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THE [N II]/[S II] GALACTIC GRADIENT DERIVED FROM SNRs

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RESUMEN

De 17 remanentes de supernova que cubren un rango galactocéntrico 5 < R < 14 kpc se encuentra un gradiente de -0.05 ± 0.01 dex kpc^{-1} en el cociente de la intensidad de líneas [N II]/[S II]. Este valor es muy similar al derivado en regiones H II y está probablemente relacionado a un gradiente de abundancias N/S. La posibilidad de contaminación del cociente N/S por las supernovas, así como la variación del cociente [N II]/Hα con la distancia galactocéntrica también son discutidas.

ABSTRACT

From 17 SNRs that cover a galactocentric range 5 < R < 14 kpc it has been found a gradient of -0.05 ± 0.01 dex kpc^{-1} in the [N II]/[S II] line intensity ratio. This value is very similar to that derived from H II regions and is probably related to a N/S abundance gradient. The possibility of contamination of the N/S ratio by the SN as well as the variation of the [N II]/Hα ratio with galactocentric distance are also discussed.

Key words: GALAXIES-MILKY WAY – NEBULAE-SUPERNOVA REMNANTS

I. INTRODUCTION

The study of abundance gradients in spiral galaxies using H II regions has been made by several authors: Searle (1971); Benvenuti, D'Odorico, and Peimbert (1973); Shields (1974); Peimbert (1975); Comte (1975); Smith (1975); Sarazin (1976); Jensen, Strom, and Strom (1976); Collin-Souffrin and Joly (1976); Shields and Searle (1978); Hawley (1978), and Rayo, Peimbert, and Torres-Peimbert (1982). For the Galaxy, there are several studies of abundance gradients using H II regions: Torres-Peimbert and Peimbert (1977); Sivan (1976); Peimbert, Torres-Peimbert, and Rayo (1978); Hawley (1978); Talent and Dufour (1979); Peimbert (1979), and Shaver *et al.* (1982). In the galaxies M 31 and M 33 the gradients have been determined studying supernova remnants: Dopita, D'Odorico, and Benvenuti (1980); Blair, Kirshner, and Chevalier (1981). Recently Binette *et al.* (1982) have obtained abundance gradients in the Galaxy from observations of supernova remnants and their shock modeling program.

In this paper we use the information that was possible to obtain from the supernova remnants to study the problem of chemical abundance gradients in the Galaxy.

II. THE DATA

In Table 1 we show the data used throughout this work. Except for MSH15-5$_6$, all the values for distances and diameters were taken from Ilovaisky and Lequeux (1972), for MSH15-5$_6$ these data are from Clark and Caswell (1976).

TABLE 1

DISTANCE, DIAMETER AND LINE INTENSITY RATIOS OF 17 GALACTIC SUPERNOVA REMNANTS

Object	ℓ	b	R (kpc)	D (pc)	log [N II]/[S II]	log [N II]/Hα
RCW103	332.4	−0.4	5.2	17	+0.32	+0.40
MSH15-5$_6$	326.3	−1.8	7.5	33	+0.30	+0.17
3C400.2	53.7	−2.2	8.1	35	-0.06	+0.08
RCW86	315.4	−2.3	8.1	35	+0.10	+0.08
W28	6.4	−0.1	8.3	20	-0.01	+0.07
W50	39.7	−2.0	8.3	35	+0.10	+0.44
G290.1-0.8	290.1	−0.8	9.7	18	+0.15	−0.17
Cygnus	74.3	−8.5	9.8	50	+0.05	+0.03
Vela	263.4	−3.0	10.1	29	-0.08	−0.02
Monoceros	205.6	−0.1	10.8	55	-0.01	−0.33
S147	180.3	−1.7	11.0	53	-0.22	−0.14
HB9	160.4	+2.8	11.0	43	+0.10	−0.25
MB3	132,7	+1.3	11.5	48	-0.11	−0.31
IC443	189.0	+3.0	12.2	23	-0.14	−0.11
OA184	166.1	+4.4	12.8	64	+0.17	−0.30
CTB1	116.9	+0.2	12.8	48	−0.16	−0.20
VR0420501	166.3	+2.5	14.1	55	−0.18	−0.25

We have used the spectroscopic data of IC443, W28, MSH15-5$_6$, W50, 3C400.2 and G290.1 – 0.8 from the work by Fesen and Kirshner (1980); Dopita, Mathewson, and Ford (1977); Dennefeld (1980); Murdin and Clark (1980); Sabbadin and D'Odorico (1976), and Elliott and Malin (1979) respectively.

