Oxygen Abundance gradients from PNe and HII

(Are PNe useful for O/H determinations in past epochs ??)

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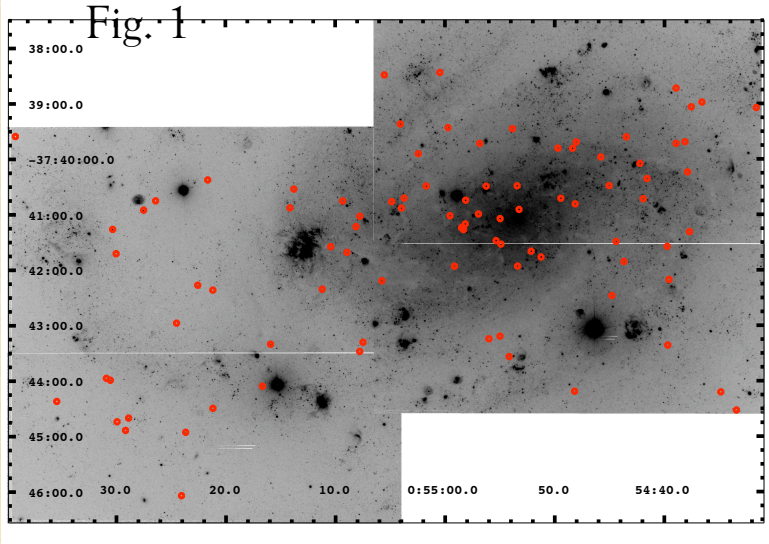
Antecedents

- PNe are important constrains to analyze chemical abundances in the past of galaxies (1 – 10 Gyrs ago). Great interest in studying how chemical gradients evolve with time.
- PNe have been analyzed spectroscopically in several external spiral galaxies and their abundance gradients have been estimated.
- Searching in the literature I have found recent data for M33, M31, M81 and NGC 300 (our work)
- Of course, PNe in the Milky Way have been analyzed and their gradients calculated by many authors (there is a big problem with the galactocentric distances of PNe in he MW, which is not that bad in external spirals)

My intention here is to revise such O/H gradients derived for PNe in comparison with those for HII regions in the same galaxies, looking for similarities or differences.

NGC 300

- **PNe and cHII regions were analyzed by us (GS, FB, YT and myself from spectroscopy with VLT FORS2). HII data obtained from Bresolin et al. (2009), were re-analyzed by us**



PNe were searched in two zones (center and outskirts). In red our candidates. Follow up spectroscopy of about 22 PNe and several cHII allowed to analyze physical conditions and chemical abundances. The behavior of O/H vs. R/R_{25} is shown in Fig. 2

O/H in PNe is much disperse than in HIIs
A clear gradient is found in both cases, but it is flatter for PNe (-0.024 dex/kpc for PNe and -0.067 dex/kpc for HIIs).

§ In the external zone (R/R_{25}> 0.7) O/H in PNe is larger than in in HII regions
§ In the center, O/H in PNe is quite disperse: some PNe have O/H similar to HIIs, many are poorer.

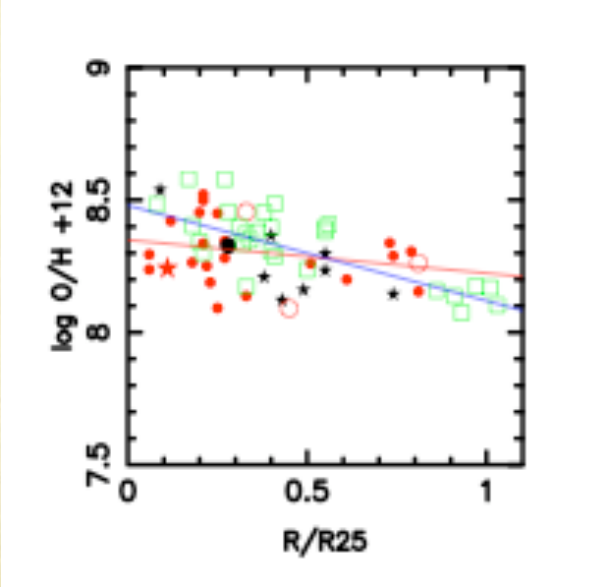


Fig. 2. Red: PNe, green: HII, black stars: cHII

M31

- PNe in the outer disk were analyzed by Kwitter et al. (2012)

