SDSS-IV MaNGA: Variations in the N/O - O/H relation bias metallicity gradient measurements

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ABSTRACT

In this paper we use strong line calibrations of N/O and O/H in MaNGA spaxel data to explore the systematics introduced by variations in N/O on various strong-line metallicity diagnostics. We find radial variations in N/O at fixed O/H which correlate with total galaxy stellar-mass; and which can induce $\sim 40\%$ systematic uncertainties in oxygen abundance gradients when nitrogen-dependent abundance calibrations are used. Empirically, we find that these differences are associated with variation in the local star formation efficiency, as predicted by recent chemical evolution models for galaxies, but we cannot rule out other processes such as radial migration and the accretion of passive dwarf galaxies also playing a role.

Keywords: galaxies: abundances - ISM - structure

1. INTRODUCTION

The accurate determination of galactic elemental abundances provides a powerful tool for exploring the assembly and evolution of galaxies into the structures that we see today. Gas-phase oxygen is produced in massive stars and redistributed into the interstellar medium (ISM) by Type II supernovae on relatively short (~ 10 Myr) timescales following an episode of star formation. The concentration of oxygen in the ISM of a galaxy, and spatial gradients in this quantity, are therefore sensitive to a number of physical processes, including gas inflows, gas outflows and the rate of star formation (e.g. Lilly et al. 2013; Belfiore et al. 2019a). The production of nitrogen in galaxies is a more complicated process.

Since the synthesis of nitrogen and oxygen occur in stars of different masses and with different lifetimes, the enrichment of the interstellar medium with these elements occurs on different timescales as well, with nitrogen continuing to be released into the ISM for over a Gyr after an initial burst of star formation (Maiolino & Mannucci 2019, but attributed to Vincenzo *in prep.* therein). This means that with varying conditions of star formation in a galaxy, the ratio of N/O at a given O/H can vary significantly. For example, if the rate of star formation is very high, oxygen is produced by Type II supernovae very rapidly, but the production of nitrogen will lag behind. This has been observed in some high-redshift starburst galaxies, where N/O at a fixed O/H can be up to

Металличность определяют двумя методами из работы Maiolino et al. (2008)

$$R23 = \frac{[OIII]\lambda 5007, 4959 + [OII]\lambda 3726, 3729}{H\beta}. \quad (1)$$

$$\log(R23) = 0.7462 - 0.7149x - 0.9401x^2 - 0.6154x^3 - 0.2524x^4 \quad (2)$$

where x is O/H relative to the assumed solar value of (x = 12 + log(O/H) − 8.69), assuming the solar value derived by

found that the ratio R = [OIII]/[NII] is adequately fitted by a third degree polynomial

