Informe 30 Abril

YGK

Introduction

This section is dedicated to clear the definitions involved in the following text and introduce the datasets used for each case. The main question surrounding this analysis is whether mass-normalized SFH affects the star-forming galaxy position in the OH-NO diagram. It is important to highlight the importance of the mass-normalized adjective, as any results depending of the mass are note really interesting, since mass is obviously an indicator of O/H (mass-metallicity relation).

The reference dataset wil be SDSS voids from the CAVITY parent sample. A comparison with MPA can be found in Fig. 1, the concordance is good except for the Hβ line, but it is expected given the intrinsic differences between methodologies, and the fact that it is absorption profile-dependent. In fact, only for the Balmer lines there are correlations between the flux and error (Fig. 1, right). The sample presented is for all $\sim$ 1700 galaxies for which the OIII 3727 line can be measured ($z \geq 0.2$). The comparison done here is corrected for foreground galactic extinction but not for internal extinction, as these are the values provided by MPA.

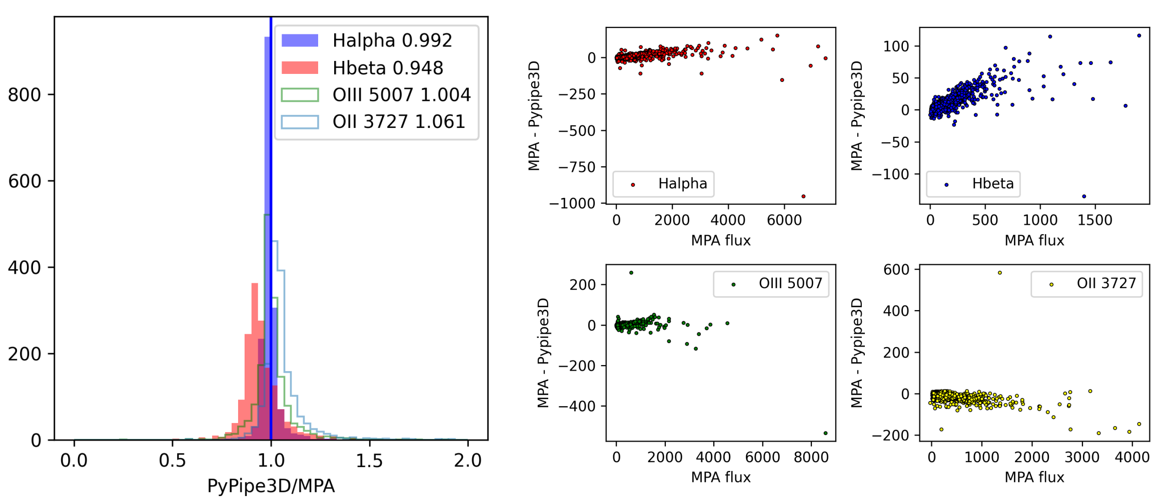

Figure 1: In the left panel, histogram of the ratio between the integrated flux given by PyPipe3D and MPA. In the right panel, the difference between integrated fluxes as function of flux.

In Fig. 2 the diagnostic diagrams are presented. As discussed in a previus meeting, the SII diagram conveys the intersection of the OI and NII diagrams, as galaxies that are both classified as AGN by NII and OI diagrams are most likely too by the SII diagram.