For all other objects, the spectroscopy was taken

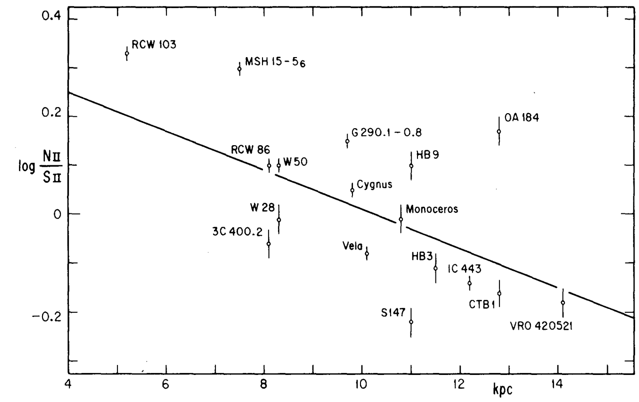

Fig. 1. A plot of the observed I(6548+6584)/I(6717+6731) line intensity ratio versus distance from the galactic center of the supernova remnants of Table 1.

from Daltabuit, D'Odorico, and Sabbadin (1976). In column 1 we give the name of the remnant; in column 2 we have the coordinates ℓ and b; columns 3 and 4 give the galactocentric distance and diameter of the remnant respectively, where we have assumed a galactocentric distance for the sun equal to 10 kpc. In columns 5 and 6 we give the logarithm of the ratios of the intensities of the lines I[N II](6548 + 6584)/I[S II](6717 + 6731) and I[N II](6548 + 6584)/I(Hα). The values given in Table 1 constitute an average for the whole object. We have not included the young remnants CasA and the Crab because their line intensities may reflect peculiar abundances of the material ejected from the supernovae (D'Odorico and Sabbadin 1976), also we excluded the Kepler SNR because of its high density that forced us to consider the collisional de-excitation of the [S II] lines, furthermore it can present some contamination from the supernova because of its small diameter.

We gave a higher weight to the photometric data over the photographic data, considering that we estimated a maximum error of 15% for the former and 30% for the latter.

III. RESULTS AND DISCUSSION

In Figure 1 we present the ratio I[N II]/I[S II] versus galactocentric distance and in Figure 2 we present the ratio I[N II]/I(Hα) versus galactocentric distance. On both figures the error bars represent the maximum errors adopted.

We fitted a straight line to the data in Figure 1. The fit shows a very high correlation and gives us a gradient of the ratio I[N II]/I[S II] along the galactic disk equal to -0.052 ± 0.014 dex kpc^{-1} (where 0.014 is the standard error); this result is similar to that obtained by Sivan (1976); Hawley (1978); Talent and Dufour (1979), and Peimbert (1979) using H II regions. The gradient of I[N II]/I[S II] is caused by a gradient of N^+/S^+, because the ratio of the line is almost independent of temperature and density for low densities (Benvenuti *et al.*

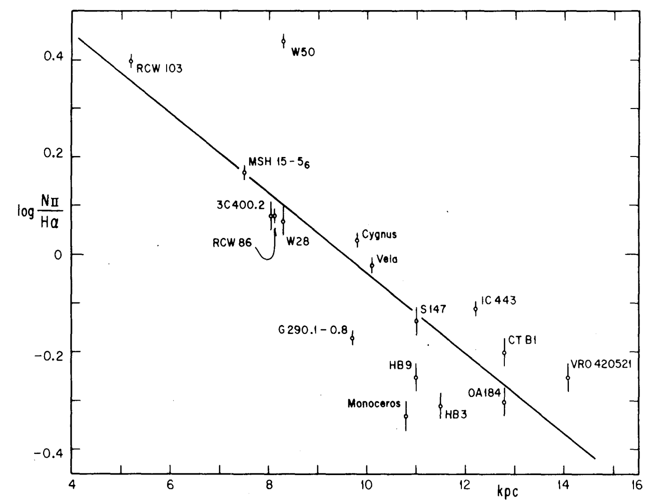

Fig. 2. A plot of the I(6548+6584)/Hα line intensity ratio versus distance from the galactic center.

1973) and probably the gradient in N^+/S^+ reflects the existence of a gradient in N/S. The expected S gradient in our galaxy is similar to that of O, and the observed value of the N/O gradient in H II regions (Peimbert 1979) is similar to the N^+/S^+ obtained from supernova remnants in this paper.

If we just consider remnants with a diameter smaller than 30 pc we also obtain a good correlation and a value for the gradient equal to -0.047 ± 0.018 dex kpc^{-1}, very similar to that mentioned above for the whole sample (-0.052). This result implies that these remnants (with a diameter smaller than 30 pc) probably are not significantly contaminated by the material from the progenitor star and consequently that they can be used to study the gradient.

TABLE 2

GALACTIC ABUNDANCE GRADIENTS

Objects	N/H	N^+/S^+	References
H II region	...	−0.04	(1)
H II region	−0.23	−0.09	(2)
H II region	−0.10	−0.05	(3)
H II region	−0.083	−0.068	(4)
H II region	−0.14	−0.05	(5)
H II region	−0.073	...	(6)
PN	−0.18	...	(7)
PN	−0.09	...	(8)
SNRs	−0.095	...	(9)
SNRs	...	−0.052	This paper

References: (1) Sivan 1976; (2) Peimbert *et al.* 1978; (3) Hawley 1978; (4) Talent and Dufour 1979;(5) Peimbert 1979; (6) Shaver *et al.* 1982; (7) Torres-Peimbert and Peimbert 1977; (8) Barker 1978; (9) Binette *et al.* 1982.

