Denoising cosmological images with neural network

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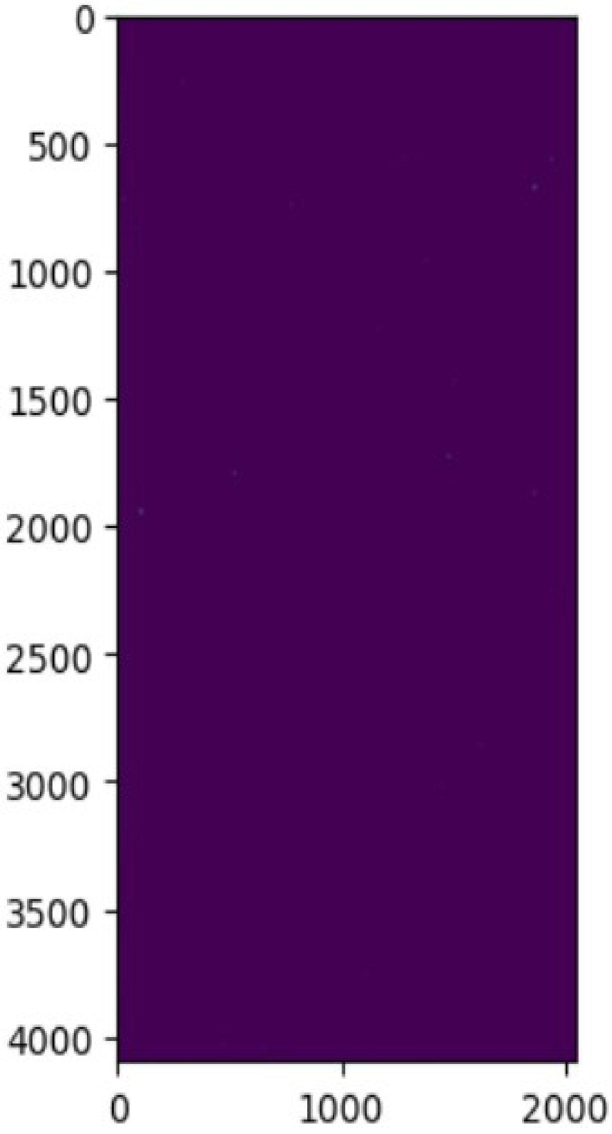
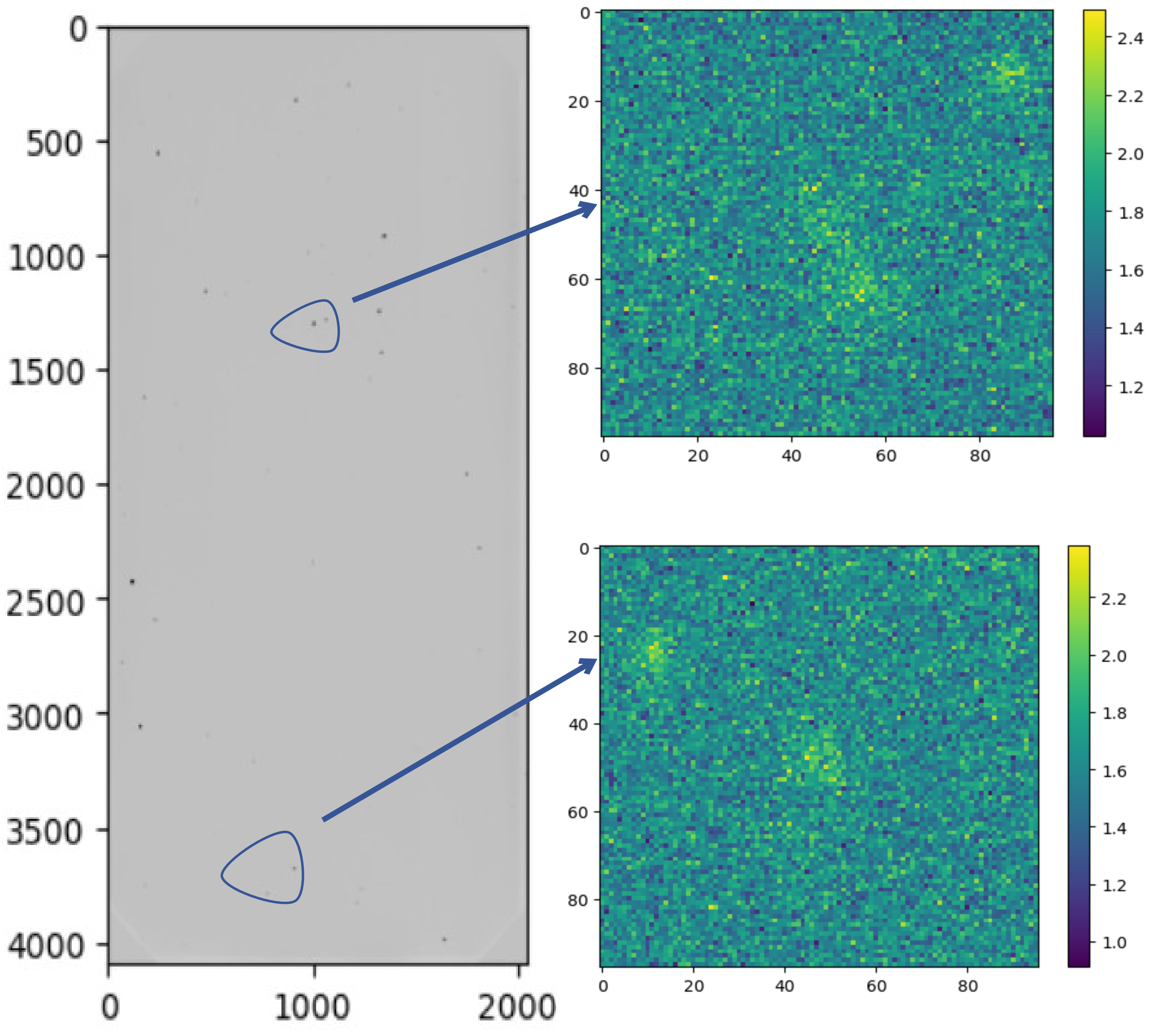
PAUdm