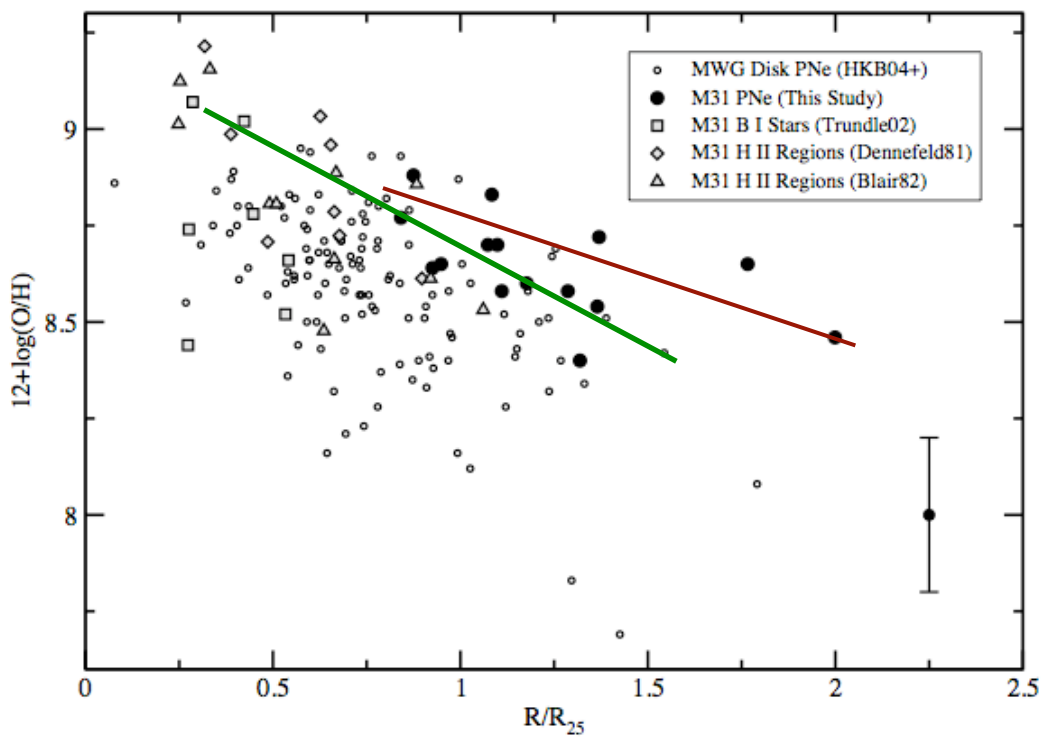


Fig. 12.— The oxygen gradient in M31 PNe. R_{25} values for M31 (22.4 kpc) and the Milky Way (13.4 kpc) were taken from Goodwin et al. (1998). M31 PNe are shown as filled circles; other M31 oxygen probes are shown as well; sources are given in the legend. We include Milky Way PNe (small circles) from HKB04, H10 and references therein; the R_{gal} window for these MW PNe lies between 5 and 20 kpc. A representative abundance uncertainty (±0.2 dex) is indicated in the lower right.