The line fitted to the I[N II]/I(Hα) ratio versus R, gives a very high correlation; we obtain a I[N II]/I(Hα) gradient of -0.085 ± 0.014 dex kpc^{-1}. This value is smaller than the N/H gradient derived from H II regions -0.14 dex kpc^{-1}, Peimbert 1979). The data are presented in Figure 2.

The I[N II]/I(Hα) ratio is very sensitive to electronic temperature, which we expect to be smaller for the objects near the galactic center, because of the higher efficiency in cooling produced by the higher metallicity. It is possible that this temperature gradient, acting in an opposite direction to that of the N/H gradient, may cause a reduction in the I[N II]/I(Hα) gradient. Furthermore, it can cause differences in the ionization degree; with our data it is not possible to relate quantitatively the I[N II]/I(Hα) gradient with the N/H abundance gradient.

Using the N/H and S/H gradients obtained by Binette *et al.* (1982), -0.095 dex kpc^{-1} and -0.07 dex kpc^{-1} respectively, a N/S gradient equal to -0.025 dex kpc^{-1} can be derived. This value is small compared with that obtained in this work. The galactic abundance gradients N/H and N^+/S^+ obtained with H II regions, planetary nebulae and supernova remnants, are shown in Table 2.

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REFERENCES

Barker, T. 1978, *Ap. J.*, **220**, 193.
Benvenuti, P., D'Odorico, S., and Peimbert, M. 1973, *Astr. and Ap.*, 28, 447.
Binette, L., Dopita, M.A., D'Odorico, S., and Benvenuti, P. 1982, preprint.
Blair, W.P., Kirshner, R.P., and Chevalier, R.A. 1981, *Ap. J.*, **247**, 879.
Clark, D.H. and Caswell, J.L. 1976, *M.N.R.A.S.*, **174**, 267.
Collin-Souffrin, S. and Joly, M. 1976, *Astr. and Ap.*, **53**, 213.
Comte, G. 1975, *Astr. and Ap.*, **39**, 197.
Daltabuit, E., D'Odorico, S., and Sabbadin, F. 1976, *Astr. and Ap.*, **52**, 93.
Dennefeld, M. 1980, *Pub. A.S.P.*, **92**, 603.
D'Odorico, S. and Sabbadin, F. 1976, *Astr. and Ap.*, **50**, 315.
Dopita, M.A., Mathewson, D.S., and Ford, V.L. 1977, *Ap. J.*, **214**, 179.
Dopita, M.A., D'Odorico, S., and Benvenuti, P. 1980, *Ap. J.*, **236**, 628.
Elliott, K.H. and Malin, D.F. 1979, *M.N.R.A.S.*, **186**, 45P.
Fesen, R.A. and Kirshner, R.P. 1980, *Ap. J.*, **242**, 1023.
Hawley, S.A. 1978, *Ap. J.*, **224**, 417.
Ilovaisky, S.A. and Lequeux, J. 1972, *Astr. and Ap*, **18**, 169.
Jensen, E.B., Strom, K.M., and Strom, S.E. 1976, *Ap. J.*, **209**, 748.
Murdin, P. and Clark, D.H. 1980, *M.N.R.A.S.*, **190**, 65P.
Peimbert, M. 1975, *Ann. Rev. Astr. and Ap.*, **13**, 113.
Peimbert, M., Torres-Peimbert, S., and Rayo, J.F. 1978, *Ap. J.*, **220**, 516.
Peimbert, M. 1979, in *IAU Symposium No. 84, The Large-Scale Characteristics of the Galaxy*, ed. W.B. Burton (Dordrecht: D. Reidel), p. 307.
Rayo, J.F., Peimbert, M., and Torres-Peimbert, S. 1982, *Ap. J.*, **255**, 1.
Sabbadin, F. and D'Odorico, S. 1976, *Astr. and Ap.*, **49**, 119.
Sarazin, L. 1976, *Ap. J.*, **208**, 323.
Searle, L. 1971, *Ap. J.*, **168**, 327.
Shaver, P.A., McGee, R.X., Newton, L.H., Danks, A.C., and Pottasch, S.R. 1982, preprint.
Shields, G.A. 1974, *Ap. J.*, **193**, 335.
Shields, G.A. and Searle, L. 1978, *Ap. J.*, **22**, 821.
Sivan, J.P. 1976, *Astr. and Ap.*, **49**, 173.
Smith, H.E. 1975, *Ap. J.*, **199**, 591.
Talent, D.L. and Dufour, R.J. 1979, *Ap. J.*, **233**, 888.
Torres-Peimbert, S. and Peimbert, M. 1977, *Rev. Mexicana Astron. Astrof.*, **2**, 281.

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