

# Classify and Modeling the optical spectrum via neural network

Based on arXiv:2311.04146, 2412.21130

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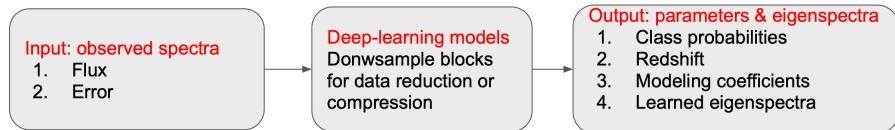
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# GaSNet introduction

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  $\mathcal{O}(10^{-3})$  times faster than classical methods.
- Estimate errors via ensemble modeling.



# High accuracy and broad-range classification

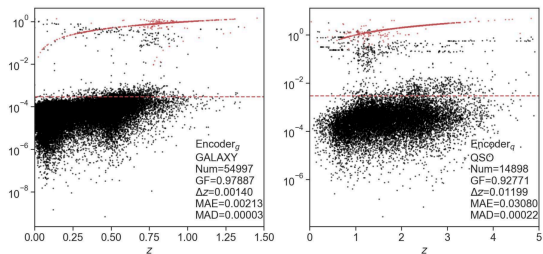
1. Coarse classification of stars, galaxies, and QSOs ( $\approx 99\%$ ).
2. More than 10 subclass classifications with  $> 92\%$  accuracy.

Encoder\_classify, Acc=0.9866

Best-Fit_CLASS	STAR	6 0.00	27 0.00	9993 1.00
	QSO	131 0.01	9741 0.97	2 0.00
	GALAXY	9863 0.99	232 0.02	5 0.00
		SDSS_CLASS		
		GALAXY	QSO	STAR

Predicted	STAR_K5	1 0.00		3 0.00		1 0.00		1 0.00		1 0.00	142 0.05	2920 0.97			
	STAR_K3					2 0.00		8 0.00		186 0.06	2719 0.91	75 0.03			
	STAR_K1		1 0.00			3 0.00		126 0.04		2748 0.92	129 0.04				
	STAR_G2		1 0.00	1 0.00		3 0.00		14 0.00	139 0.05	2882 0.96					
	STAR_F9				3 0.00					2725 0.91	95 0.03	64 0.02	9 0.00	2 0.00	
	STAR_F5		1 0.00				1 0.00	165 0.06	2899 0.97		21 0.01				
	STAR_A0						2 0.00	2832 0.94	87 0.03			1 0.00	1 0.00		
	QSO_nan											2 0.00		1 0.00	
	QSO_BROADLINE														
	GALAXY_nan													1 0.00	1 0.00
	GALAXY_STARFORMING														
	GALAXY_STARBURST														
	GALAXY_AGN														
			GALAXY_AGN	XY_STARBURST	_STARFORMING	GALAXY_nan	SO_BROADLINE	QSO_nan	STAR_A0	STAR_F5	STAR_F9	STAR_G2	STAR_K1	STAR_K3	STAR_K5

# High redshift accuracy and efficiency compared to others

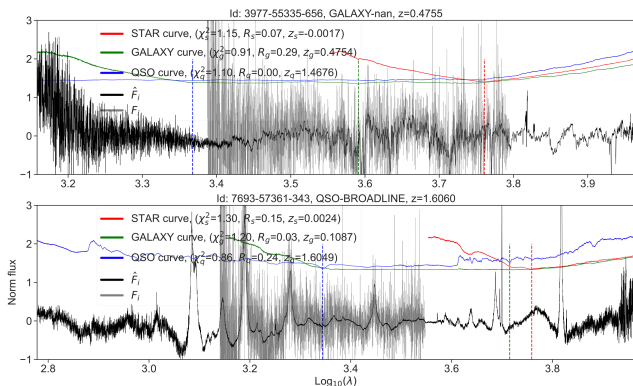


Method	MAD <sub>g</sub> /10 <sup>-4</sup>	GF' <sub>g</sub>	MAD <sub>q</sub> /10 <sup>-4</sup>	GF' <sub>q</sub>	Time
QXP++	3.7	0.980	-	-	0.4
Redmonster	0.27	0.999	4.52	0.977	<0.4
pPXF	772.3	0.854	-	-	0.03
Encoder	0.33	0.994	2.04	0.982	<0.001
UNet	0.31	0.994	2.65	0.954	<0.001

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

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

# Spectrum modeling and chi-square diagnostics



Model	$\chi_s^2$	$\chi_g^2$	$\chi_q^2$
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!