Outer-disk PNe show a gradient
-0.011±0.004 dex/kpc
(in red)

For HIIs, Trundle et al 2002 estimated a gradient from
-0.027 to -0.017 dex/kpc
(average in green)

It seems evident that:

- O/H in PNe is very disperse
- At $R/R_{25} > 0.8$
  O/H(PNe) > O/H(HII)

M33

- PNe were analyzed by Bresolin et al. (2010) and Magrini et al. (2009)
- HII regions, analyzed by Bresolin et al. (2010)

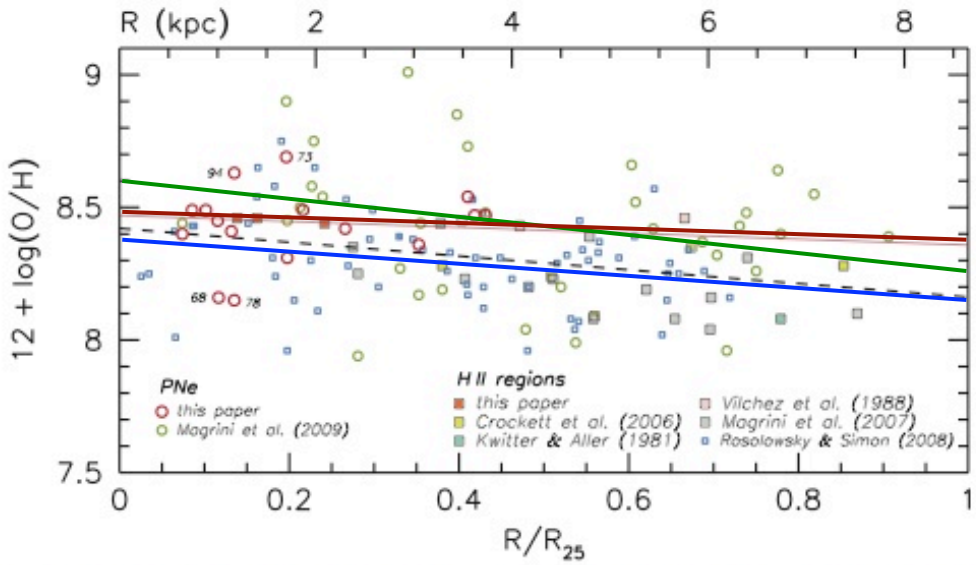


Figure 15. O/H radial gradient for PNe and H II regions. Radial distances are given both in terms of the isophotal radius R_{25} (bottom axis) and in kpc (top axis). The different symbols used are summarized in the legend. Linear regressions are shown by the red continuous line (PNe) and the dashed black line (H II regions). The four planetaries that deviate the most from the PN regression, PN 68, PN 73, PN 78 and PN 94, are labelled.

PNe (circles) very disperse
PNe gradient (red line)
-0.013±0.016

HII gradient (blue line)
-0.030±0.008

B-supergiants gradient (green)
-0.041±0.027

The authors declare equal gradients within uncertainties

However it appears that the gradient for PN is slightly flatter
And some PNe have larger O/H than HII regions at the same R/R_{25}

M 81

- PNe and HII regions analyzed by Stanghellini et al. 2010.

