Self-consistent population spectral synthesis with Fado: III. Nebular contributions and main sequence galaxies

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FADO
FITTING ANALYSIS USING DIFFERENTIAL EVOLUTION OPTIMIZATION

1. Introduction

Galaxies are one of the most important physical systems to investigate, being the building blocks of the Universe. A method widely used to extract the physical properties of galaxies is the spectroscopic analysis. However, an important caveat of this approach is the underlying assumption that the contribution to the observed emission due to the presence of ionised gas is negligible. The University of Porto recently developed a method for the interpretation of a spectrum called FADO (Fitting Analysis using Differential Evolution Optimisation), which considers both the stellar and the nebular contribution to the galactic spectrum.

Objective: In this work it was studied the effect on the Star Formation Rate (SFR) of considering the nebular continuum when fitting the galactic spectrum instead of assuming that is negligible. With the estimated SFR, it was plotted the Main Sequence (MS), a relation between the SFR and the stellar mass of the galaxy.

2. FADO

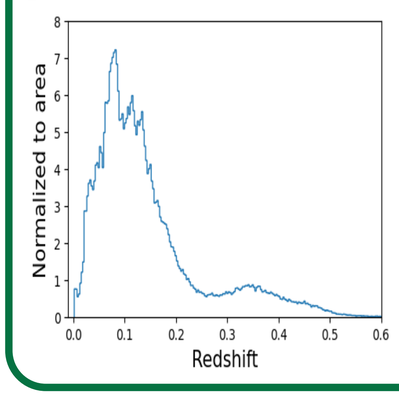
FADO (Gomes & Papaderos, 2017) is a spectral synthesis code capable of fitting self-consistently the emission due to the stellar and nebular component. Its objective is to interpret a galactic spectrum by constraining the properties of the galaxy. Some of the characteristics that make FADO an unique tool are:

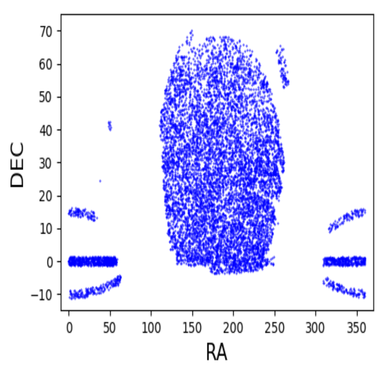
1. Only spectral synthesis code that takes into account the main nebular characteristics
2. Convergence to solutions in a stable way and within a reasonable computational time
3. Diminished biases in determination of galactic properties

3. The Sample

The SDSS is a survey of photometric and spectroscopic data across π sr, conducted at the 2.5 m telescope at Apache Point Observatory. The data analysed in this study is drawn from the Data Release 7 of SDSS which has approximately 900 000 galaxies. In the following image the redshift distribution and sky position are presented.

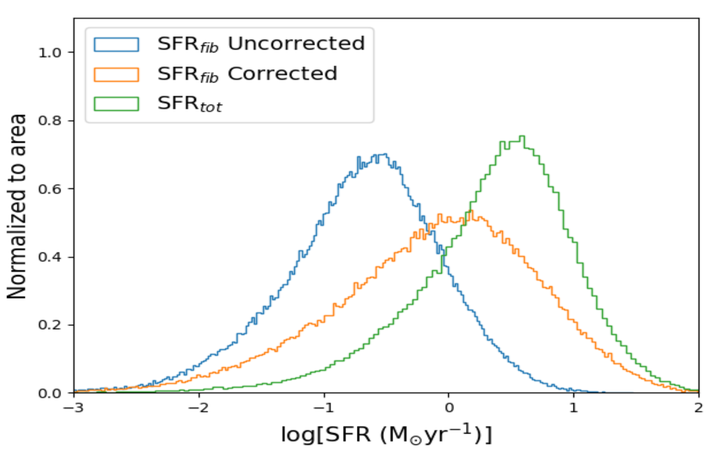
FADO was applied to the SDSS and the results compared with the MPA-JHU SDSS catalogue.





