Chemical abundances in nearby galaxies from the Palomar Survey

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ABSTRACT

We present the results for the chemical abundances obtained from the nuclear spectra of a sample of nearby galaxies in the Palomar Spectroscopy Survey. These chemical abundances have been obtained using the code HII-CHI-MISTRY adapted for Active Galactic Nuclei (AGN). The code allows to consider both star forming galaxies and AGN, since both ionizing mechanisms are implemented on it. Whereas a number of recent works analyze the metallicity in Seyferts 2, a systematic analysis is still lacking for low-luminosity AGN, which are the most common in the local Universe. Our work provides a deep study of their metallicity in the nuclear regions of galaxies of all spectral types, providing the ionization mechanisms for their emission lines. We limit the original sample to those galaxies with accurate measurements which amount to a total of 186 galaxies: 107 star-forming galaxies (57.5%), 23 Seyferts 2 (12.4%) and 56 LINERs (30.1%). We also show how the different properties of the host galaxies (morphology, Supermassive Black Hole mass, absolute B-magnitude, H_α luminosity and stellar mass) relate to the chemical abundances obtained for the different objects.

Keywords: Active, Nuclei, ISM, Abundances, Palomar

1. INTRODUCTION AND CONTEXT

1.1. INTRODUCTION

The nuclear emission from a galaxy is explained as due to star formation or AGN activity. The different mechanisms for photoiniozation, emission from hot massive short-life stars (star-forming galaxies) or from the accretion disk surrounding a SMBH (AGN) is translated into differences in the emission lines. In addition, the emissivity of the emission lines depends on the chemical composition of the molecular clouds where the emission lines arise.

The information derived from the metallicity in different regions of galaxies is key for the study of their evolution. The enrichment of the ISM is caused by metals that are formed in the core of stars and driven to the surface by convective flows and deposited into the ISM by stellar winds.

Since the most abundant metal in mass is the oxygen O, the metallicity is usually expressed in terms of the relative density of O to H, by the chemical abundance 12+log(O/H). Another important value is the chemical abundance ratio log(N/O), since it reflects if their metals have a primary (formed during the helium burning of stars) or a secondary origin (already presented in the gas).

1.2. CONTEXT

Chemical abundaces having an impact on the emission lines, their estimation relies upon the measurement of such lines. For many years, different techniques in the optical range were developed to determine the chemical abundances in star-forming galaxies:

1) The direct (or electronic temperature) method, which requires the measurement of faint emission lines (auroral lines).

2) Photoionization models, which generate grids (varying the chemical abundances) of models to match the emission line ratios.

3) Optical calibrations based on strong emission lines.

Only in recent years the above techniques have been applied for AGN, but only tested in Seyferts 2. The optical calibrations for Seyferts 2 only trace the chemical abudance 12+log(O/H), and they assume a fixed relation between O/H and N/O which is observed for star-forming galaxies.

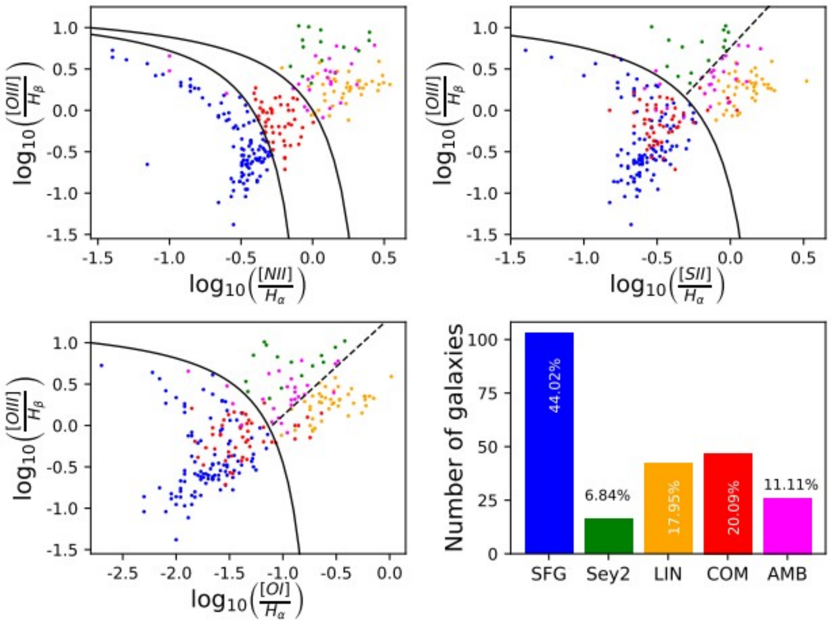
Our study provides an analysis of the chemical abundances for star-forming galaxies and Seyferts 2, and also for LINERs, that are practically omitted in these studies. We use a technique based on photoionization models that does not assume any underlying relation between O/H and N/O.

