AI learns stellar spectroscopy

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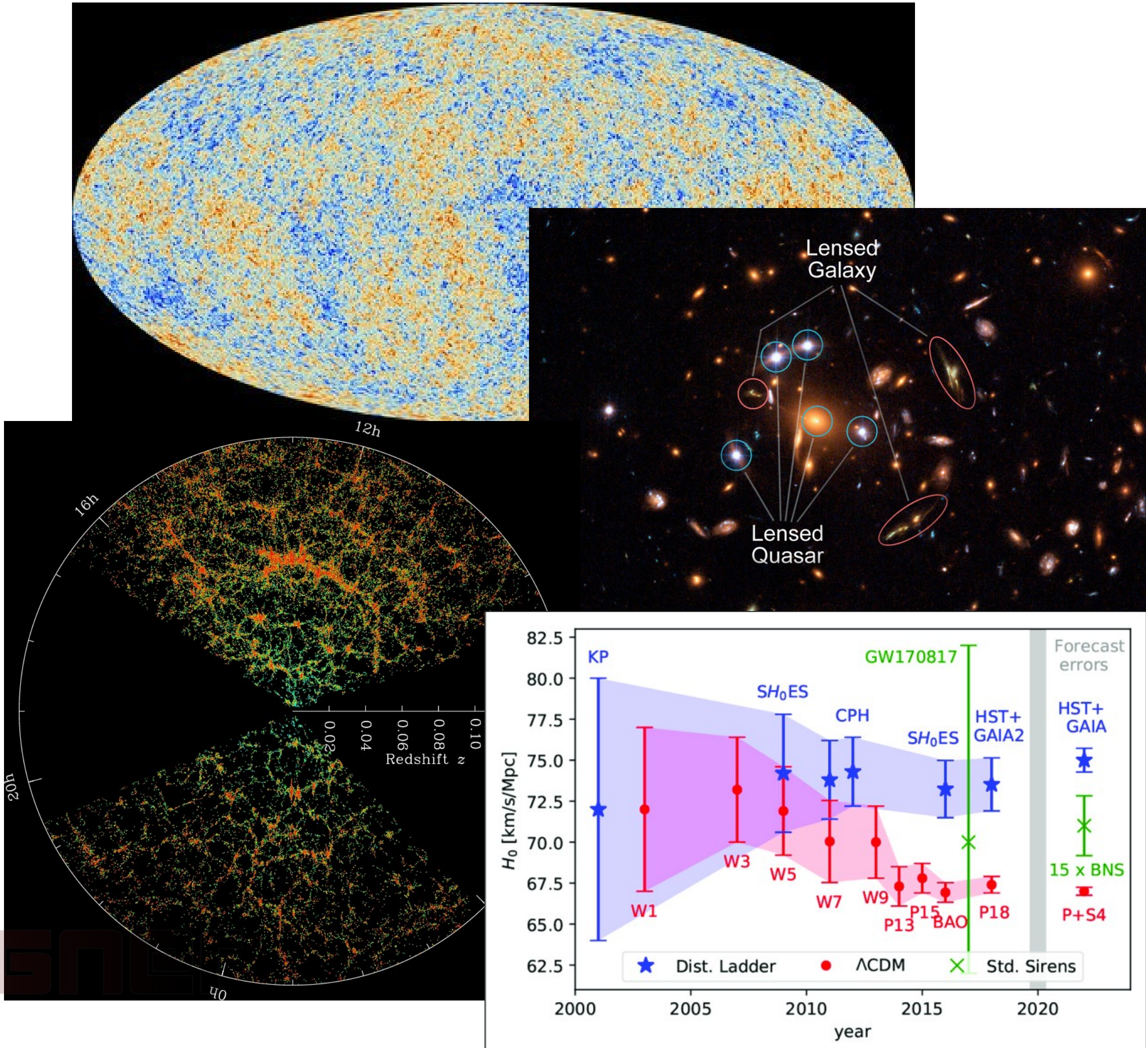
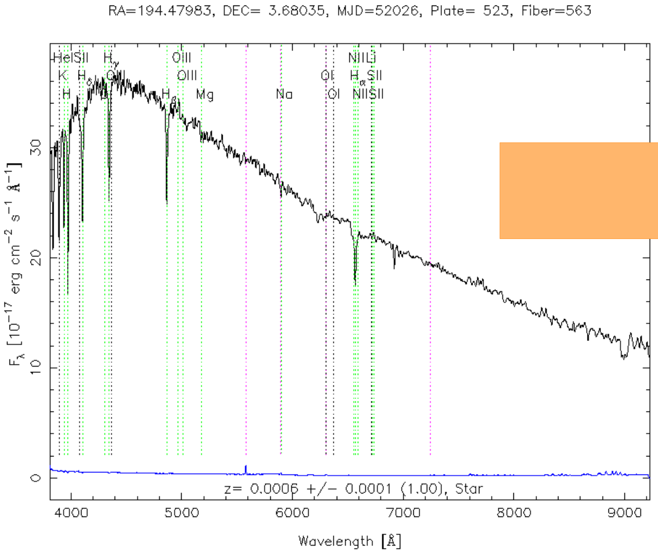
Wigner Scientific Computation Laboratory, Wigner RCP
XIII. GPU Day – 2023