color map



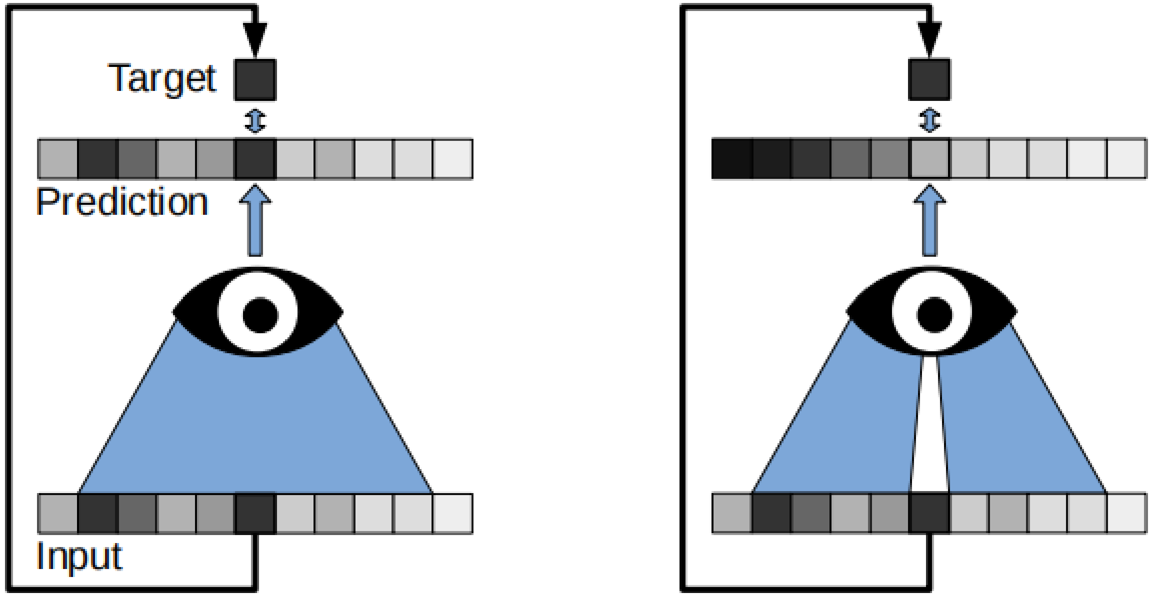
black and withe picture
(cmap = 'Greys')

