Gas-phase Oxygen Abundances and Radial Metallicity Gradients in Nearby Spiral Galaxies

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Introduction and Method

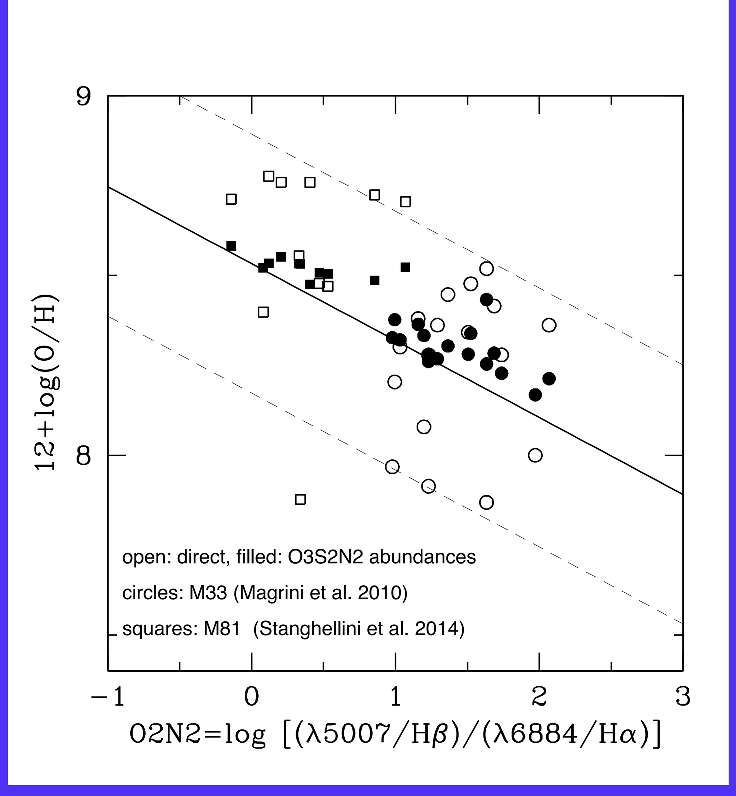
We present a gas-phase abundance study in HII regions of two spiral galaxies, NGC 7793 in Sculptor, and NGC 4945 in the M83 group, which are considered "twins" respectively of M33 and the Milky Way, based on their masses and morphologies.

HII region spectroscopy (and pre-imaging) was performed with GMOS-S. Strong-line abundances have been measured with the O3S2N2 (Pilyugin & Mattsson 2011), and O3N2, N2 (Marino et al. 2013) strong-line calibrations.

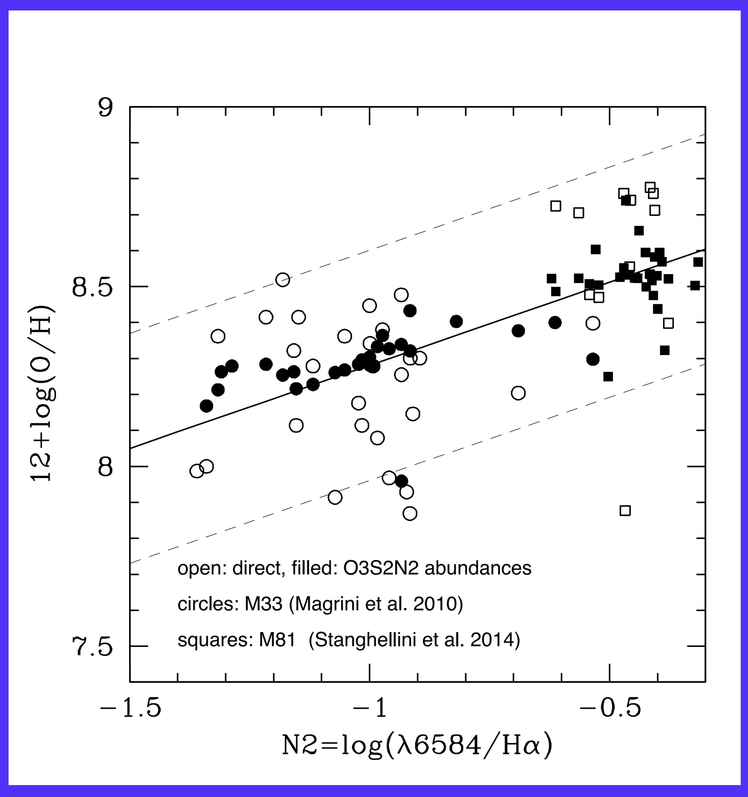
Comparison of strong-line and direct abundances in well-studied galaxies (M33, M81) indicates that the O3S2N2 index should be preferred.