$$\log(R) = 0.4520 - 2.6096x - 0.7170x^2 + 0.1347x^3, \quad (3)$$

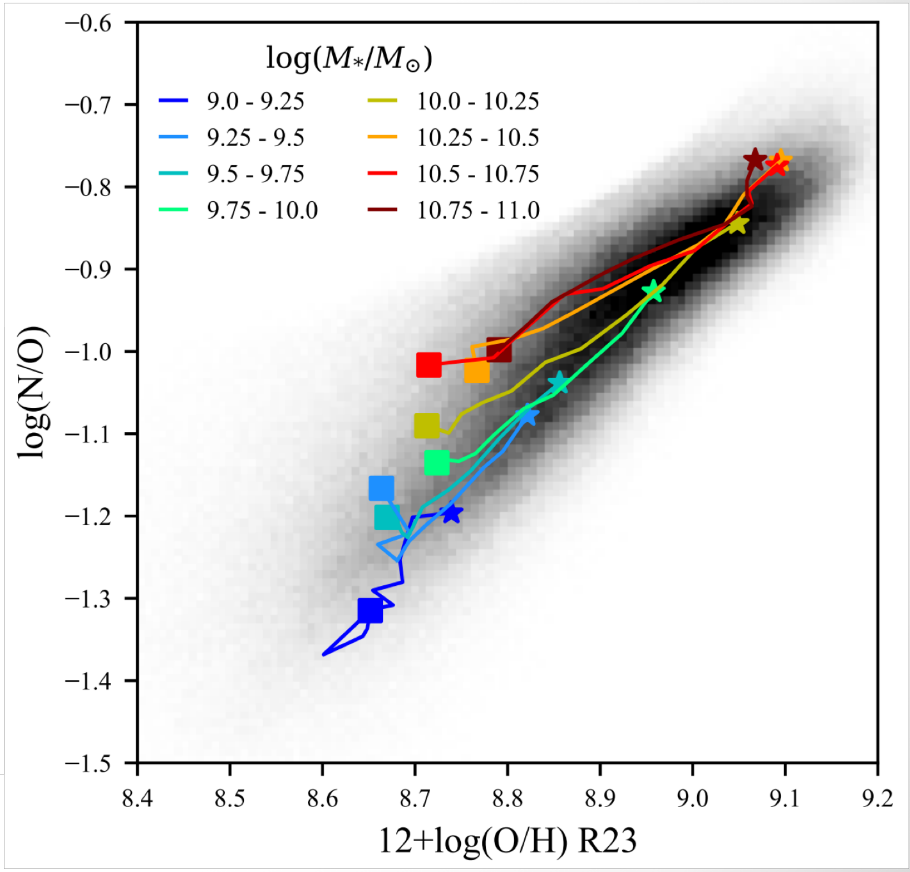
Оценка N/O по [NII]/[OII] и R23

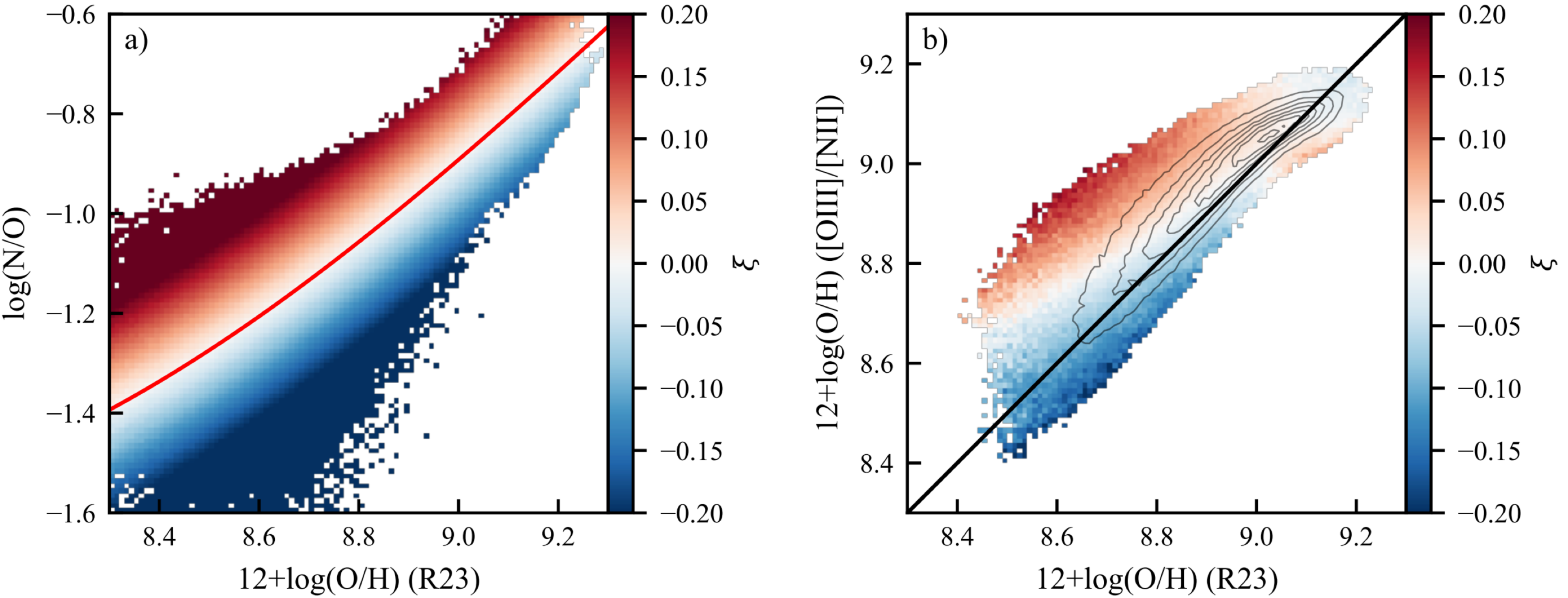
$$\log(N/O) = \log\left(\frac{[NII]\lambda 6548, 6584}{[OII]\lambda 3726, 3729}\right) + 0.307 - 0.02\log(t_{II}) - \frac{0.726}{t_{II}}. \quad (4)$$