Science

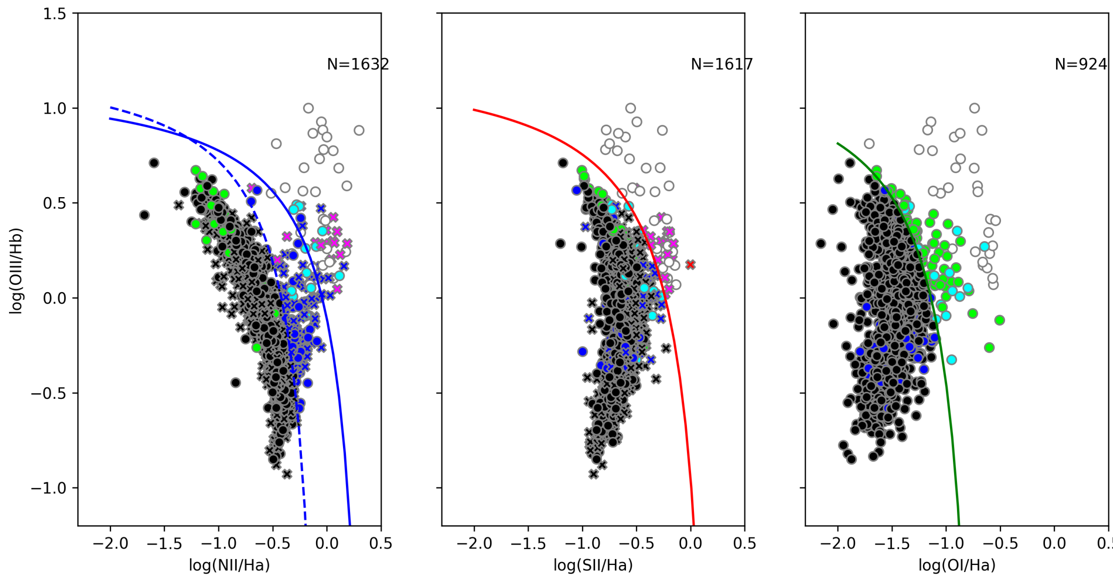

Figure 2: From left to right, diagnostic plots for NII, SII and OI lines. They are color coded depending whether the galaxy is classified as star-forming or AGN by the different plots so that colors are combined or substracted. E.g., galaxies regarded as AGN by the NII and SII diagram are colored magenta (red and blue), galaxies regarded as AGN by NII and OI are colored cyan (blue and green). The crosses in the NII and SII diagrams are datapoints without OI informaiton.

For our dataset, we fix the following quality i) SN > 3 for the emission lines used, ii) star-forming given Kauffman diagram, iii) gas extinction, $A_{v,g} > 0$ (usually this is set to zero for negative values, but this way I do not have to deal with these 5% of galaxies). We can start by responding some basics questions. To use Domínguez-Gómez+'s classification, we crossmatch the results obtained via pyPipe3D with Dominguez-Gómez+'s classification. This sample already has a signal to noise ratio over 20 and is aperture corrected by fixing a limiting radius for the galaxy.

Question 1: Does the long-term, short-term classification have any impact on the N/O distribution?

When we plot the N/O histogram (obtained via Florido+'s N2O2 calibration), we find a higher N/O overall trend for short-term (ST) galaxies, nonetheless, if we sample both distributions so that the mass distribution is the same (Fig. 3, left), these differences largely disappear. This behaviour can be completely explained by the fact that long-term galaxies are biased towards late-type galaxies and viceversa, and the colour-mass relation (Fig. 3, right) Finally, the result directly brings us to the next point: if there is no correlation between N/O and Dominguéz-Gómez's classification, which is closely related to T30 and T50 (the time for which 30 and 50 percent of the mass is formed), then, what SFH variables do have an impact on the N/O distribution?

A short explanation of the mass-controlled sample We first bin the sampled variable (mass) and compare the number of galaxies inside for both LT and ST type galaxies. The number of galaxies per mass bin extracted will be the minimum count between the two samples. For example, if in the range $10 < M_* < 10.5$ there are 40 LT galaxies and 50 ST galaxies, we sample 40 ST galaxies and choose all of the LT galaxies, ultimately balancing the samples by mass. To avoid statistical variations, we do this procedure $N = 1000$ times and plot the average histogram.

