC □, SMC △).

with He/H abundance. This correlation is interpreted as the mixing of the 2[nd] *dredge-up* products (He and N) into the envelope. The different slopes are a clear indication that the enrichment processes are more efficient in metal poor galaxies than in our own Galaxy.

We show that the CN or ON cycles are more effective with lower initial metallicities and are always complete for Type I nebulae. The final C+N or C+N+O sum in the PNe is not a constant (proof that the 3[rd] dredge-up always takes place) and is greater than in the reference (H II regions). Huge carbon enrichment (>100 times) is seen in the non-Type I PNe. It is shown that this dredged-up carbon is sometimes transformed into nitrogen by Hot-Bottom Burning, but only in a few objects (the more massive) and not even in all the Type I PNe. This fresh carbon, in proton rich layers is also transformed into ^{13}C or ^{16}O.

In studies of galaxy chemical evolution through the analysis of gaseous nebulae, oxygen is usually taken as a reference for the global metallicity and is then used as a tracer of the evolution, assuming that no processing of the initial O abundance has occured during the progenitor star life-time. The average O in PNe is not different from the mean abundance in H II regions. However, looking into more details in the various diagrams, one sees that 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 upon, and it is also raised by recent theoretical works (Marigo, Bressan, & Chiosi 1996; Marigo et al. 1998; Herwig & Blöcker 1999). Indeed, O can be affected by processing in PNe progenitor stellar cores, and this can happen in at least two ways. First, in the more massive progenitor stars, O destruction occurs during the ON cycle and thus affects the observed abundance. It is strongly metallicity dependent (for Type I and stronger for SMC than for LMC). As the Type I nebulae are generally believed to arise from higher mass and younger progenitors (larger Ar abundance close to the H II region mean value), this effect cannot be due to a lower initial metallicity. Second, we have also shown that nebular abundances are highly enhanced during the 3[rd] dredge-up by mixing with freshly core-processed material. Not only C is produced and transported but also O with the large quantities of He and C available (α capture on a C nucleus). During the thermal pulse phase fusion of H produces ^{13}C, and O is then also produced from this ^{13}C. 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 is particularly true in the Magellanic Clouds because the low initial metal content (enrichment processes are more efficient).

Recent semi-analytical models of Marigo et al. (1996) agree well with our observations. While the O production for a solar metallicity is negligible, an enrichment is predicted at low metallicity. The explanation of the large enrichments observed lies both in the lower initial metallicities and in the corresponding increase of duration and efficiency of the thermal pulses phase at the end of the AGB stage.

The only other elements not affected by transformation during the AGB phase a priori, whose abundances can easily be determined from optical spectroscopy, are argon and sulfur. Only a few objects present Ar abundances larger than those of the H II regions (which was not the case for O). Therefore, Ar and S are good tracers of the chemical evolution of a galaxy in time (over 10 billion years for the PNe).

3. CONCLUSIONS

1. 1st Dredge-up increases the He abundance.
2. 3nd Dredge-up always takes place ($C_{prim} \rightarrow$ N at 100% SMC and $\sim$ 50% LMC).
3. Production rates (CNO cycle – dredge-up – HBB) are more efficient at low metallicity.
4. O destruction (Type I) or O production (non-Type I).
5. O cannot be used as a metallicity tracer, we have to use sulfur or argon instead.

REFERENCES

Herwig F., & Blöcker T. 1999, 35th Liege Ins. Ast. Col.
Leisy P., & Dennefeld M. 1996, A&AS, 116, 96
Marigo P., Bressan A., & Chiosi C. 1996, A&A, 313, 545
__________. 1998, A&A, 331, 564

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