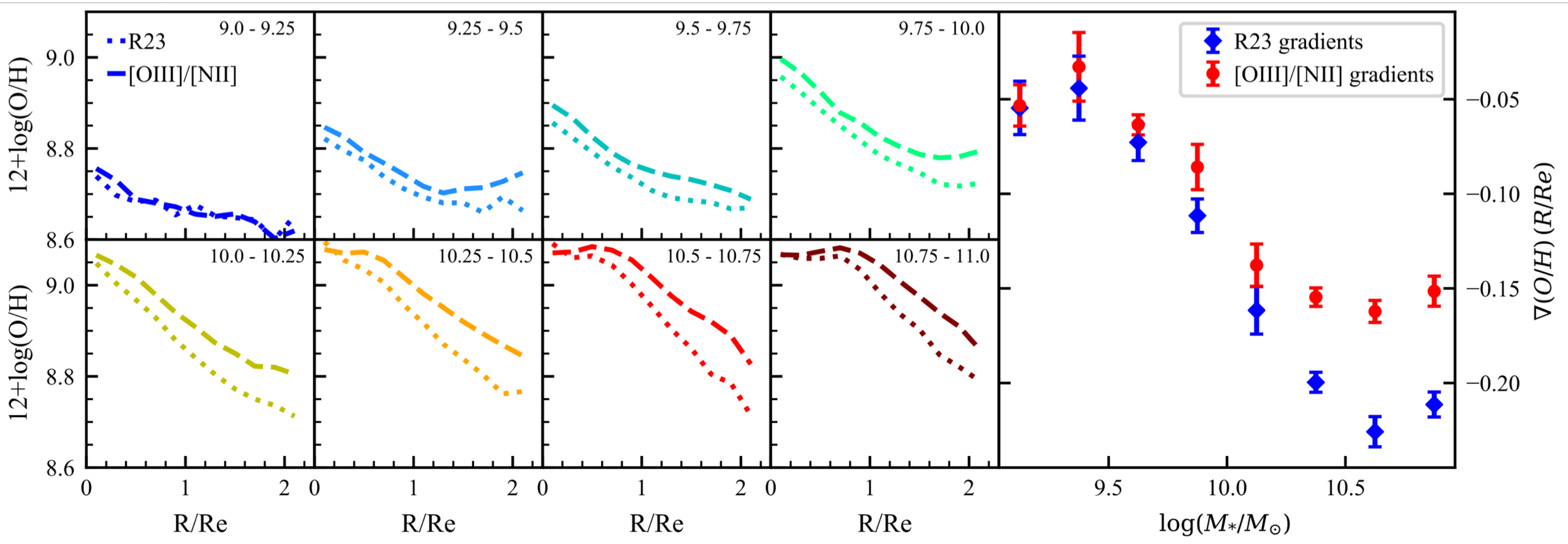
For our purposes, we derive the temperature using the R23 ratio,