2. SAMPLE

Our sample of galaxies is based on the Palomar Spectroscopic Survey, with the following restrictions:

1) They show nuclear emission lines once the stellar compontent is substracted.
2) They do not show broad emission lines (Type-I AGN are discarded).
3) Their emission lines are measured accurately (the relative error is below 20%).

Our sample is made of 234 galaxies, classified in the diagnostic diagrams as shown:



Spectral type	Non Ambiguous	Ambiguous	Total	Percentage (%)
Star-forming	103	4	107	45.7
Seyfert 2	16	7	23	9.9
LINER	42	14	56	23.9
Composite	47	-	47	20.1
Unknown	-	1	1	0.4
Sum	208	26	234	100.0

3. METHODOLOGY

To estimate the chemical abundances in our sample of galaxies, we use the HII-CHI-MISTRY (HCm) code, which is based on the construction of photoionization models to match emission line ratios (taken as input) and then provides the values of 12+log(O/H), log(N/O) and log(U).

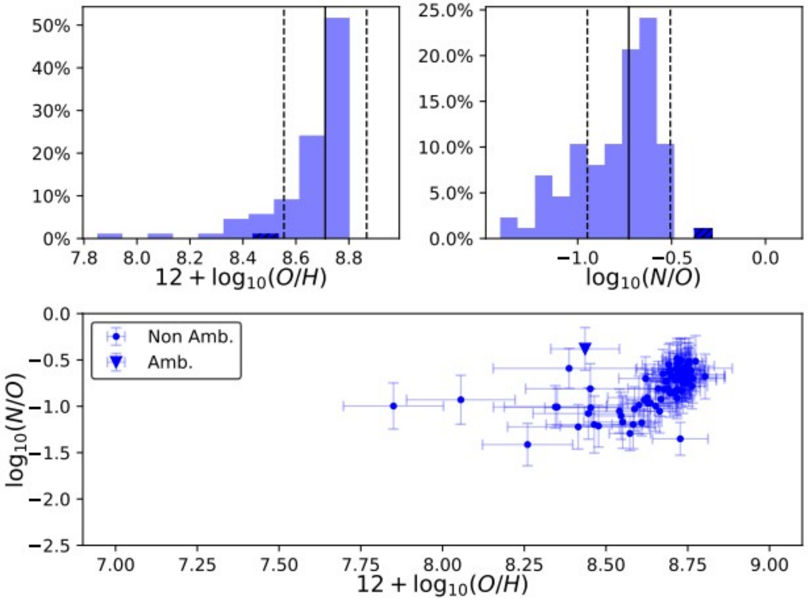
Since we are considering different spectral types (star-forming galaxies and Type-II AGN), we choose different SEDs:

1) Star-forming SED, using POPSTAR code, with a burst of 1 Myr and ratio dust/gas $7.5 \cdot 10^{-3}$.
2) AGN SED, with a Big Blue Bump with a maximum at 13.6 eV, $\alpha_X = -1$ and $\alpha_{OX} = -0.8$.