Question 2: What SFH variables are correlated with N/O? We propose a myriad of possible variables representative of the SFH and search for direct correlations between them and N/O. The proposed variables are:

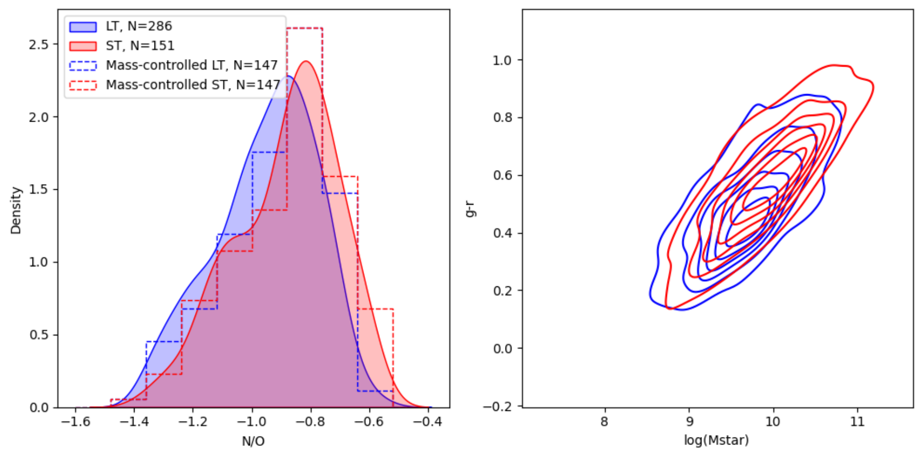

Figure 3: Left panel: distribution of N/O for the voids LT and ST samples with and without mass sampling. Right panel: distribution of LT and ST galaxies in the g-r versus mass plane.

- NO, Florido+24's calibration for NO
- `OH_R23`, the oxygen abundance with R23 calibration
- log(Mstar), the stellar mass as given by Dominguez-Gómez+2021's list
- g-r, color, as provided by Domínguez-Gómez+2021
- T30, pyPipe3D's interpolated time for when the galaxy formed 30% of its mass
- T70, pyPipe3D's interpolated time for when the galaxy formed 70% of its mass
- `T30m_corr`, Dominguez-Gómez+2021's time for the 30% mass formation
- `is_class`, classification in ST (0) and LT (1)

We factually know that sSFR is correlated with NO (Mallery+2007); as a proxy for sSFR we will define

$$\mathrm{sSFR} \equiv \log_{10} \sum_{j}^{100\,\mathrm{Myr}} c_{j,\mathrm{mass}}, \tag{0.1}$$

where $c_{j,\mathrm{mass}}$ is simply the fraction of mass formed at a certaing age. The sum gives the mass fraction formed during the last 100 Myr, which is an upper limit for the death of low-intermediate mass (LIM) stars (N contributors).

In Fig. 4 (see also Fig. 8), we present the correlation matrix for the candidate variables to work as a representative proxy of the SFH. Excluding the well-studied mass-metallicity relation, sSFR and g-r are the only variables significally correlated with NO, with a correlation coefficient -0.57 and 0.64 respectively. Both are at the same correlated, since they give a rough idea about the lattest star formation in the galaxy. Most importantly, there is no apparent correlation between extremely old SFH and present SFH, as the correlation values for $T30$ and sSFR, both from pyPipe3D, and Domínguez-Gómez+2021, are low (-0.041 and -0.35). The comparison between T30 and `T30m_corr` is complex and will be posponed until the final version of the pipeline is implemented. Overall, there seems there is no clear connection between old SFH and N/O. This result is not surprising if we take into account that the path described in the O/H-N/O plane that we can observe is biased for star-forming galaxies, by