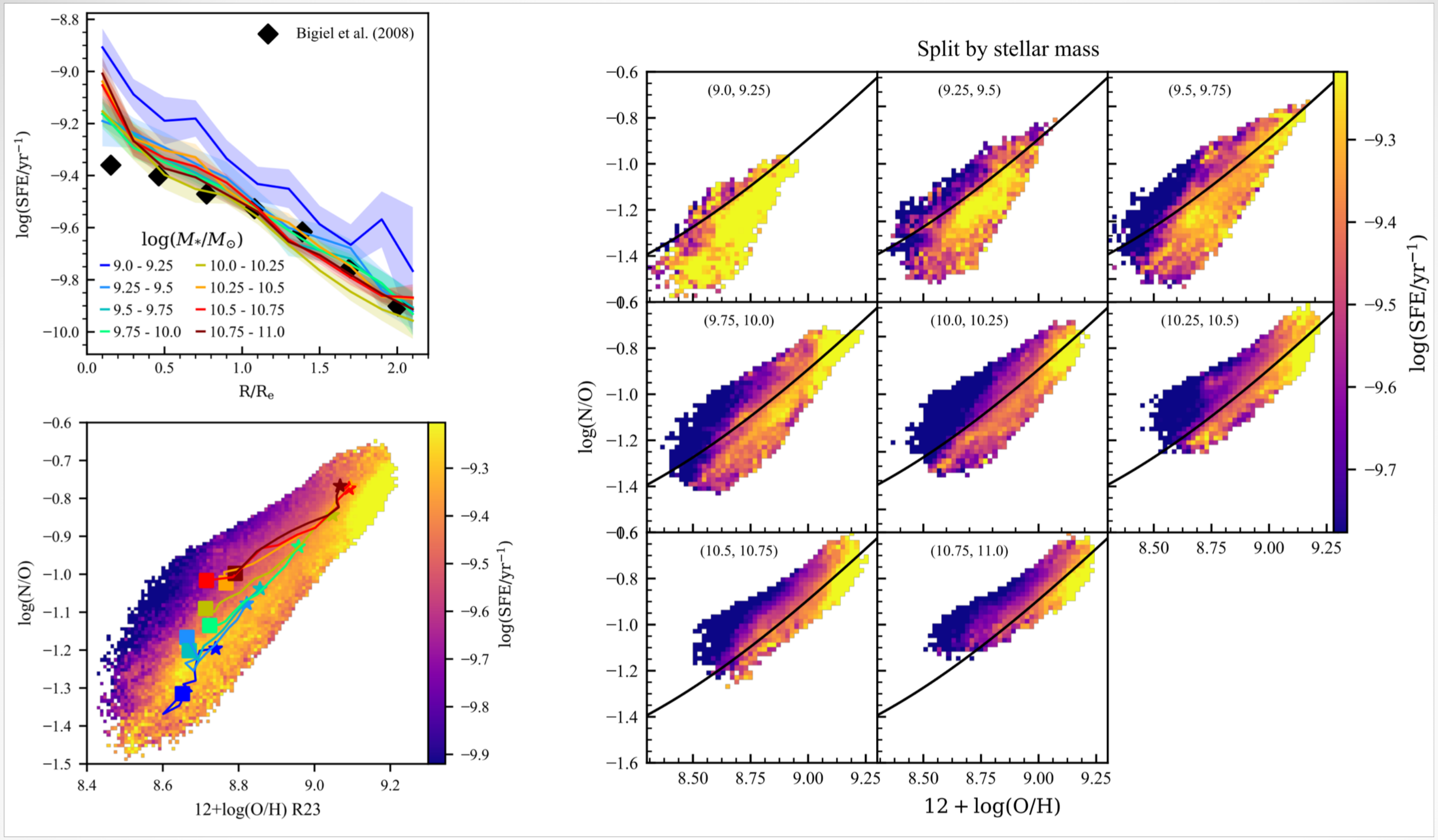
$$t_{II} = 6065 + 1600\log(R23) + 1878(\log R23)^2 + 2803(\log R23)^3, \quad (5)$$

which was derived from a set of photionisation models by Thurston et al. (1996). The estimation of the N/O ratio suffers




a)
b)
log(N/O)
12+log(O/H) (R23)
12+log(O/H) ([OIII]/[NII])
ξ
−0.6
−0.8
−1.0
−1.2
−1.4
−1.6
8.4
8.6
8.8
9.0
9.2
0.20
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.20


R23
[OIII]/[NII]
9.0 - 9.25
9.25 - 9.5
9.5 - 9.75
9.75 - 10.0
10.0 - 10.25
10.25 - 10.5
10.5 - 10.75
10.75 - 11.0
12+log(O/H)
R/Re
R23 gradients
[OIII]/[NII] gradients
∇(O/H) (R/Re)
log($M_*/M_\odot$)
9.5
10.0
10.5
−0.05
−0.10
−0.15
−0.20



Barrera-Ballesteros et al. (2018) and Schaefer et al. (2019): Поверхностную плотность газа считают по поглощению в предположении зависимости dust-to-gas от металличности (Wuyts et al. 2011). SFR – по светимости в Halpha.

Выводы: Вариации N/O влияют на градиент металличности, особенно для массивных галактик. Вероятно, связано с разной эффективностью звездообразования. Предлагают использовать методы, не опирающиеся на N/O или использующие коррекцию.