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IRON DEPLETION IN IONIZED NEBULAE OF THE LARGE MAGELLANIC CLOUD[1]

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RESUMEN

Presentamos resultados preliminares de un análisis de la abundancia de hierro en el gas ionizado de tres nebulosas planetarias y una región H II de la Gran Nube de Magallanes (GNM). Comparamos estos resultados con los obtenidos para una muestra de nebulosas Galácticas y extragalácticas. Encontramos que los factores de depleción del hierro en granos de polvo en las nebulosas de la GNM son similares a los encontrados en nebulosas de la Galaxia. Los objetos con menor metalicidad muestran depleciones menores, pero sería necesaria una muestra más grande de objetos para explorar las causas de esta tendencia.

ABSTRACT

We present here preliminary results of an analysis of the iron abundance in the ionized gas of three planetary nebulae and one H II region of the Large Magellanic Cloud (LMC). These results are compared with the ones we obtain for a sample of Galactic and extragalactic nebulae. We find that the amounts of iron depletion into dust grains in LMC nebulae are similar to those found in Galactic nebulae. Objects with lower metallicities show lower depletions, but a larger sample of objects is needed to explore the reasons behind this trend.

Key Words: dust, extinction — H II regions — galaxies: ISM — ISM: abundances — planetary nebulae: general

1. INTRODUCTION

Dust is produced in the outflows of evolved stars, and then is injected into the interstellar medium, where grains can grow in the densest regions, and are eventually destroyed by different mechanisms (Whittet 2003). Planetary nebulae (PNe) and H II regions are powerful tools to study the life cycle of dust grains in the ionized medium. On the one hand, the dust present in PNe was recently formed in the cool atmospheres of their progenitor stars. On the other hand, H II regions contain grains that were located before in the associated molecular clouds, and can be considered processed dust. Therefore, the study of the dust present in ionized nebulae of different characteristics will provide clues on the processes responsible for the formation and evolution of the grains and on the role played by metallicity in the efficiency of these processes.

One way to study dust in ionized nebulae is through the analysis of their iron depletion factor, which is defined as the ratio between the expected abundance of iron and the one measured in the gas phase. Recently, we performed a homogeneous analysis of the iron abundance in a sample of 8 Galactic H II regions and 48 Galactic PNe, and we found that less than 20% of their iron atoms are in the gas (Delgado-Inglada et al. 2009; Delgado-Inglada & Rodríguez, in preparation). Here, we extend this analysis to a sample of extragalactic ionized nebulae, and we explore the behavior of iron depletions at different metallicities.

2. RESULTS

Deep echelle spectra were obtained for the Large Magellanic Cloud (LMC) PNe SMP 1, SMP 48, and SMP 85, and the H II region N11B with the MIKE spectrograph mounted on the 6.5 m Magellan-Clay telescope. The wavelength coverage was 3350–5050 Å in the blue side, and 4800–9120 Å in the red side. Total exposure times on individual objects range from 50 minutes to 1 hour and 15 minutes. For each object, we derived a mean electron density using between two and four different diagnostic ratios, and two electron temperatures. We followed the same procedure as for the Galactic objects: we derived the total gaseous abundance of iron using the Fe^{++} abundance, and correcting for the contri-

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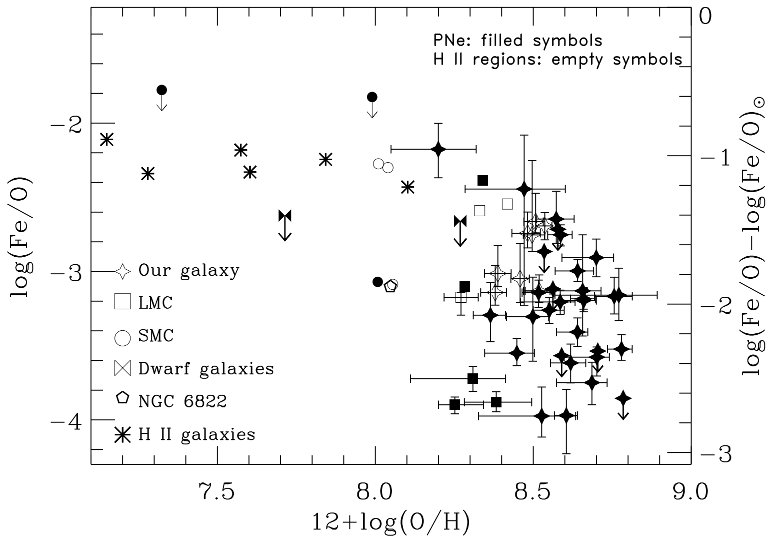

Fig. 1. Values of Fe/O (left axis) and the depletion factors for Fe/O ([Fe/O] = log(Fe/O) − log(Fe/O)$_\odot$, right axis) as a function of the oxygen abundance. Total iron abundances were derived using equations 3 and 4 of Rodríguez & Rubin (2005). Upper limits represent objects with a doubtful identification of the [Fe III] line used in the calculations.

bution of higher ionization states with the ionization correction scheme of Rodríguez & Rubin (2005). We also calculated the iron abundances in a sample of H II galaxies and some extragalactic PNe and H II regions from the literature (Peimbert 2003; Tsamis et al. 2003a,b; Rodríguez & Rubin 2005; Leisy & Dennefeld 2006; Kniazev et al. 2007, 2008; Peimbert et al. 2005; Izotov et al. 2009; López-Sánchez & Esteban 2009).

Figure 1 shows our results for the Fe/O abundance ratio, as well as an estimate of the depletion factor [Fe/O] = log(Fe/O) − log(Fe/O)$_\odot$, as a function of the oxygen abundance for all the objects. We refer the reader to Rodríguez & Rubin (2005) for a discussion of the use of the solar abundance ratio (Fe/O)$_\odot$ to estimate depletion factors at different metallicities.

Rodríguez & Rubin (2005) found a trend of decreasing depletions at lower metallicities. Figure 1 shows a similar result but for a larger sample of objects. This trend is mainly defined by H II galaxies (see also Izotov et al. 2006) and it shows a higher dispersion as the metallicity increases. The trend suggests that iron atoms are significantly less attached to dust grains at low metallicity. This could be due to changes in the efficiencies of the processes responsible for dust formation, growth or destruction.

As we mentioned above, PNe can provide information about the efficiency of circumstellar dust production. However, data for low metallicity PNe are scarce and unreliable (since they are often based on doubtful line identifications). The LMC PNe show iron depletion factors similar to the ones found in Galactic PNe, but PNe with lower metallicity could have lower iron depletions, as in the case of the H II regions. To answer this question, and to study the changes with metallicity of the total range of depletion factors, deep spectra for a larger sample of low-metallicity nebulae, especially PNe, are needed.

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