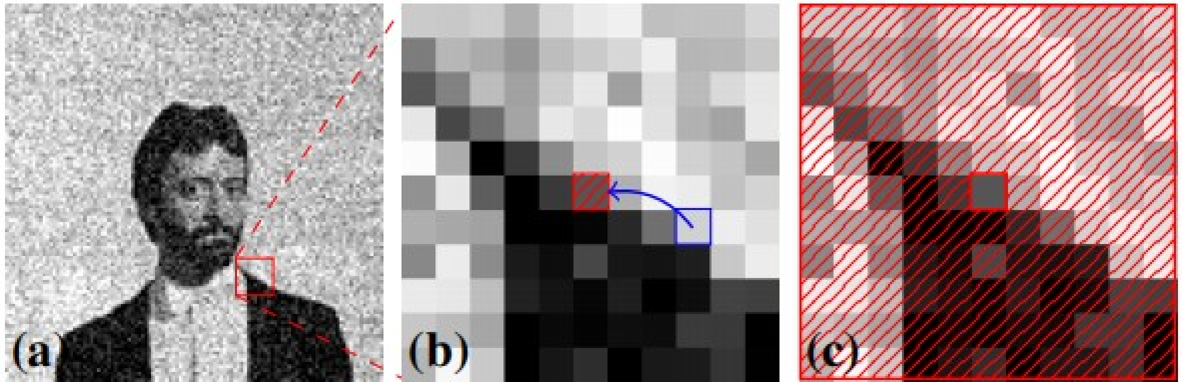
PAUCam is an 18-detector camera with 40 narrow-band filters, covering the range from 450nm to 850nm in steps of 10nm. PAUCam is built for the Physics of the Accelerating Universe Survey (PAUS).

One image is in the shape of (4096,2048). We can locate the galaxies.

aperture_x	aperture_y
696.31506	3928.8652
696.31506	3928.8652
645.49896	3910.0217
645.49896	3910.0217
169.05666	3901.1675
...	...

