Classify and Modeling the optical spectrum via neural network
Based on arXiv:2311.04146, 2412.21130

Speaker: Fucheng Zhong [1]
Supervisor: Nicola R. Napolitano [2]
Collaboration: 4MOST-IWG9

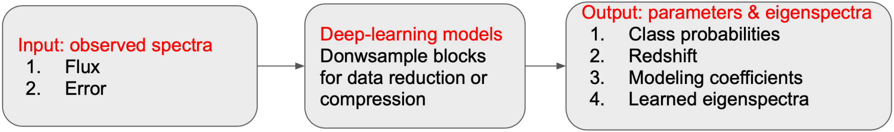
[1]School of Physics and Astronomy, Sun Yat-Sen University
[2]Department of Physics E. Pancini, University Federico II

10th March 2025

GaSNet introduction

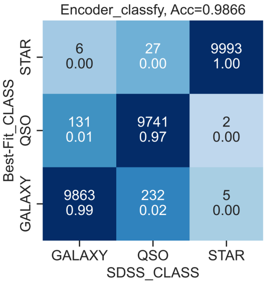
We develop a deep-learning-based tool, ”GaSNet,” for optical spectrum processing. GaSNet can:

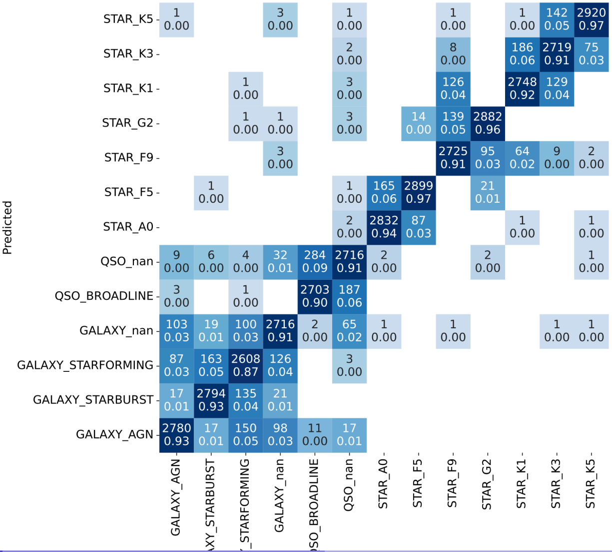
- Classify spectrum (tested on SDSS, DESI, and 4MOST), providing a wide range of classifications (>10 classes).
- Estimate redshifts with accuracy comparable to traditional methods.
- Model spectra approximately $O(10^{-3})$ times faster than classical methods.
- Estimate errors via ensemble modeling.



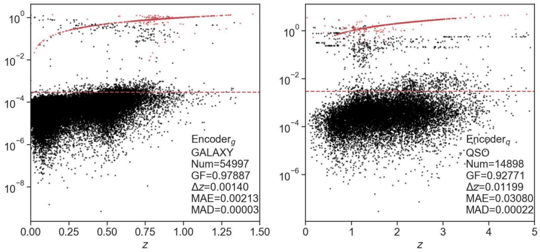
High accuracy and broad-range classification

1. Coarse classification of stars, galaxies, and QSOs ($\approx 99\%$).
2. More than 10 subclass classifications with $> 92\%$ accuracy.





High redshift accuracy and efficiency compared to others

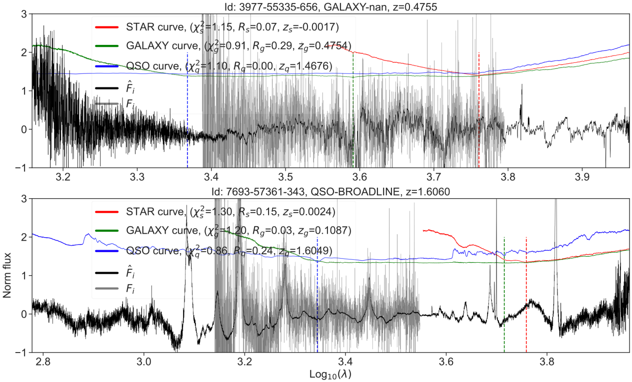


Method	MAD_g $/10^{-4}$	GF'_g	MAD_q $/10^{-4}$	GF'_q	Time
QXP++	3.7	0.980	-	-	0.4
Redmonster	0.27	0.999	4.52	0.977	<0.4
pPXF	772.3	0.854	-	-	0.03
Encoder	0.33	0.994	2.04	0.982	<0.001
UNet	0.31	0.994	2.65	0.954	< 0.001

$$\Delta z = \frac{|z_p - z_t|}{1 + z_t}$$

- Comparable accuracy with other methods
- Lower Median Absolute Deviation (MAD)
- Higher efficiency ($> \mathcal{O}(10^{-3})$)

Spectrum modeling and chi-square diagnostics



Model	χ_s^2	χ_g^2	χ_q^2
Encoder	1.089	1.203	1.378
UNet	1.004	1.163	1.244
SDSS model	1.624	1.432	1.304

Reconstructed rest-frame spectrum and generated chi-square curves for three different classes.

What's the next?

Based on deep learning and information theory, we aim to solve the following:

- Can we recognize anomalies from latent space or residuals?
- How can we build a comprehensive framework for fully modeling and extracting parameters, including error estimation?
- Can we clearly separate noise and signal (denoising)?
- How many parameters can accurately represent a spectrum (theory limit)?

Thank you for your attention!