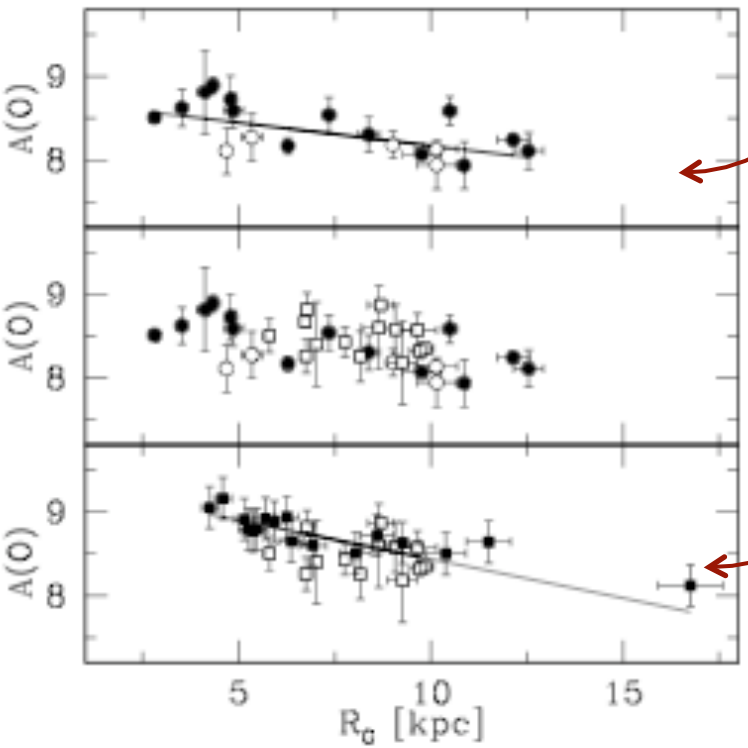


Fig. 5. Oxygen abundances vs. galactocentric distances for M 81 targets. *Top panel*: the observed sample of PNe, with formal error bars and least square fit represented by solid line. Open symbols represent those PNe whose extinction constant might be overestimated. *Middle panel*: the H II region sample from MMT spectra (open squares) superimposed to the PN population of the top panel. *Bottom panel*: the H II regions from GS87 (filled squares) superimposed to the MMT H II regions of the middle panel (open squares). The line represents the least square fit for the combined sample, as given in Table 6.

PNe

HII

Their results:

PN gradient: -0.055±0.02, $O_C \approx 8.7$
HII gradient: -0.093±0.02, $O_C \approx 9.1$

PNe show a flatter gradient!

It appears that at R >13 kpc, the lines could cross

The Milky Way - 1

- Gradients from PNe and HII regions from the literature (it is a mess!)

PNe	reference	HII regions	reference
-0.05 (no-e) 8.9	C04	-0.070±0.015 9.38	Shaver83
-0.016±0.008 8.75	P06	-0.040±0.005 8.82	D00
-0.058±0.006 9.1	H10	-0.060±0.010 8.67	R06
-0.024±0.006 8.75	SH10	-0.044±0.010 9.04 -0.033±0.002 ~9.0	E05 (ORL) A-supergiants Przybilla

References:
C04, Costa et al. 2004
P06: Perinotto & Morbidelli 2006
H10: Henry et al. 2010
SH10: Stanghellini & Haywood 2010
D00: Deharveng et al. 2000
R06: Rudolph et al. 2006
E: Esteban et al. 2005 (ORLs)
Przybylla: this meeting

Time variation of the galactic gradient from PNe:

Analyzing different PN populations (Type I, II, III):

- Maciel et al. 2003 found the gradient flattening with time.
- SH10 found the gradient steepening with time.

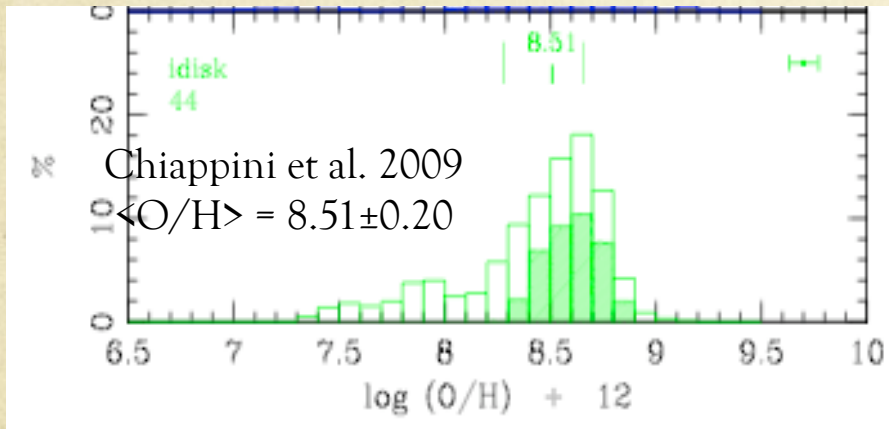
From recent work with A-B supergiants, the gradient for the Milky Way is better known and it appears very flat (Przybilla, this meeting).