Neural network:Noised to void

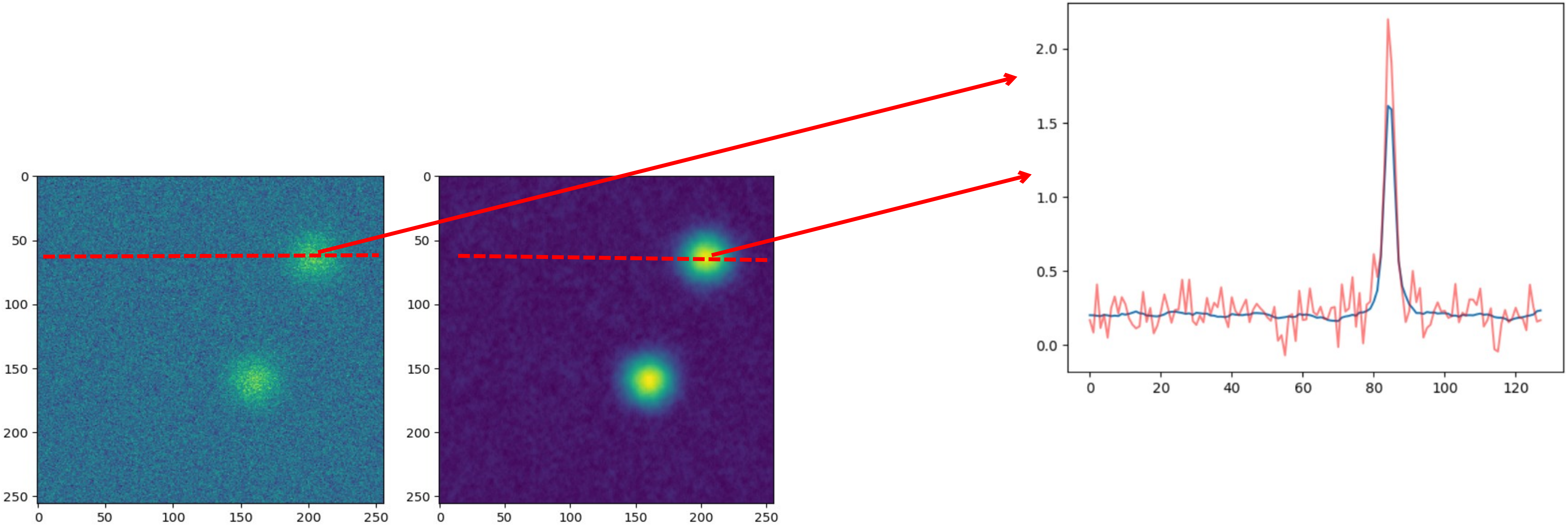




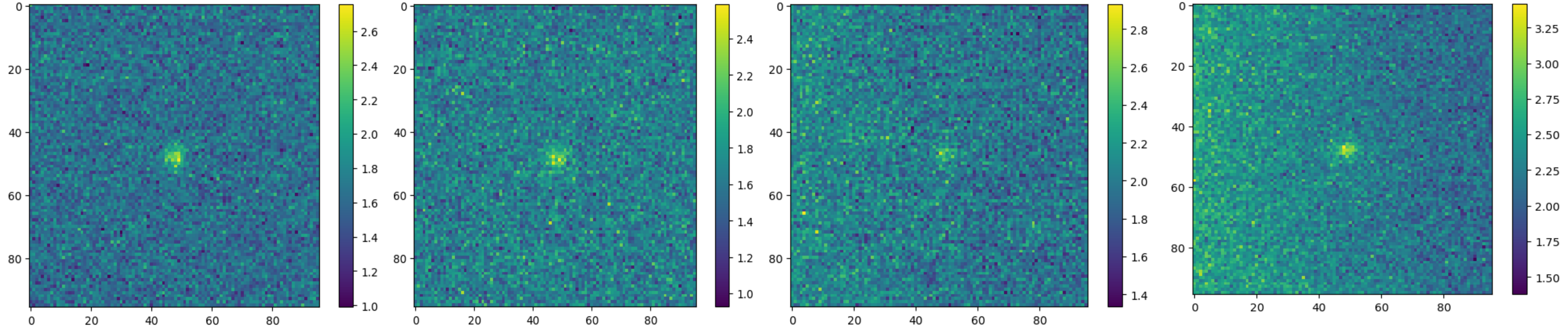
- 1.A noisy training image
- 2.Create image patches
- 3.A randomly selected pixel is chosen (blue rectangle) and its intensity copied over to create a blind-spot (red and striped square)
- 4.The target patch corresponding to (b). We use the original input with unmodified values also as target. The loss is only calculated for the blind-spot pixels.

Test of denoising

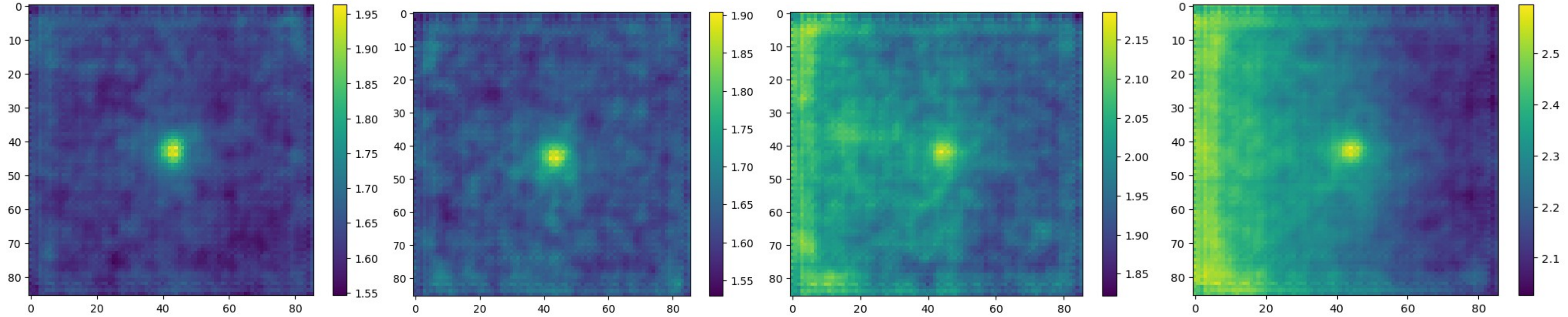
- 1.Generating images by adding noise to the noiseless images
- 2.Some remained noise, but big improvement