The stellar masses are estimated from WISE observations available for our sample of galaxies.

4. RESULTS

4.1. CHEMICAL ABUNDANCES IN STAR-FORMING GALAXIES

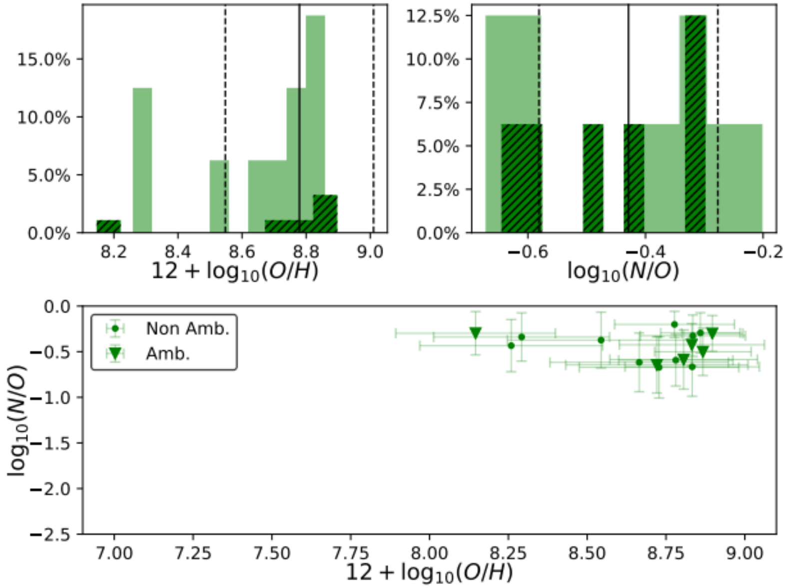


1) 12 + log(O/H) is related to log(N/O): N/O increases with O/H for 12+log(O/H) > 8.6.

2) The ionization parameter U is anti-correlated with O/H (r = -0.92).

3) N/O is bi-valuated for the ionization parameter U.

4.2. CHEMICAL ABUNDANCES IN SEYFERTS 2

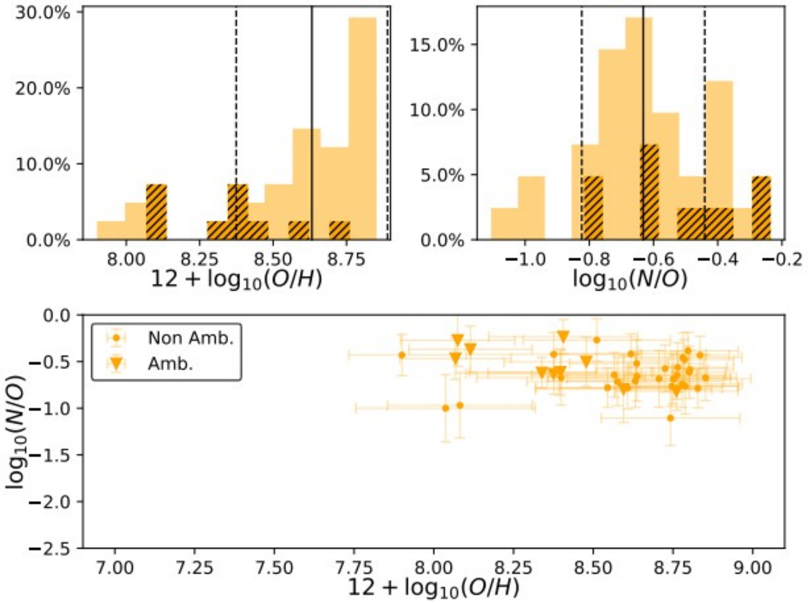


1) The chemical abundances O/H and N/O show higher median values than for star-forming galaxies.

2) The chemical abundances O/H and N/O are not correlated.