Goals of modern cosmology

- **Improve** the standard model of cosmology
- **Solve challanges** of the ΛCDM model
  - Eg. H_0 tension (CMB vs SNe)
  - Eg. violations of homogeneity and isotropy
  - ...and lots of other problems...
- Tweaks?
- Alternative cosmologies?

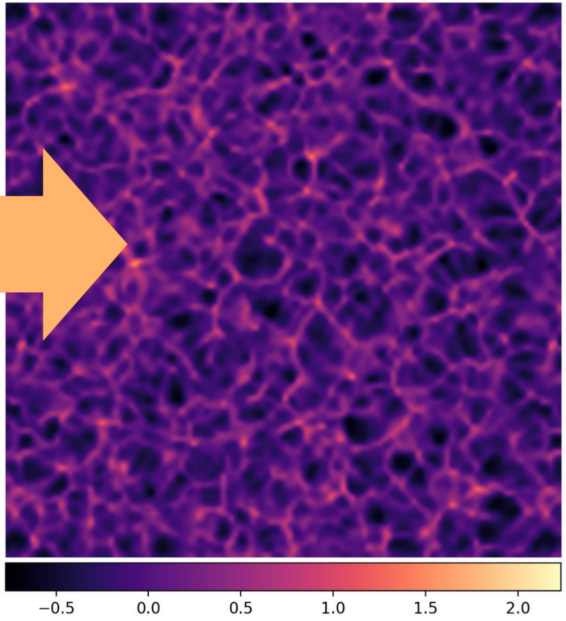


Galactic Archaeology and the Subaru PFS



Source: Sloan Digital Sky Survey / SkyServer

Source: NASA, ESA, and the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration



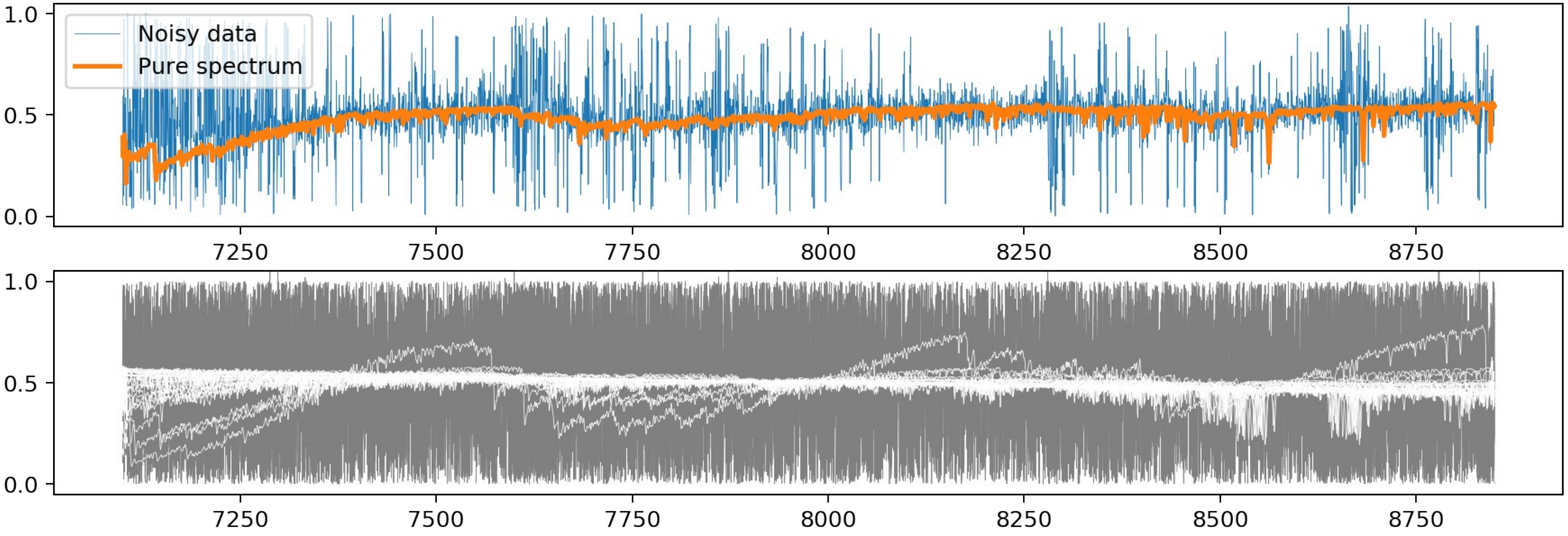
General relativistic cosmological simulation using the BSSN formalism – Own work

