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New results on the time variation of the radial abundance gradients from planetary nebulae†

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Abstract. New results on the time variation of the radial abundance gradients in the galactic disk are presented on the basis of four different samples of planetary nebulae. These comprise both smaller, homogeneous sets of data, and larger but non-homogeneous samples. Four different chemical elements are considered, namely, O, S, Ar, and Ne. Other objects such as open clusters, cepheids and HII regions are also taken into account. Our analyses support our earlier conclusions in the sense that, on the average, the radial abundance gradients have flattened out during the last 6 to 8 Gyr, with important consequences for models of the chemical evolution of the Galaxy.

Keywords. planetary nebulae, chemical evolution, abundances

1. Introduction

The time variation of the radial abundance gradients is possibly the most important information that can be obtained from the abundance variations in the galactic disk. In this respect, planetary nebulae (PNe) play a particularly important role, as they have relatively well determined abundances and are originated from stars within a reasonably large mass (and age) bracket (see for example Maciel & Costa 2003).

Using PNe, Maciel *et al.* (2003) suggested a time flattening of the O/H gradient from roughly −0.11 dex/kpc to −0.06 dex/kpc during the last 9 Gyr. More recently, Maciel *et al.* (2005a) extended the original discussion by estimating the [Fe/H] gradient and using other objects such as open clusters, cepheid variables, HII regions and stars in OB associations. In the present work, we consider four chemical elements (O, S, Ar, and Ne) and take into account four different PN samples. A detailed discussion can be found in Maciel *et al.* (2006).

2. The Data

The four samples considered are: (i) the basic sample, which is essentially the same used in our previous work (Maciel *et al.* 2003, 2005a, 2005b, Costa *et al.* 2004). This sample contains up to 234 objects and is the largest one considered, but it is a compilation, albeit careful, of several different determinations in the literature; (ii) the homogeneous sample of Henry *et al.* (2004); (iii) the sample recently presented by Perinotto *et al.* (2004), and (iv) our own data, which we will call the IAG/USP sample. This is a highly homogeneous sample, although relatively small, reaching about 70 nebulae (see Costa *et al.* 2004 for details).

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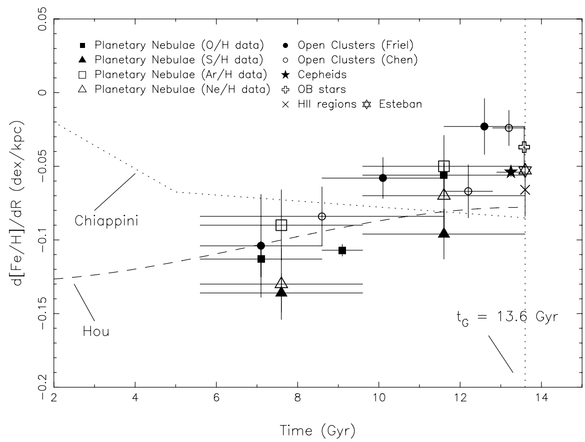

Figure 1. Time variation of the [Fe/H] gradient using PNe, open clusters, HII regions, Cepheids and OB stars. Theoretical models by Hou *et al.* (2000) and Chiappini et al. (2001) are also shown. The age of the galactic disk is taken as 13.6 Gyr.

3. Results and Discussion

Abundance gradients were determined for O, S, Ar, and Ne assuming a linear variation in the abundances with the galactocentric distance R. The ages of the PN progenitors were estimated in the following way. First, the heavy element abundances were converted into [Fe/H] metallicities and then the ages were determined using an age-metallicity relationship (AMR) which also depends on the galactocentric distance. Once the individual ages had been determined, the nebulae in each sample were divided into two age groups, Group I (younger) and Group II (older). We considered the age separation of the groups t_I in the range 3.0 to 6.0 Gyr, and for each of these values we calculated the gradients of Groups I and II. Comparing the derived gradients for all four elements and samples, we conclude that the gradients of the younger Group I are systematically flatter than the corresponding gradients of the older Group II. Considering the other objects studied in our previous work, namely open clusters, cepheid variables, HII regions and stars in OB associations, the general picture of the time variation of the gradients becomes more clear, as can be seen in Fig. 1. Predictions of models by Hou *et al.* (2000) and Chiappini *et al.* (2001) are also shown, as illustrations of theoretical models of chemical evolution. It can be concluded that the flattening rate is essentially the same as derived before, namely, $d[\mathrm{Fe/H}]/dR \sim 0.005$ to $-0.010\,\mathrm{dex\,kpc^{-1}\,Gyr^{-1}}$ for the last 6 to 8 Gyr.

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