3) The ionization parameter U is not correlated either with O/H (r = 0.36) or N/O (r = 0.48).

4.3. CHEMICAL ABUNDANCES IN LINERS

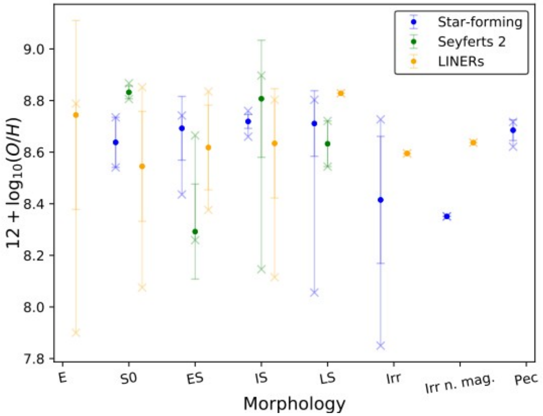


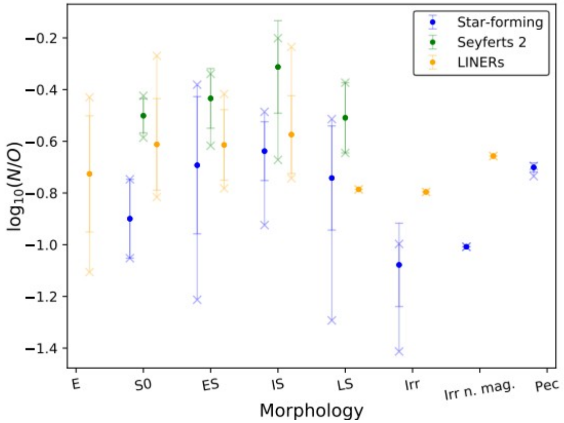
1) The median of chemical abundance O/H is lower than for star-forming galaxies and the median of N/O is similar to that for star-forming galaxies.

2) The chemical abundances O/H and N/O are not correlated.

3) The ionization parameter U is not correlated either with O/H (r = -0.34) or N/O (r = -0.22).

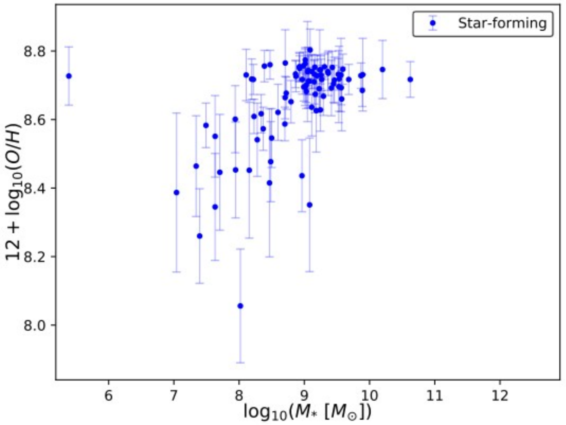
4.4. METALLICITY AND MORPHOLOGY

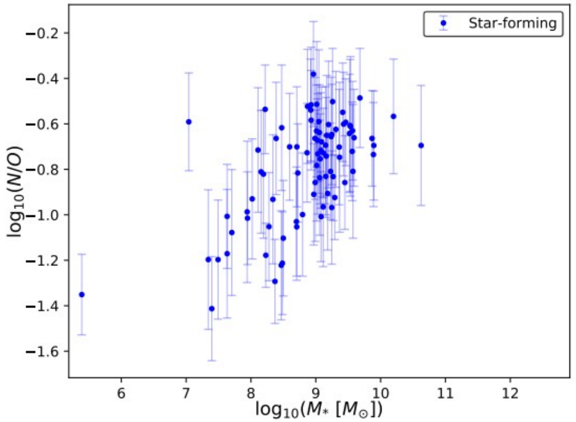




The morphological type only introduces significant changes in star-forming galaxies, showing lower abundances for irregular galaxies. For a given morphology, Seyferts 2 shows the highest abundances.