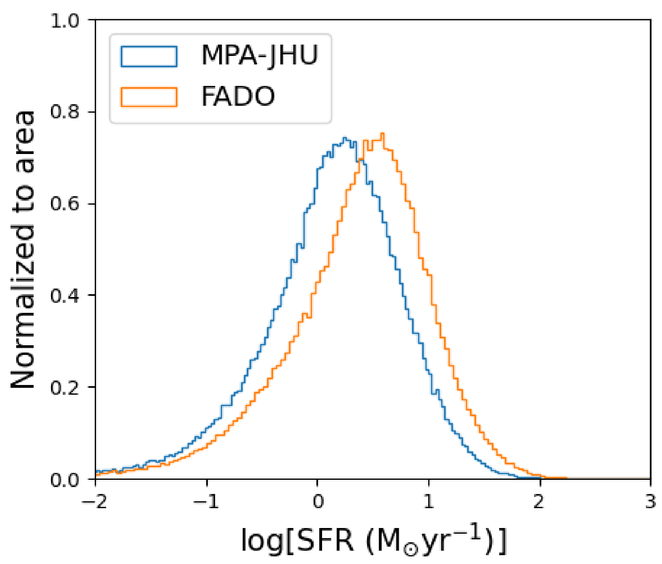
4. Method

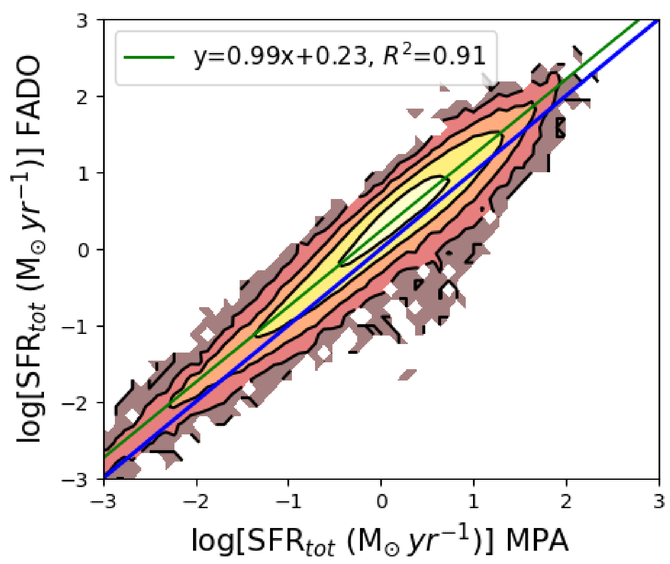
A sample of approximately 180636 star-forming galaxies was studied in order to quantify their SFR. The SFR was estimated from its relation to the Hα luminosity, which in turn can be calculated from the measured Hα flux and distance to the galaxy. The Hα flux was corrected for the nebular extinction using the Balmer decrement (Hα/Hβ). The SFR estimated from the Hα luminosity only corresponds to the part of the galaxy sampled by the fibre and has to be corrected to the total SFR of the galaxy. The fibre SFR obtained with the uncorrected and corrected Hα flux and the total SFR for FADO are shown in the following plot.



5. Results

The comparison between the total SFR for MPA-JHU and FADO is presented in the following plot. On the left, the distribution of the SFR from FADO is shifted to the right and extends to higher values of SFR, meaning that FADO retrieves higher values of SFR relative to MPA-JHU. This is even more clear on the contour plot, as it shows that most galaxies are above the blue reference line which means that their SFR is overestimated by FADO relative to MPA-JHU. This behaviour arises from the consideration of the stellar and nebular component by FADO when fitting the galactic spectrum, whereas the method used in MPA-JHU only considers the stellar component. The emission lines are characteristic of star-forming regions and so they contribute significantly to the estimated SFR. FADO measures higher fluxes, thus obtaining higher SFRs.