1. **Stellar attributes**

2. **Galactic evolution**

3. **Cosmological implications**

Example synthetic spectra



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Using AI for... *what?*

- In case of stellar spectra
  - Learn the physical information stored in a spectrum (Reconstruction)
  - Subtract any noise that pollute the spectrum (Denoising)
    - Greatly assists classical methods
    - Saves a lot of time and money
    - ...
  - ...

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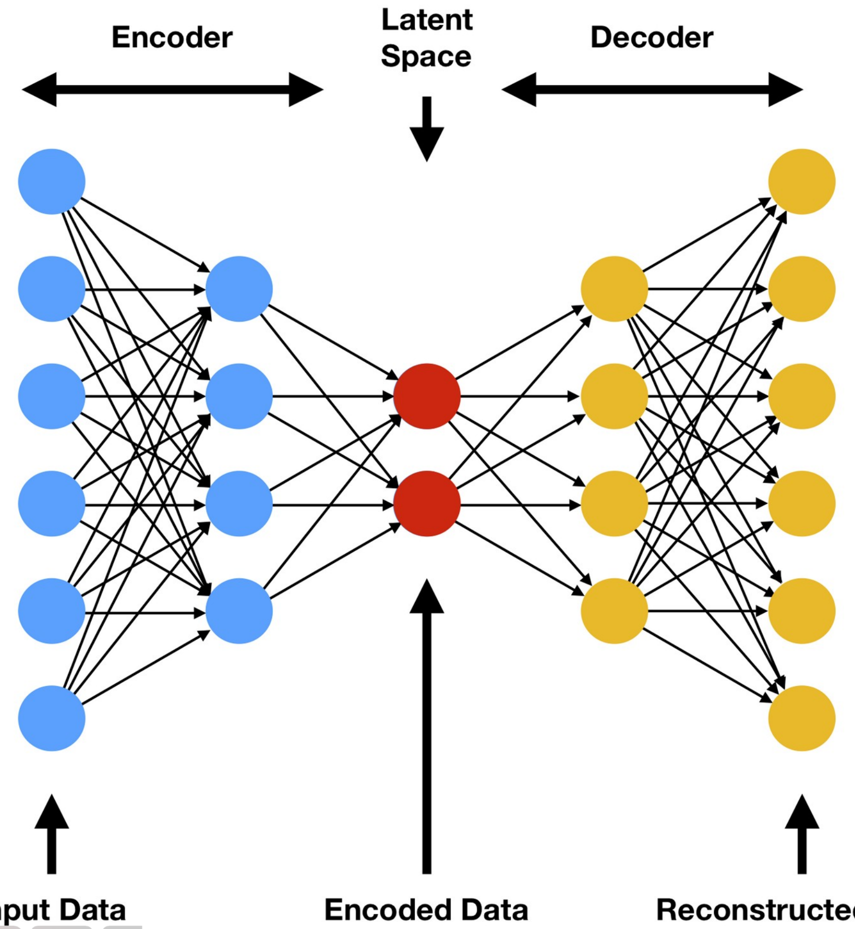
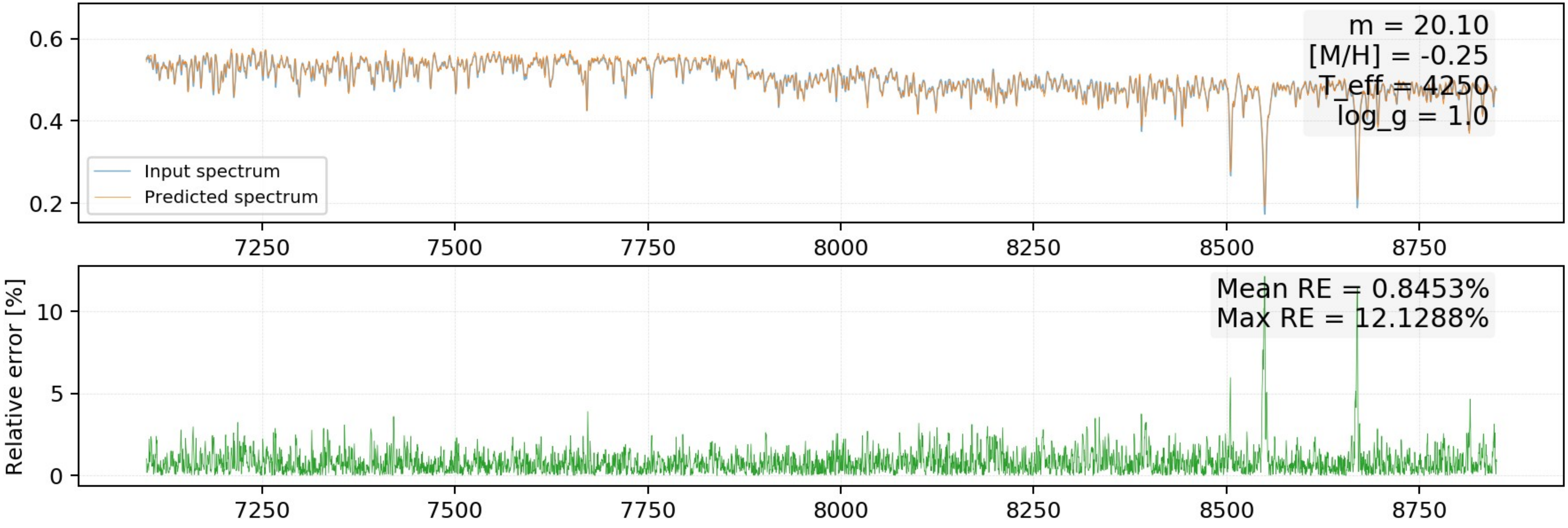
Structure of the base autoencoder