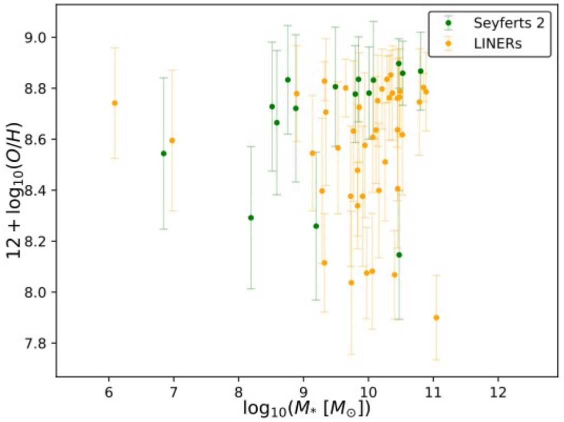
4.5. MASS-METALLICITY RELATION IN STAR-FORMING GALAXIES

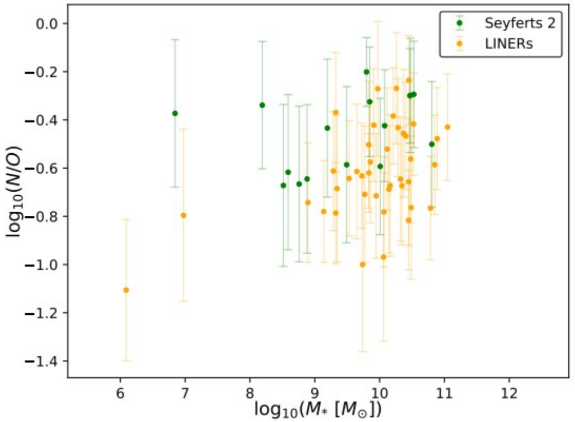




Star-forming galaxies reproduce the mass-metallicity relation: the chemical abundances increase for $\log(M_*) < 9$ and for higher masses the curve is flattened.

4.6. MASS-METALLICITY RELATION IN AGN





Seyferts 2 reproduce the mass-metallicity relation in O/H, but it is more flattened. This relation is not presented in N/O.

LINERs do not show such a relation in any of the chemical abundances.

5. CONCLUSIONS AND IMPACTS

Our study of the Palomar Spectroscopic has probed that the HII-CHI-MISTRY code is a very efficient tool to estimate chemical abundances in large sample of galaxies. This program does not assume any relation between O/H and N/O. Our results show that:

1) There is a relation between the chemical abundances O/H and N/O for star-forming galaxies.

2) No relation is found for both abundances in Type-II AGN.

3) The chemical abundance O/H and N/O is higher in Seyferts 2, followed by star-forming galaxies and then by LINERs.

4) The chemical abundances O/H are strongly anti-correlated with the ionization parameter in star-forming galaxies, but not in Type-II AGN.

Finally, we have studied the impact of different host galaxy properties in the chemical abundances, finding that:

1) The chemical abundances do not show any dependence with M_B^0, $L(H_\alpha)$ or SMBH mass.

2) The morphology slightly changes the chemical abundances for star-forming galaxies, but not for AGN.

3) The mass-metallicity relation is presented in star-forming galaxies and is more flattened in Seyferts 2. LINERs do not present such a relation.

4) The spectral type introduces more changes in the chemical abundances than the host galaxy properties.

6. FUTURE PERSPECTIVES

Our sample of Seyferts 2 galaxies needs to be enlarged, so the results obtained for this class can be confirmed.

Our methodology can be applied for sample of galaxies with better spectral coverage, which will allow us to use larger sets of emission line ratios to estimate chemical abundances.

Our preliminary study of composite galaxies, reveals that most should be considered as star-forming galaxies. Higher spatial resolution spectroscopic data may provide new insights on how important is the star formation for these kind of objects.