Below, we show the O3N2 and N2 indexes, calibrated with direct abundances of hundred of extragalactic HII regions, against the direct oxygen abundances and O3S2N2-calibrated oxygen abundances of M33 and M81 HII regions observed with Gemini/GMOS and MMT/hectospec by us.

Oxygen abundance vs. O3N2 index.



Oxygen abundance vs. N2 index.



Results

We found that the sub-solar galaxy NGC 7793 has a well-defined gas-phase radial oxygen gradient:

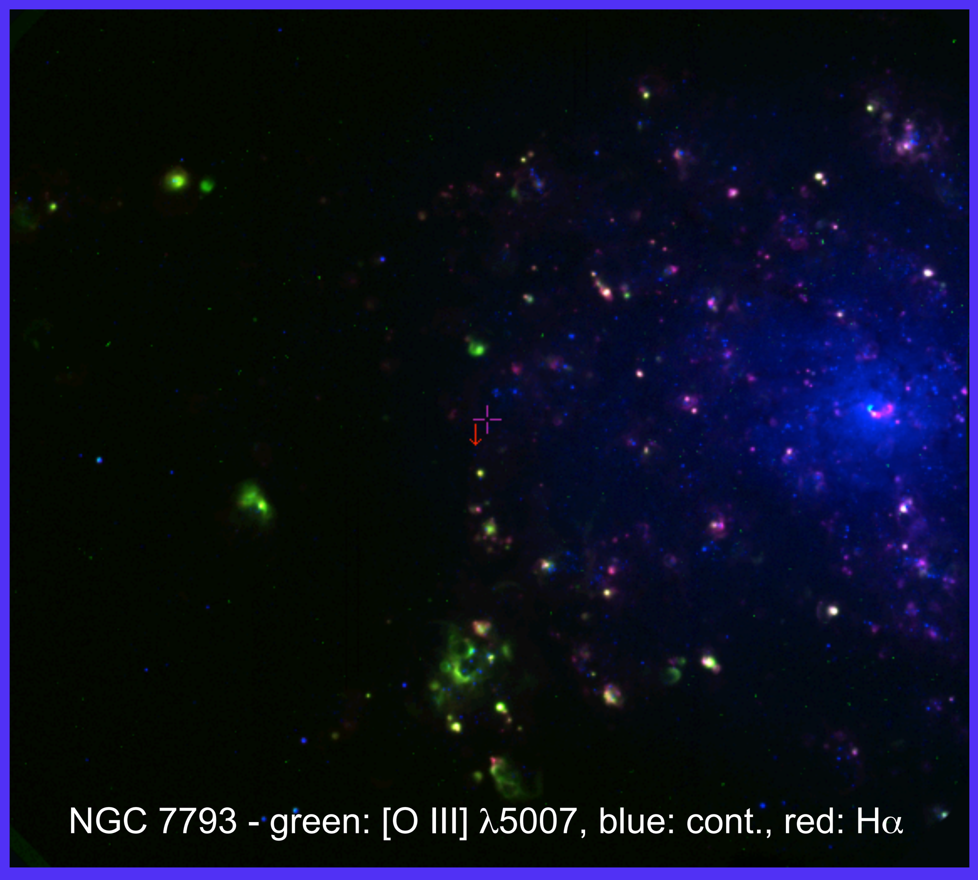
$$\log(O/H)_{NGC\ 7793} = (-0.419 \pm 0.112)\ R_G/R_{25} + (8.633 \pm 0.063)$$

