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AN OVERABUNDANCE OF OXYGEN IN PLANETARY NEBULAE OF THE SOLAR NEIGHBORHOOD

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RESUMEN

Estudiamos la abundancia de oxígeno en cinco regiones H II y siete nebulosas planetarias (NPs) situadas a menos de 2 kpc de distancia del sol que tienen espectros disponibles de alta calidad. Nuestro análisis usa un procedimiento similar y los mismos datos atómicos para calcular las abundancias en todos los objetos. Los resultados encontrados con líneas de excitación colisional para las regiones H II indican que el medio interestelar local es muy homogéneo, con $12 + \log(\mathrm{O/H}) = 8.45 - 8.54$. En cuanto a las NPs, seis de las siete muestran abundancias significativamente mayores: $12 + \log(\mathrm{O/H}) = 8.65 - 8.80$. Esta sobreabundancia de oxígeno en las NPs se mantiene cuando consideramos las abundancias que implican las líneas de recombinación.

ABSTRACT

We study the oxygen abundance in five H II regions and seven planetary nebulae (PNe) located within 2 kpc from the Sun that have available spectra of high quality. Our analysis uses a similar procedure and the same atomic data to derive abundances in all the objects. The results calculated with collisionally excited lines for the H II regions indicate that the local interstellar medium is very homogeneous, with $12 + \log(\mathrm{O/H}) = 8.45 - 8.54$. As for the PNe, six out of seven show significantly higher abundances: $12 + \log(\mathrm{O/H}) = 8.65 - 8.80$. This overabundance of oxygen in PNe also holds when we consider the abundances implied by recombination lines.

Key Words: H II regions — ISM: abundances — planetary nebulae: general

1. INTRODUCTION

We present a comparison between the oxygen abundances derived homogeneously for ionized gas in H II regions and planetary nebulae (PNe) of the solar neighborhood. This approach is the only way in which we can compare the abundances of the interstellar medium (ISM, represented in this context by H II regions) with stellar abundances (represented by PNe) using the same procedure and the same atomic data. Furthermore, the abundance analysis is based on optically thin lines, providing a large advantage over abundances derived directly for stars. We choose oxygen for this analysis because it is the element for which we can get the most reliable abundances in ionized gas. Besides, the oxygen abundance is not expected to be substantially modified by the evolutionary processes that take place in the progenitors of PNe with near-solar metallicity (although the most massive progenitors can achieve a small amount of destruction – see, e.g., Karakas 2010).

In principle, our approach has one disadvantage. Weak recombination lines (RLs) of heavy elements imply higher abundances than collisionally excited lines (CELs), by factors around or above 2, both in H II regions and PNe (e.g., García-Rojas et al. 2006; Liu et al. 2000). To avoid this difficulty, we will consider here the results implied by both RLs and CELs. However, different explanations of the discrepancy imply that the best abundance estimates will be close to the ones implied by either RLs or CELs, or will be intermediate between them (see Rodríguez & García-Rojas 2010, and references therein). Hence, the interpretation of the results must take into account that the explanation of the discrepancy can be different for H II regions and PNe.

Our sample contains five H II regions (M8, M16, M17, M20, and M42) and seven PNe (NGC 3132, NGC 3242, NGC 6210, NGC 6543, NGC 6572, NGC 6720, and NGC 6884) with deep spectra (Esteban et al. 2004; García-Rojas et al. 2006, 2007; Liu et al. 2004; Tsamis et al. 2003; Wesson & Liu 2004). All the objects have individual distance determinations locating them at distances below 2 kpc. This constraint should minimize the effects of the Galactic abundance gradient. The PNe were selected from the sample of low-ionization nebulae compiled by Delgado-Inglada et al. (2009), and are estimated to have $\mathrm{O}^{3+}/\mathrm{O} < 0.15$. Since no [O IV] lines are observed in the optical along with all the other lines we will be using, this restriction reduces the uncertain-

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