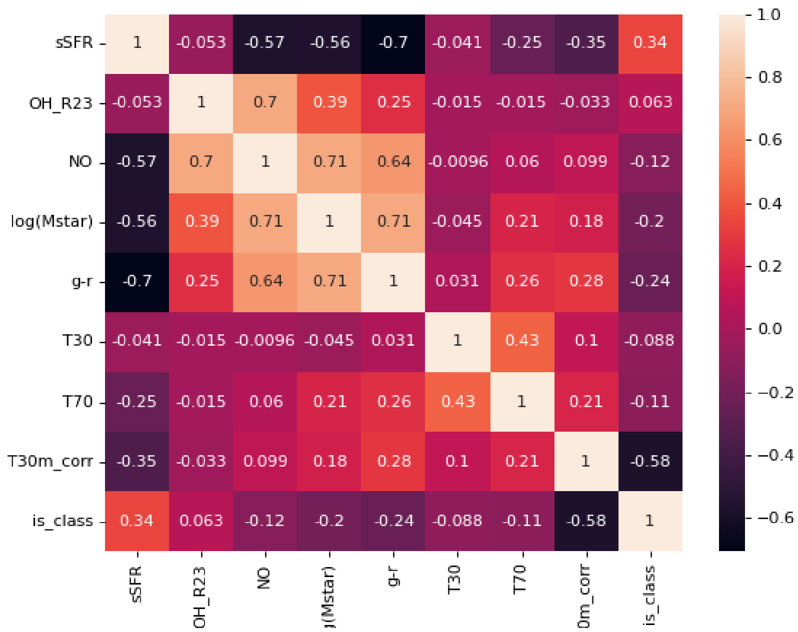

Figure 4: Correlation matrix for the variables described in the main text. The values range from a perfect linear correlation (± 1) and no linear relation (~ 0).

defintion, for bluer, more massive galaxies in the secondary N production regime. This regime already indicates a somewhat evolved galaxy, for which the complex galactic processes can partially erase the information about the past SFH (open-system interactions such as gas accretion, merging, etc).

As it was already addressed in Mallery+2007, the sSFR of a galaxy is an indicator of the ratio between the already contributed nitrogen and the present, recently introduced by massive stars, oxygen. We see this same trend in Figs. 5 and 6 for galaxies in which higher (lower) N/O is linked to lower (higher) sSFR. The bins in left panel are color-coded by the mean sSFR in the O/H-N/O bin and normalized by the median value in the respective column (i.e, approximately same oxygen metallicity). Larger values indicate a lower-than-median sSFR in the corresponding bin when compared to the same oxygen. The results obtained are in line with Mallery+2007. The relation between sSFR, N/O production and the N/O-O/H plane induced by consecutive bursts was has been already presented in Torres-Papaqui+2012, which explains all this paradigm in a whole more detail .

It is clear that there is an effect on the ratio N/O, but we can also check that sSFR has no effect on the O/H coordinate using the same scheme as in Question 1, a mass-controlled sample divided by high and low sSFR. The resulting histogram is shown in Fig. 7 with a division between galaxies with higher (lower) than the median sSFR value. There is no noticeable effect whatsoever in the O/H position, technically contradicting the proposed relation between sSFR and O/H that was displayed in Mollá+2008, more especifically, it is not the sSFR and SFH that positions the galaxy in a "more evolved" position (higher O/H and N/O) but the overall mass production. Laura already pointed this out, as the SFRs shown in figure 7 (in their paper) are not normalized to total production, the models with lower sSFR (higher N/O) simply produced more mass up to that point.

Summary and to-do

As it stands right now, the results indicate that star-forming galaxies follow an almost invariant track in the

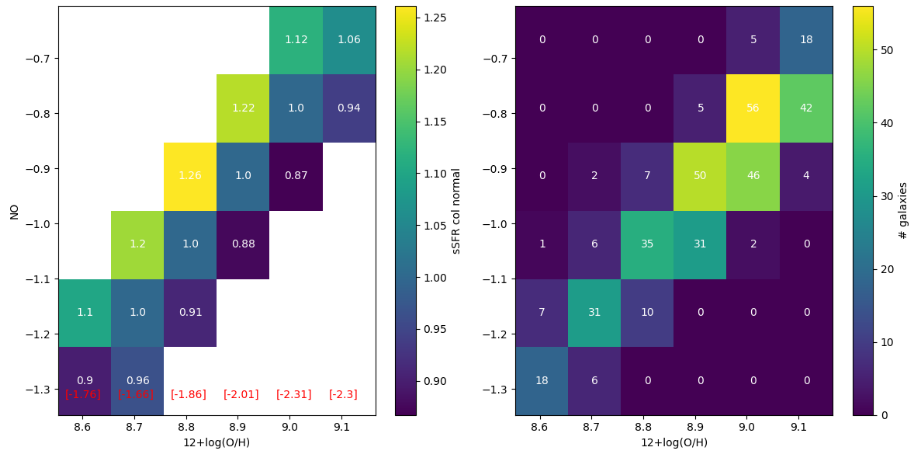

Figure 5: Plot for sSFR and density as a function of N/O and O/H, Tremonti+2004 calibration. The color code in the left panel represents the average sSFR in the bin and is normalized to the median value in each column, i.e, the value is divided by the median value in the same oxygen column. In the sampe panel, the mean sSFR per oxygen column is presented in red. In the right panel, the usual histogram showing the number of galaxies per bin.

