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On the total O/H abundance ratio in Galactic and extragalactic H II regions

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Abstract. To determine the primordial helium abundance and to study the chemical evolution of galaxies it is necessary to derive the total O/H ratio in H II regions. To determine the total O/H ratio in H II regions it is necessary to add to the gas-phase component the dust-phase component of O atoms. Based on the Fe/O ratio and other considerations we estimate the dust-phase fraction as a function of O/H.

Keywords. ISM: abundances – H II regions – galaxies: abundances, evolution, irregular – Galaxy: disk – early universe

1. Introduction

In this note we present a preliminary discussion on the fraction of O trapped in dust grains, elsewhere we present a full discussion of this problem (Peimbert & Peimbert 2010a). Mesa-Delgado *et al.* (2009) based on three different methods have estimated that the fraction of O atoms trapped in dust in the Orion nebula amounts to 0.12 ± 0.03 dex.

2. The Fe/O ratio

In Figure 1 we present the Fe/O versus O/H ratio compiled from many sources in the literature. Part of the scatter in Figure 1 could be due to errors in the determinations of the gas-phase Fe/O ratios and part to the different star formation histories of the different galaxies. The closer in time to a recent burst of star formation the lower the total Fe/O ratio in the ISM. In the solar vicinity at present all the O abundance is due to core collapse supernovae, while about 40% of the Fe is due to core collapse supernovae and the other 60% to Type Ia supernovae (e.g. Pagel 2009). There is a time delay in the Fe formation relative to the O formation, and consequently the Fe/O ratio depends on: the star formation rate, the initial stellar mass function, and the gas flows from and into the intergalactic medium. There are two well established Fe/O ratios from observations: the one when the Sun was formed, called the protosolar ratio that amounts to -1.19 dex (Asplund *et al.* 2009), and the present value in the solar vicinity based on observations of B stars that amounts to -1.32 dex (Przybilla, Nieva, & Butler 2008). From the previous discussion we will adopt for the ISM of the objects in Figure 1 a total value of Fe/O = -1.3 dex.

From Figure 1, and assuming that the total Fe/O ratio amounts to -1.3 dex, we obtain that for the Galactic and extragalactic H II regions with abundances in the $8.35 < 12 + \log \mathrm{O/H} < 8.85$ range the average fraction of Fe in the gaseous-phase is about 4% . For the extragalactic H II regions with abundances in the $7.75 < 12 + \log \mathrm{O/H} < 8.35$ range the fraction of Fe in the gaseous-phase is about 20%. For the extragalactic H II regions

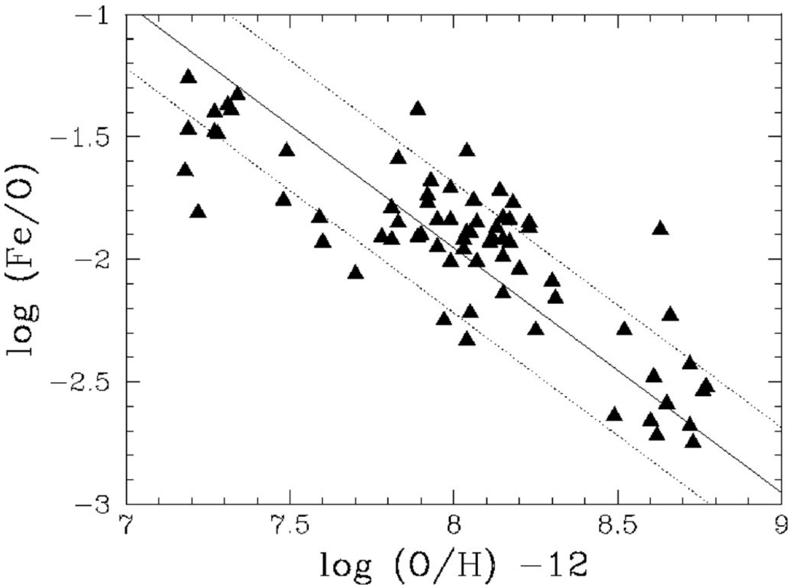

Figure 1. Log Fe/O versus 12 + log O/H gas-phase abundance ratios. The data comes from the literature. The straight line corresponds to 12 + log Fe/H = 6.05 ± 0.27.

in the $7.15 < 12 + \log \mathrm{O/H} < 7.75$ range the fraction of Fe in the gaseous phase is about 40%.

3. Conclusions

We find that the gaseous 12 + log Fe/H ratio is typically in the 6.05 ± 0.27 range for H II regions with 12 + log O/H in the 7.35 to 8.85 range. The almost constancy of the gas-phase Fe/H ratio reflects the efficiency of the processes of dust formation and dust destruction. It probably implies that there is a minimum threshold for dust formation given by a gas-phase 12 + log Fe/H ratio of about 5.7.

We estimate that the dust-phase fraction of O in Galactic and extragalactic H II regions is in the 0.08 ± 0.03 to 0.12 ± 0.03 dex range. We also consider that the H II region abundances derived from the $T(4363)$ method underestimate the O/H ratio by about 0.2 to 0.4 dex (Peimbert & Peimbert 2010b, and references therein). These two effects taken together imply that to obtain the gas-phase plus the dust-phase O/H abundance ratio it is necessary to increase the O/H gas values derived from the $T(4363)$ method by about 0.25 to 0.50 dex.

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