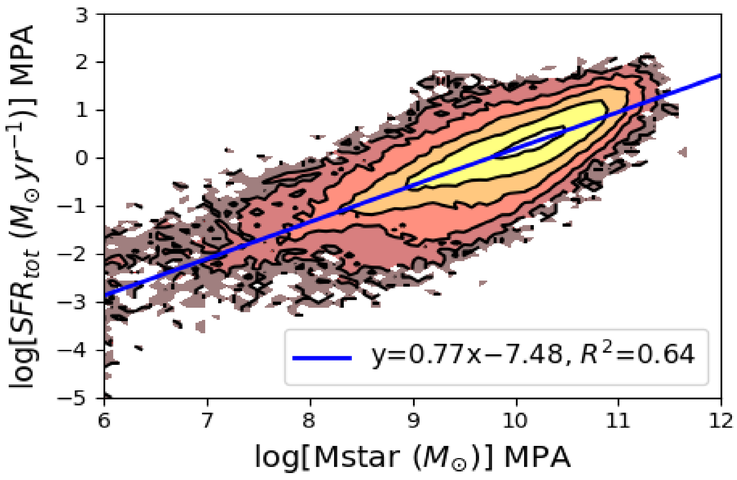


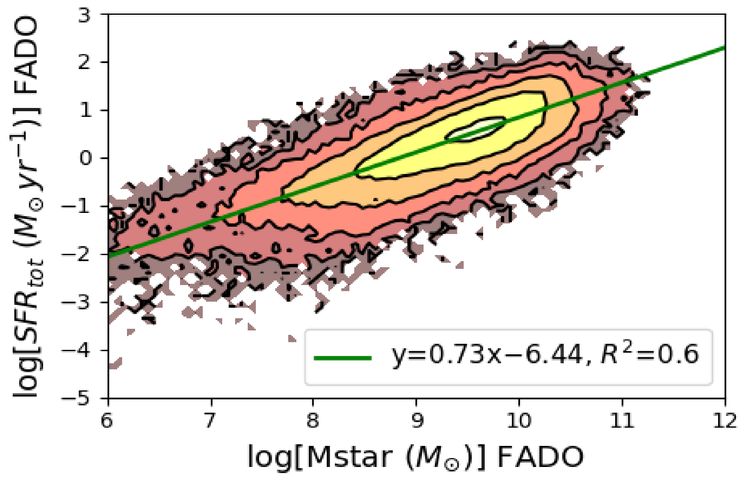


In order to quantify how much FADO overestimates relatively to MPA-JHU it was calculated the median difference between the total SFR obtained with FADO and MPA-JHU from the Hα flux. The results are present in the following table. It is shown that the estimated SFR is consistently overestimated by FADO relatively to MPA-JHU. Moreover, as the SFR increases, higher is the overestimation by FADO and so higher the importance of considering the nebular component when fitting the galactic spectrum.

	log(SFR)<0	0≤ log(SFR)<1	log(SFR)≥1	Complete Sample
Nº Galaxies	44685	111242	24709	180636
FADO	-0.388	0.513	1.202	0.437
MPA-JHU	-0.576	0.255	0.939	0.181
FADO−MPA-JHU	0.189 (55%)	0.258 (81%)	0.298 (98%)	0.243 (75%)

The star-forming MS for MPA-JHU and FADO are compared in the following image. The estimation of the SFR by FADO up to higher values shifts the MS for MPA-JHU into higher SFR values. The stellar masses for FADO extend to lower values comparatively to MPA-JHU. Thus, FADO by taking into account the nebular continuum changes a very important and established relation.





6. Conclusions

Applying the unique capability of FADO of considering the nebular continuum in the fitting process of the galactic spectrum, to the determination of the SFR leads to the conclusions:

1. FADO estimates higher SFRs relative to a pure stellar code
2. The importance of FADO in the determination of the SFR increases as the SFR increases
3. The Main-Sequence is shifted to higher SFRs and to smaller stellar masses

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