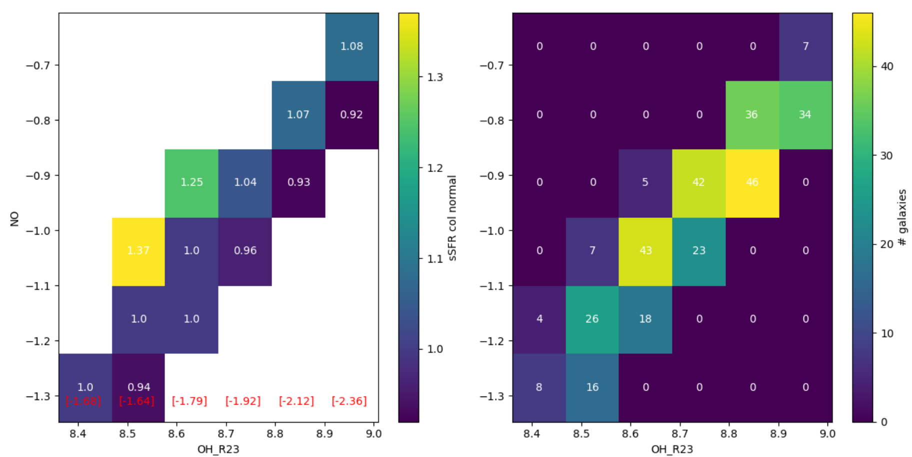

Figure 6: Same as Fig. 5 but with R23's oxygen calibration.

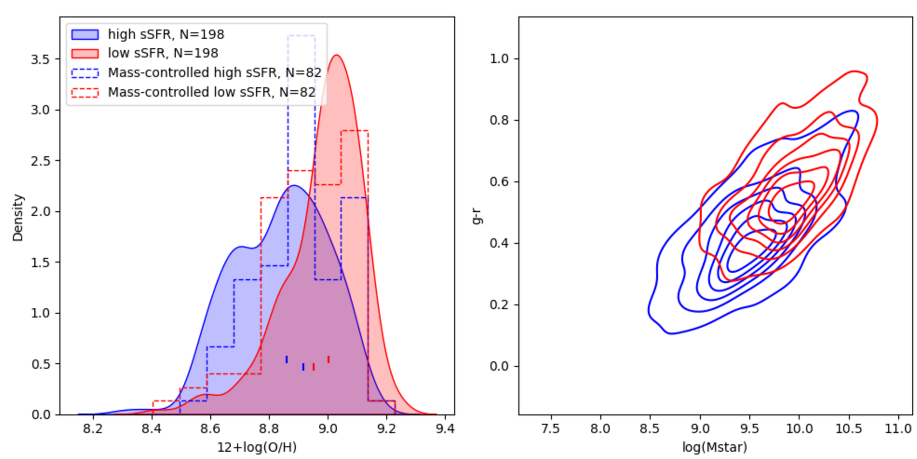

Figure 7: Same as Fig. 3, but with a division between higher than median and lower than median sSFR.

O/H-N/O plane, only perturbed by low or high sSFRs, which could indicate the beginning or end of a burst. The only true real indicator of a more “evolved” galaxy being the stellar mass. I still have planned some things:

- ↪ Create a new classification and double check everything. I will be using Kullback distance to compare the SFR density with a proposed model (flat, i.e, LT model)
- ↪ Plot SII/Hα and other measurements to check no correlations or problems in flux measurements and internal extinction correction (as in e.g., Coziol+1999)
- ↪ Check if there are any density patterns in the O/H-N/O space since some patterns could emerge related to how these SFR bursts are distributed in the cosmological evolution scale.
- ↪ Maybe it would be interesting to plot this N/O evolution for same oxygen and different sSFR timescales (100, 50, 20 Myr). Could be used to constrain the actual time onset.

