RevMexAA (Serie de Conferencias), **26**, 24–25 (2006)

USING PLANETARY NEBULAE TO DETERMINE THE ABUNDANCE GRADIENT IN THE GALAXY

M. Peña,[1] G. Stasińska,[2] and S. K. Gorny[3]

RESUMEN

Se discuten algunos problemas en la determinación de gradientes de abundancias en la Vía Láctea utilizando nebulosas planetarias. Se propone una nueva determinación usando una muestra amplia y homogénea de objetos y se presenta un nuevo método para determinar las distancias de las nebulosas planetarias de manera consistente.

ABSTRACT

We discuss some problems on the determination of galactic abundance gradients in the Milky Way using planetary nebulae. We reexamine the O/H gradient based on a large homogeneous sample of objects and propose a new method to determine the distances to the PNe.

Key Words: **ISM: ABUNDANCES — PLANETARY NEBULAE: GENERAL**

1. INTRODUCTION

The determination of the abundance gradient in spiral galaxies is crucial to constrain the chemical evolution models of galaxies. For the Milky Way, a lot of effort has been done to estimate the amount for this gradient by using photo-ionized regions (HII regions and PNe), and stars (open clusters, Cepheids, B stars, ...). Different values have been determined generating much controversy. Among the most recent results using PNe, are those of Maciel & Quireza (1999) who reported that gradients flatten with galactocentric distance and those of Maciel et al. (2003) who estimated the ages for different populations of PNe and, based on this, have suggested that the O/H gradient has changed with time, becoming flatter (from -0.11 dex to -0.06 dex) in the last 9 Gyr.

PNe are particularly useful to study the ISM chemistry in galaxies as they probe a larger age range than other abundance indicators. But the use of these objects for determining abundance gradients in the Milky Way requires much attention to a number of things. First, the abundance data sets in the literature should be revised as they are highly inhomogeneous. When comparing the abundances for the same object from different authors (e.g., Aller & Keyes 1987; Kingsburgh & Barlow 1994; Henry et al. 2004), large differences (0.5 dex or larger) can be found. Second, it is known that stellar nucleosynthesis modifies the nebular abundances. Recent modeling of intermediate and low mass stars shows that the PN progenitors can modify the original atmospheric abundances of a number of elements (e.g., He, C, N, O, Ne, Mg, Al), depending on the initial metallicity and other factors (Charbonnel 2005). And, in particular, distances for Galactic PNe are highly uncertain and this strongly affects any determination of abundance gradients. Galactic O/H gradients determined with published abundances and different distance scales as published by different authors, are different.

2. THIS WORK

2.1. *The data-set*

In this work we analyze the behavior of chemical abundances vs. galactocentric distance for a large sample of PNe. We have performed observations with the 2-m telescope of OAN, México, of more than a 100 objects in a consistent manner. High and low resolution spectra were obtained for most of the objects. Our data cover a large wavelength range from about 3700 to 7000 Å. Most of the important line ratios to determine physical conditions (electron temperature and density) for plasma diagnosis were obtained and abundances for He, O, N, Ne, Ar and S have been computed. These data will be published elsewhere (Peña et al. in preparation) as a catalogue of emission line fluxes, physical conditions and chemical composition of the PNe observed.

To increase our sample we have included well observed objects from the literature (Henry et al. 2004;

[1] Instituto de Astronomía UNAM, Apartado Postal 70 264, México D.F., México (miriam@astroscu.unam.mx).

[2] LUTH, Observatoire de Paris-Meudon, Meudon, France (grazyna.stasinska@obspm.fr).

[3] Nicolaus Copernicus Astronomical Center, Torun, Poland (skg@ncac.torun.pl).

Kingsburgh & Barlow 1994; the compilation by Maciel et al. 2003). Thus we have gathered data for more than 240 PNe. From the line emission ratios reported for all these objects, we have recomputed their physical conditions and chemical abundances with the classical method using the electron temperature T(OIII) and the density given by the [SII] lines and the atomic data collected by Stasińska (2005). The abundances computed in such a way for a same object and the data of different authors agree reasonably well although differences of about 0.3 dex still occur occasionally.

