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THE GALACTIC BULGE: THE STELLAR AND PLANETARY NEBULA POPULATIONS

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RESUMEN

Comparamos los patrones de abundancia de los elementos observados en las estrellas y nebulosas planetarias del bulbo galáctico. Algunos elementos α, como Mg y Ti, son sobreabundantes con respecto a Fe; y otros, como He, O, Si, S, Ar, y Ca, no lo son. Los primeros indican una evolución rápida del bulbo galáctico y los segundos, una mucho más lenta.

ABSTRACT

We compare abundance patterns in the Galactic bulge for elements observed in stars and in planetary nebulae. Some α elements, like Mg and Ti, are overabundant in respect to Fe, and others, like He, O, Si, S, Ar, and Ca, are not. The first ones favor a quick evolution of the Galactic bulge, and the seconds a much slower one.

Key Words: **PLANETARY NEBULAE: GENERAL — STARS: ABUNDANCES — GALAXY: BULGE**

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1. INTRODUCTION

Color-magnitude diagrams are nowadays available down to the main sequence in the Galactic bulge with *HST*, and show without any doubt that stars in the bulge are old (Feltzing & Gilmore 2000). However, due to the age-metallicity degeneracy, it is very hard to make precise age determinations. Chemical evolution arguments can be here very helpful.

Planetary Nebulae (PNe) are interesting objects, because they concentrate the energy of their central stars in the emission lines of their spectra, and can therefore be observed relatively easily at this distance. Furthermore the masses of their progenitor stars varying from 0.8 to $8 M_{\odot}$, their ages span from 50 Myr to 25 Gyr, covering more than 95% of the possible ages in the Universe, and of course in the Galactic bulge.

The only stars with a similar age range, where elemental abundances are reasonably determinable at the distance of the Galactic bulge, are the red giants. They are actually the direct precursors of PNe. Some elements have their abundances unmodified by the stellar evolution in red giants as well as in PNe. These elements keep the fingerprints of the chemical composition of the ISM when the progenitor star was born, and because of the span of their ages, they allow to follow its evolution over a very wide time range.

One particular point of interest are the relative abundances of elements produced in Type II and in Type Ia supernovae. Type II supernovae explode very rapidly, after some Myr, e.g., quasi instantaneously on the bulge evolution time scale, whereas Type Ia supernovae explode after a period of the order of one Gyr. The relative abundances of Type II and Type Ia supernovae should thus allow to measure the time scale of the bulge formation.

On the other hand, elements produced during the lifetimes of the progenitor stars should allow to determine their ages—at least statistically. In PNe, nitrogen is very easily detectable, and its abundance has been modified in high mass progenitors, that are short lived. Nitrogen abundances in PNe should thus help to identify recent star formation. Such a recent star formation is not detected in the stars, but this has to be checked in the PNe.

2. ABUNDANCES IN STARS AND IN PLANETARY NEBULAE

We derived abundances for a sample of 30 PNe, that we observed with high quality spectroscopy (Cuisinier et al. 2000). These abundances being of really better quality than others available in the literature, we will only consider these ones here.

Abundances for individual elements in stars are up to now only available for a sample of 11 red giants, from McWilliam & Rich (1994).

Unfortunately, a direct comparison of abundances is not possible, the elements detectable in stars with a good confidence being different from those detectable in PNe.

We compare therefore the distributions of O, S, and Ar in planetary nebulae in the bulge and in the disk, these elements representing the pristine abun-

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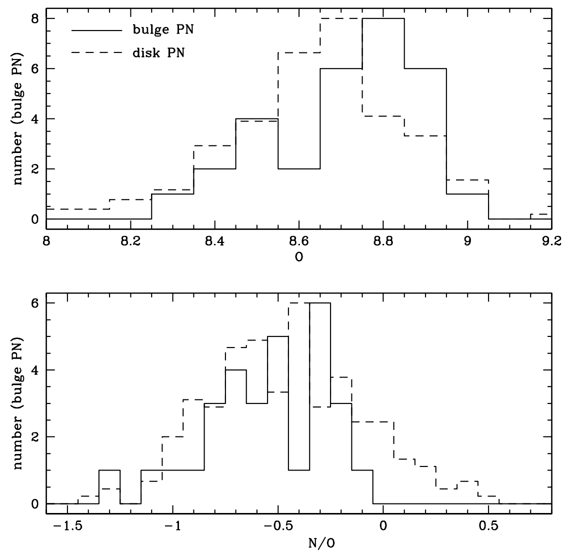

Fig. 1. Top panel: Oxygen abundance distribution, on a logarithmic scale, where 12 is the abundance of hydrogen. Bottom panel: Nitrogen over oxygen ratio distribution.

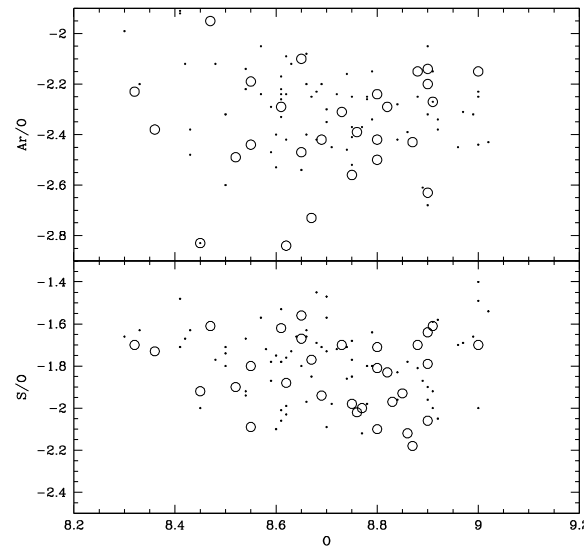

Fig. 2. Ar/O and S/O ratios as a function of the oxygen abundance. Dots represent bulge PNe, points Type II PNe of the disk.

dances of the ISM (Fig. 1, upper panel, for O). We find the abundance distributions to be quite similar, like the Fe abundances in the stars (McWilliam & Rich 1994). Furthermore, a comparison of S/O and Ar/O ratios as a function of the O abundances shows no particular tendency (Fig. 2), they are fairly constant over the whole range of O abundances, at the disk PNe value.

In giant stars, on the other hand, such a comparison shows an overabundance of some elements in the bulge in respect to the disk tendencies (Mg and Ti), and equivalent abundances for other elements such as Si and Ca (McWilliam & Rich 1994).

The N/O ratio comparison in the bulge and the disk (Fig. 1, lower panel) show that the young progenitors, N-rich PNe, that are present in the disk, are lacking in the bulge. From the PNe, like from the stars, the bulge does not seem to have formed stars recently.

If the red giant and PNe populations in the bulge seem to be quite similar in the light of our study, the picture that arises from a comparison of the various elements originating from Type II and Type Ia supernovae that are detected in PNe and in red giants remains very puzzling: Mg and Ti, that are enhanced over Fe, seem to favor a quick evolution, whereas He, O, Si, S, Ar, and Ca show normal abundances patterns, and favor a much slower evolution.

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