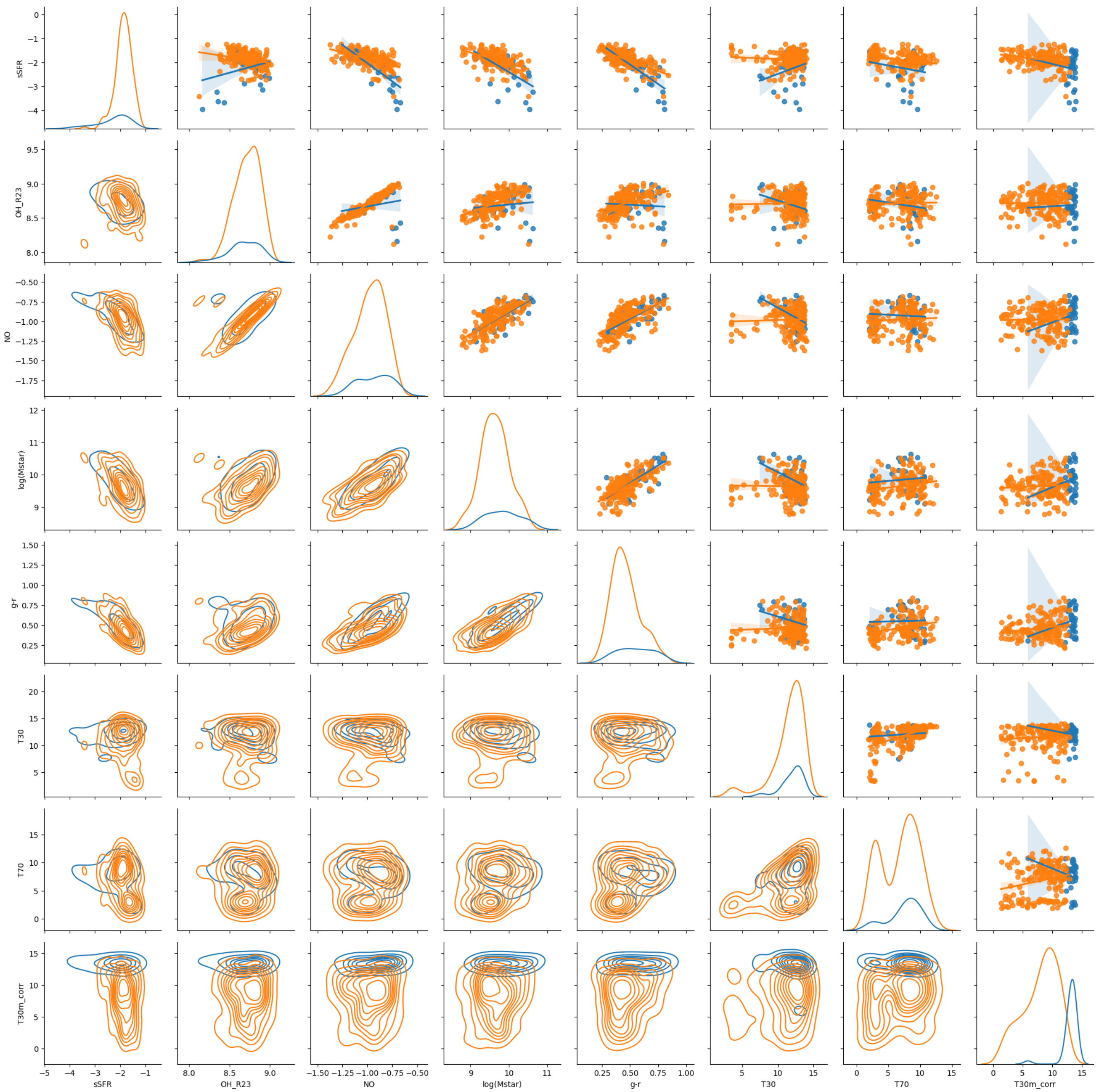

Figure 8: Linear correlation plot between all the variables defined and corresponding histograms. The LT and ST samples are shown in blue and orange.