2.2. *The distances*

The most important uncertainty in analyzing the gradient provided by galactic PNe is their galactocentric distance. All the statistical methods (e.g., Shklovsky 1956, Cahn et al. 1992; Van de Steene & Zijlstra 1994) assume that there is an invariant parameter for all planetary nebulae. To overcome such a problem, we have constructed a wide grid of detailed photo-ionization models, covering ample ranges of stellar and nebular parameters. So far the models are spherically symmetric and a black body distribution is assumed for the stellar fluxes. Free parameters for the grid are the stellar temperature and luminosity, the nebular density, the inner nebular radius and the total ionized mass. Wide intervals for these parameters are used in order to cover the entire range of observed values.

For each object in our sample the distance is obtained by interpolation in the grid, using as constraints the stellar magnitude, the nebular radius, the total flux in Hβ, the HeII 4686 and HeI 5876 fluxes, and the ionization structure (O^{++}/O^{+}, He^{++}/H^{+}, He^{+}/H^{+}, ...). An important constrain for the grid of models is that the *median* of the distances found for PNe within 10 degrees from the Galactic center is 7.94 kpc, the distance to the Galactic Center from Eisenhauer et al. (2003).

Our preliminary distances, when compared with those of Cahn et al. (1992) or Van de Steene & Zijlstra (1994) show a good correlation but a systematic bias that should be carefully analyzed. However our values provide a good distribution of the distances for the PNe within 10 degrees of the Galactic center, contrary to the distributions with the other authors distances. In addition our distances can be largely refined by using more realistic models for the nebulae or for the stellar atmosphere fluxes. The results of this work will be published in detail in Stasińska et al. (2006, in preparation).

2.3. *Our preliminary results*

Based on our data we re-discuss the abundance gradients in the Galaxy. We find a clear gradient for the O/H abundance that seems to level off in the inner parts of the galaxy which would be in agreement with recent stellar data (Smartt et al. 2001). The O/H abundances for bulge PNe show a larger dispersion in agreement with the results found by Gorny et al. (2004). Also a possible vertical gradient (with height from the galactic plane) is found.

Our work however needs to be refined in a number of aspects. In particular, the distance determination method should be checked with distances of PNe in the Magellanic Clouds and other samples with known distances.

M.P. is grateful to D.A.S., U. de Chile for hospitality during a year's sabbatical visit, supported by grants from DGAPA/UNAM and FONDAP/Chile. G. S. and M. P. have benefited from a CNRS/CONACYT grant. G. S. and S.K.G. have been partly supported by the Laboratoire Européen Associé "Astronomie Pologne-France".

REFERENCES

Aller, L. H., & Keyes, C. D., 1987, ApJS, 65, 405
Cahn, J. H., Kaler, J. B., & Stanghellini, L., 1992, A&AS, 94, 399
Charbonnel, C., 2005, in Planetary Nebulae as Astronomical Tools, ed. R. Szczerba, G. Stasinska & S. K. Gorny, AIP Conference Proceedings 804, p. 117
Eisenhauer, F., Schodel, R., Genzel, R., et al., 2003, ApJ, 597, 121
Górny, S. K., Stasińska, G., Escudero, A. V., & Costa, R. D. D., 2004, A&A, 427, 231
Henry, R. B. C., Kwitter, K. B., & Balick, B., 2004, AJ, 1217, 2284
Kingsburgh, R. L., & Barlow, M. J., 1994, MNRAS, 271, 257
Maciel, W. J., & Quireza, C., 1999, A&A 345, 629
Maciel W. J, Costa, R. D. D., & Uchida, M. M., 2003, A&A, 397, 667
Shklovsky, I. S., 1956, Sov. Astron. J., 33, 315
Smartt, S. J., Venn, K. A., Dufton, P. L., et al., 2001, A&A, 367, 86
Stasińska, G., 2005, A&A, 434, 507
Van de Steen, G. C., & Zijlstra, A. A., 1994, A&ASS, 108, 485