But the situation for PNe gradient is far from satisfactory

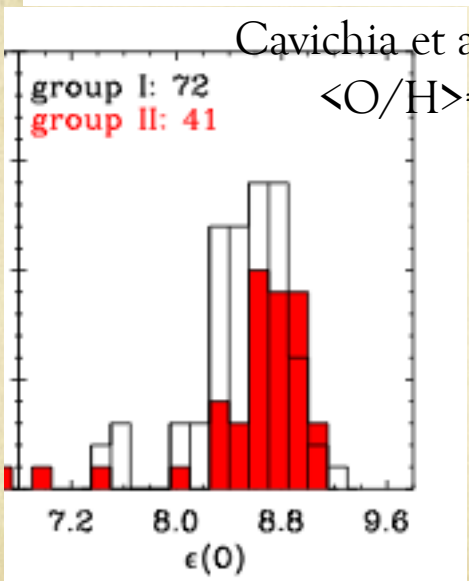
The Milky Way - 2

- For PNe, looking in the recent literature it is found:

Inner disk PNe

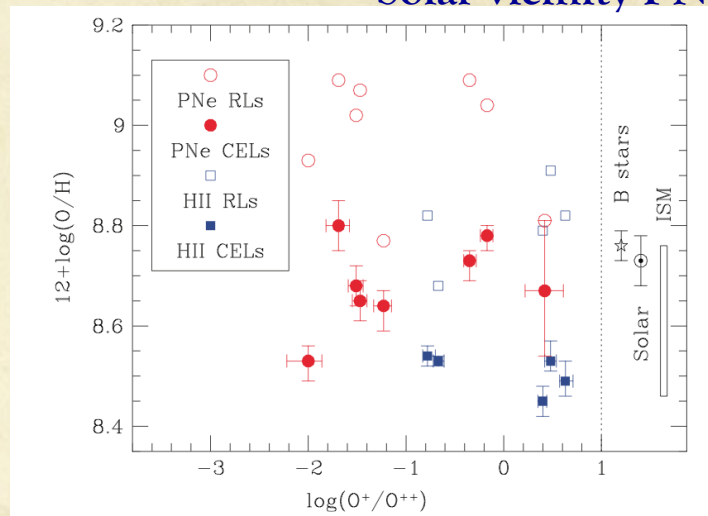


Chiappini et al. 2009
<O/H> = 8.51±0.20



Cavichia et al. 2011 (red distrib.)
<O/H>=8.69±0.06

Solar vicinity PNe



Rodríguez & Delgado-Inglada 2011
<O/H> = 8.70±0.10
$d_{GC} \approx$ 8kpc

If Chiappini et al.'s sample is adopted ($d_{GC} \approx 1$ kpc), it is found a POSITIVE gradient for PNe.
If Cavicha et al.'s is adopted, the gradient for PNe is 0!!

What is apparent is that in the inner disk O(PNe) ≤ O(HIIs) and it is the opposite in the solar vicinity.
PNe gradient is flat and, at some point it crosses the HII's gradient.

Discussion

- For all the galaxies included in this study, M31, M33, NGC300, M81 and the MW, it is found that the slope Δ(O/H) / ΔR is flatter for PNe than for HII regions (the case of M33 is marginal).

- For NGC300, M81, M31 and the MW, O/H in the inner disk is higher in HII regions than in PNe, but at distances of about 0.7 R/R_{25} or larger, the effect is inverted. O/H is higher in PNe than in HII regions

- It is not easy to find a reason, but it appears clear that O depleted in dust grains in HII regions (as suggested by Rodríguez & Delgado-Inglada for the solar vicinity) is not enough as explanation because a large amount of dust is not needed in the inner disk

- Important migration of old population of stars (like the PN progenitors) could be taking place at large scales, **flattening the gradient for PNe**

- Difficult to understand why at large R, PNe show, in average, O/H larger than in HII regions **Are PNe modifying their O at large R?**

- **Based on this, it seems that PNe are, so far, not adequate for analysis of abundance gradients in galaxies in he near past.**

Thanks!!!