- Dense Autoencoder
- Dimensions
  - Input/output: **4096**
  - Latent space: **< 4096**
- **Encoder** and the **Decoder**
  - 4+4 layers
  - Same amount of neurons
  - No batch normalization
  - No dropout layers



Source: Mahony, Niall O., et al. "Representation learning for fine-grained change detection." Sensors 21.13 (2021): 4486.

Example for reconstruction



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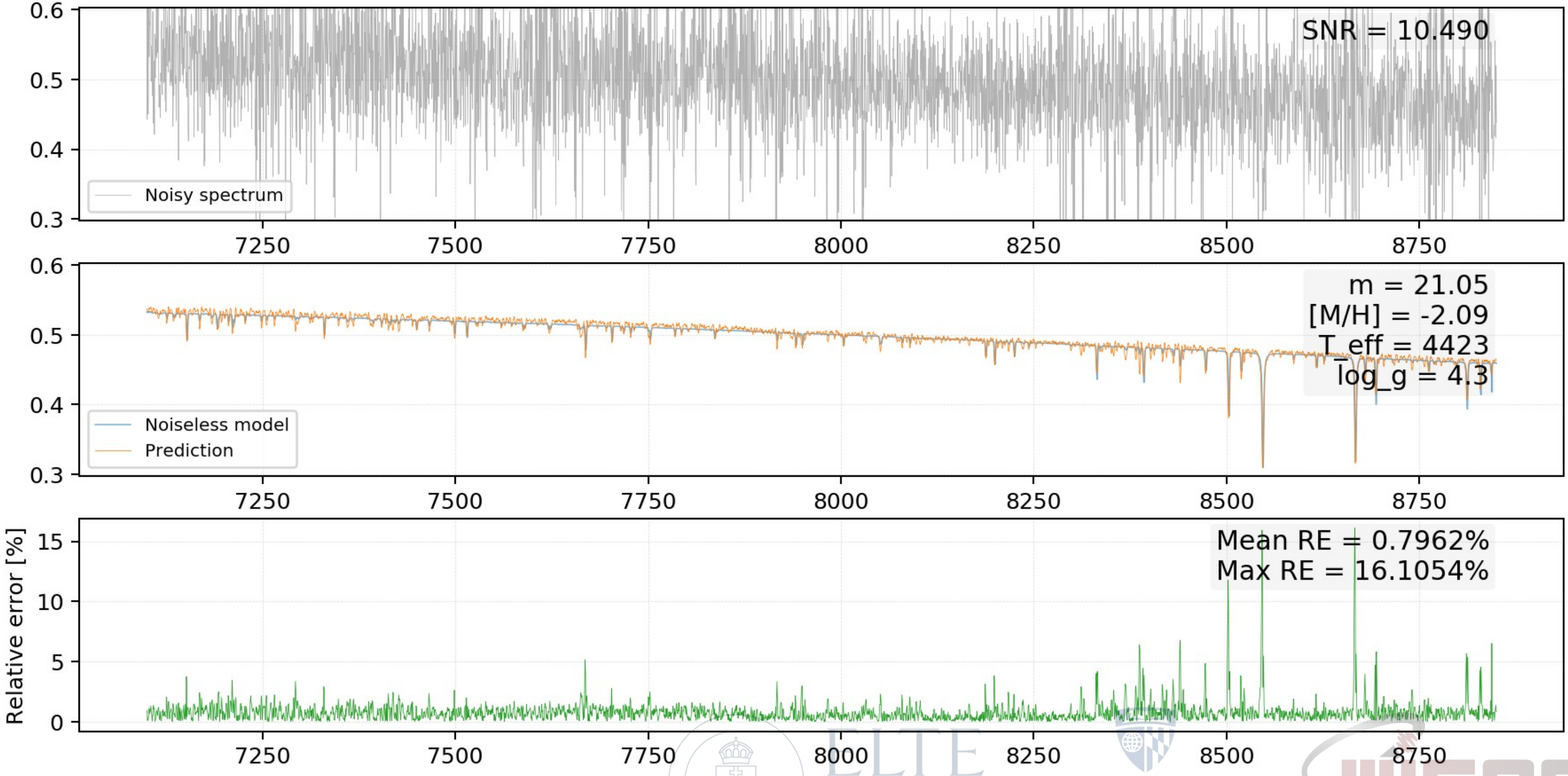
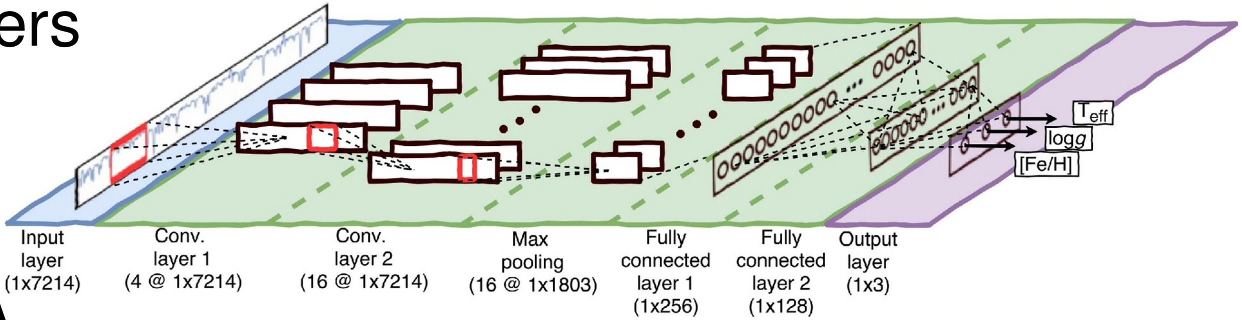
Example for denoising



Future considerations

- Convolutional Autoencoders
  - Translation invariance! (Invariant for redshift)
  - **CNNs outperform dense models** and PCA methods in stellar parameter reconstruction
- Continuum normalization?
  - Can it really work?
- The sky is the limit for ideas



StarNet CNN – Fabbro, S., et al. "An application of deep learning in the analysis of stellar spectra." Monthly Notices of the Royal Astronomical Society 475.3 (2018): 2978-2993.

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Thank you for your attention!