$\Delta \log(O/H)/\Delta R_G = -0.07 \pm 0.019$ [dex kpc^{-1}] $\langle O/H\rangle = (2.64 \pm 0.64)\times10^{-4}$

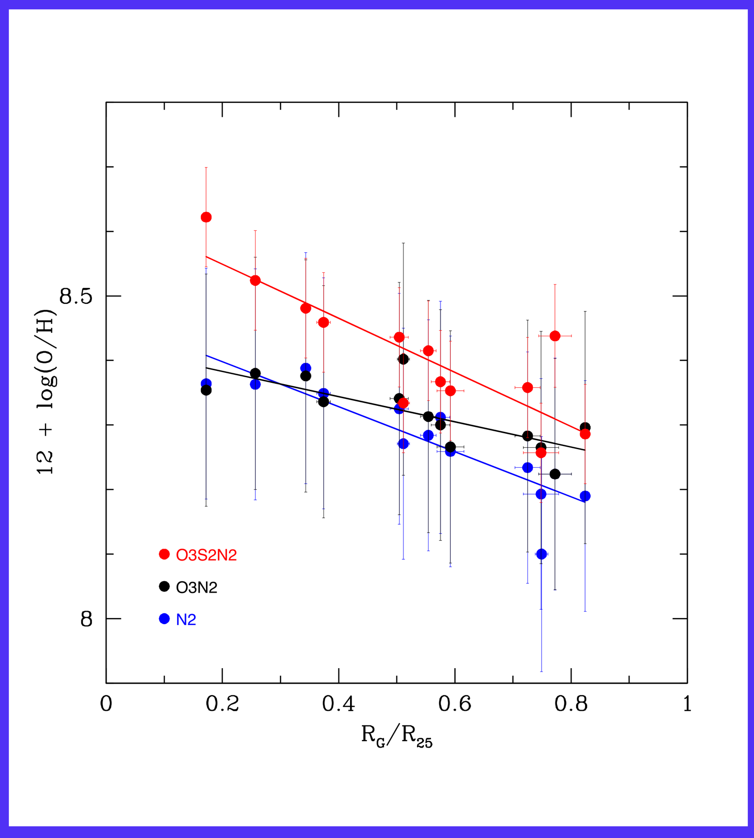
An almost flat radial gradient slope, and with larger uncertainties, for NGC 4945:

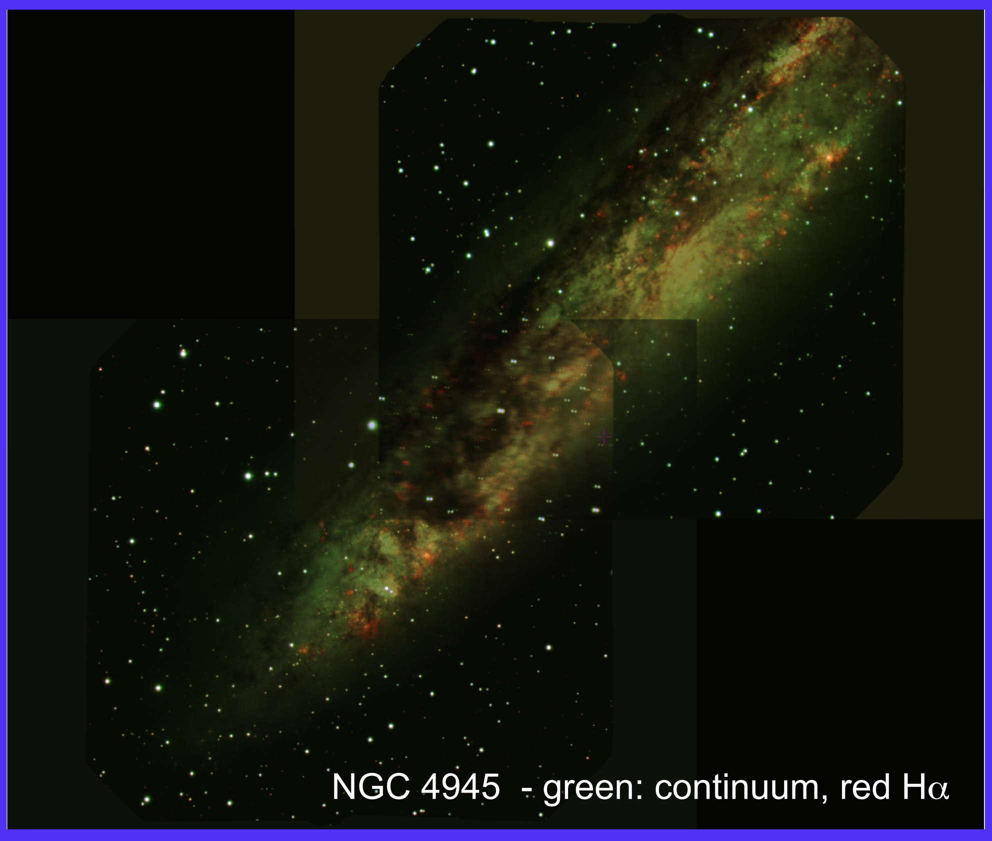
$$\log(O/H) = (-0.240 \pm 0.183)\ R_G/R_{25} + (8.655 \pm 0.048),$$

$\Delta \log(O/H)/\Delta R_G = -0.018 \pm 0.014$ [dex kpc^{-1}] $\langle O/H\rangle = (3.99 \pm 0.47)\times10^{-4}$

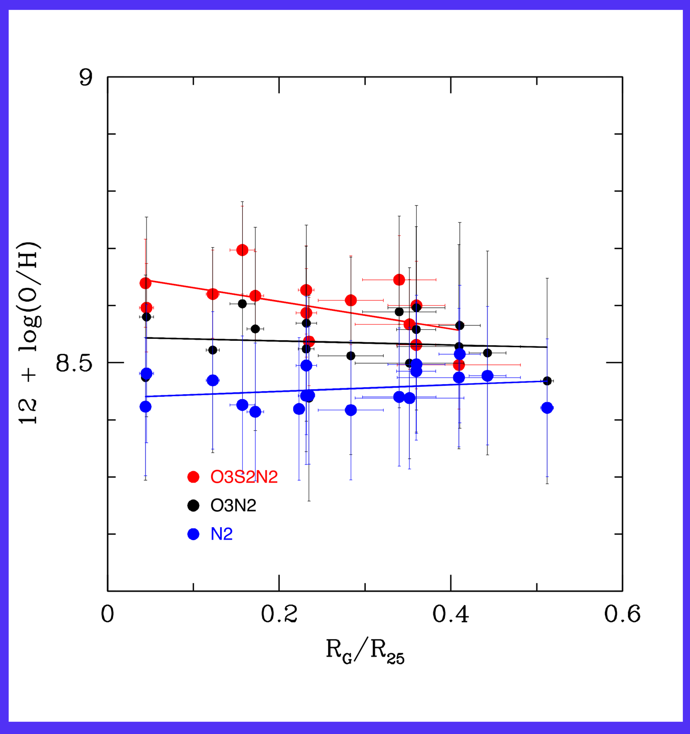

NGC 7793 - green: [O III] λ5007, blue: cont., red: Hα

Radial oxygen gradient of NGC 7793 HII region

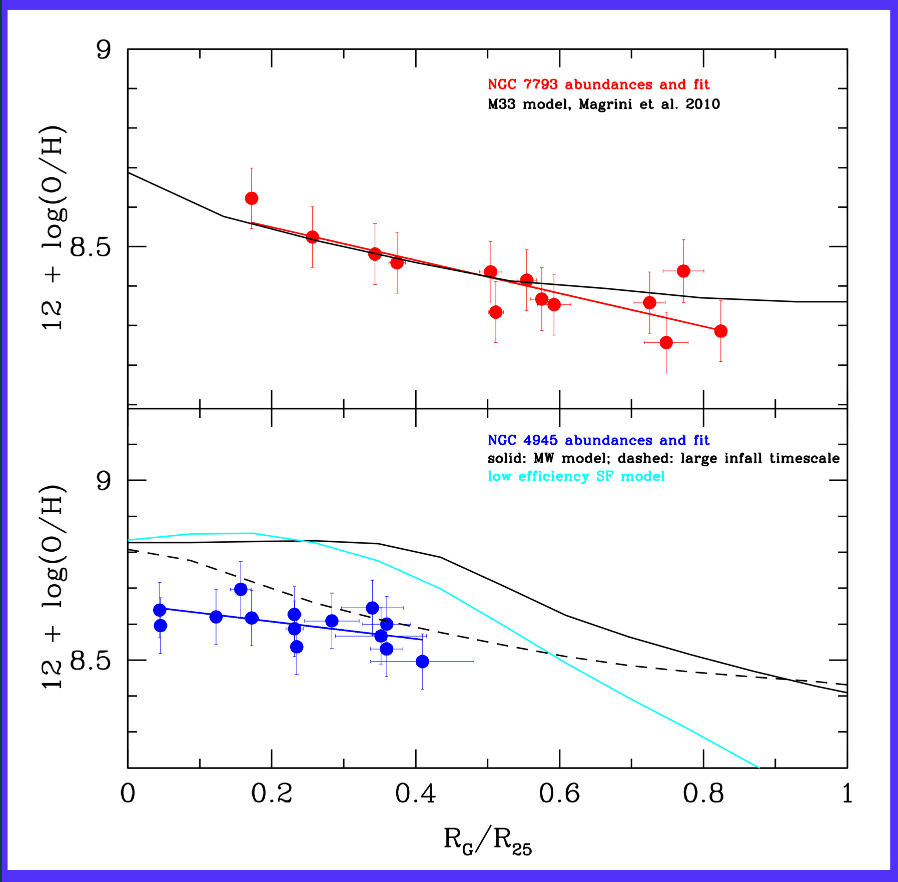



NGC 4945 - green: continuum, red Hα

Radial oxygen gradient of NGC 4945 HII regions



Since, at zero-th order, we expect the radial metallicity gradients to depend on mass and galaxy type, we compared our galaxies in the framework of radial metallicity models best suited for M33 and the Galaxy respectively. We found a good agreement between M33 and NGC 7793, thus disclosing a similar evolution for the two galaxies. We noticed instead differences between NGC 4945 and the radial metallicity gradient model that best fits the Milky Way. We used our modified chemical evolution models to find that these differences are likely related to enhanced infall in NGC 4945.



Top panel: Radial oxygen gradient of NGC 7793 HII regions, with data from our observations and the O3S2N2 abundances, and the M33 model (Magrini et al. 2010). The M33 model is comparable to the NGC 7793 observations for a large fraction of the inner isophotal radius. The relative scaling of the two abundance sets is also very similar.
Bottom panel: same, for NGC 4945, compared to Milky Way models (Magrini et al. 2007). The NGC 4945 gradient approaches the MW gradient when an enhanced infall is added to the basic model.

	NGC 7793	M33	NGC 4945	MW
Type	SA(s)d	SA(s)cd	SB(s)cd	SAB(rs)bc
M_V	-20.01±0.24	-19.4	-20.6	-20.9
M [10^{10} $M_\odot$]	>0.5	0.8 – 1.4	8 – 15	21

Conclusions

- We found that the O3S2N2 method is the most reliable for strong-line abundances
- We derive metallicity gradients for two nearby spiral galaxies.
- We also outlines similarities with other nearby galaxies that have been studied before, starting a study of twin galaxies and their chemical history.
- We plan to extend similar studies to other galaxies. We are also planning to re-examine published gradients with the same method. Since gradients are shallow, accurate uncertainty analysis and using similar method applied to large samples make conclusions reliable.
- Parts of this project are in Stanghellini et al., ApJ, submitted

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