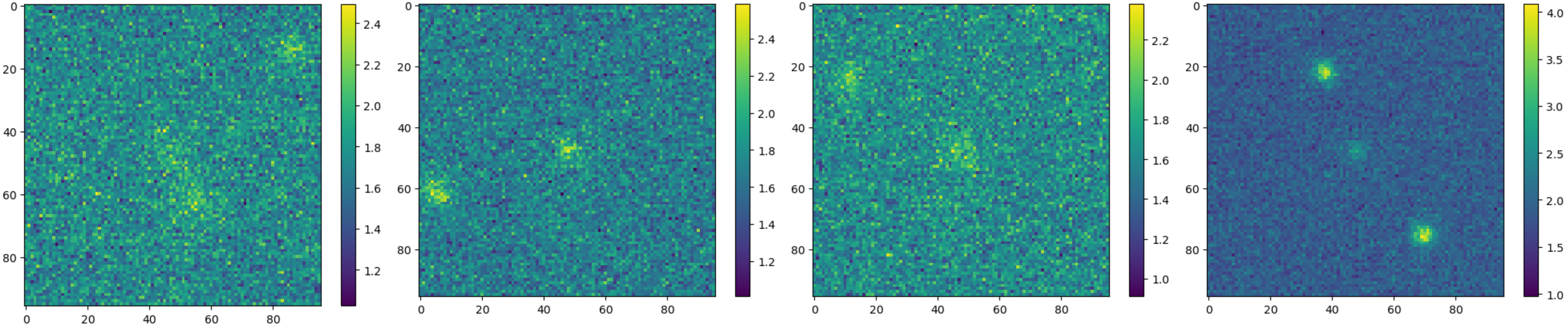
Examples of denoise



The original stamps↑
The denoised stamps↓

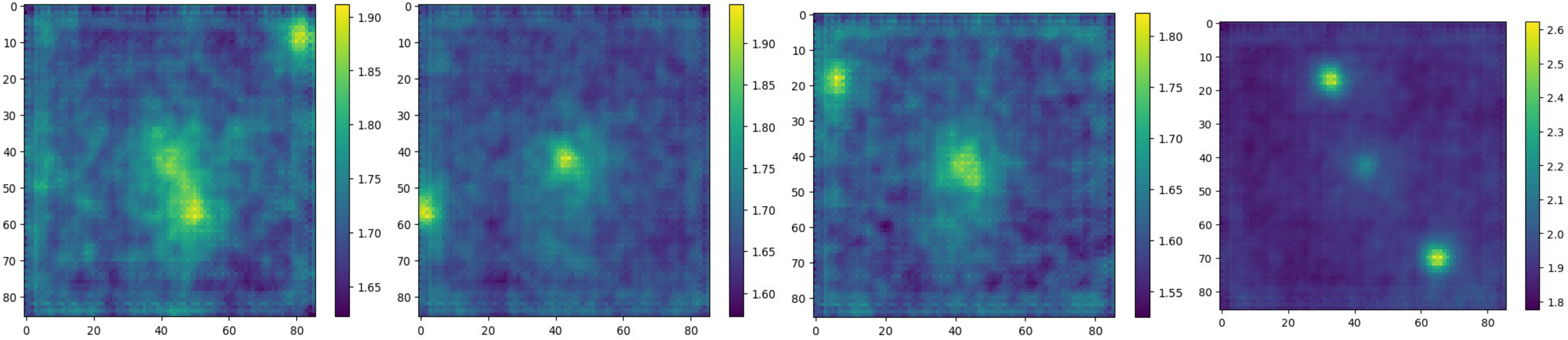


Some examples of having galaxies in one stamp

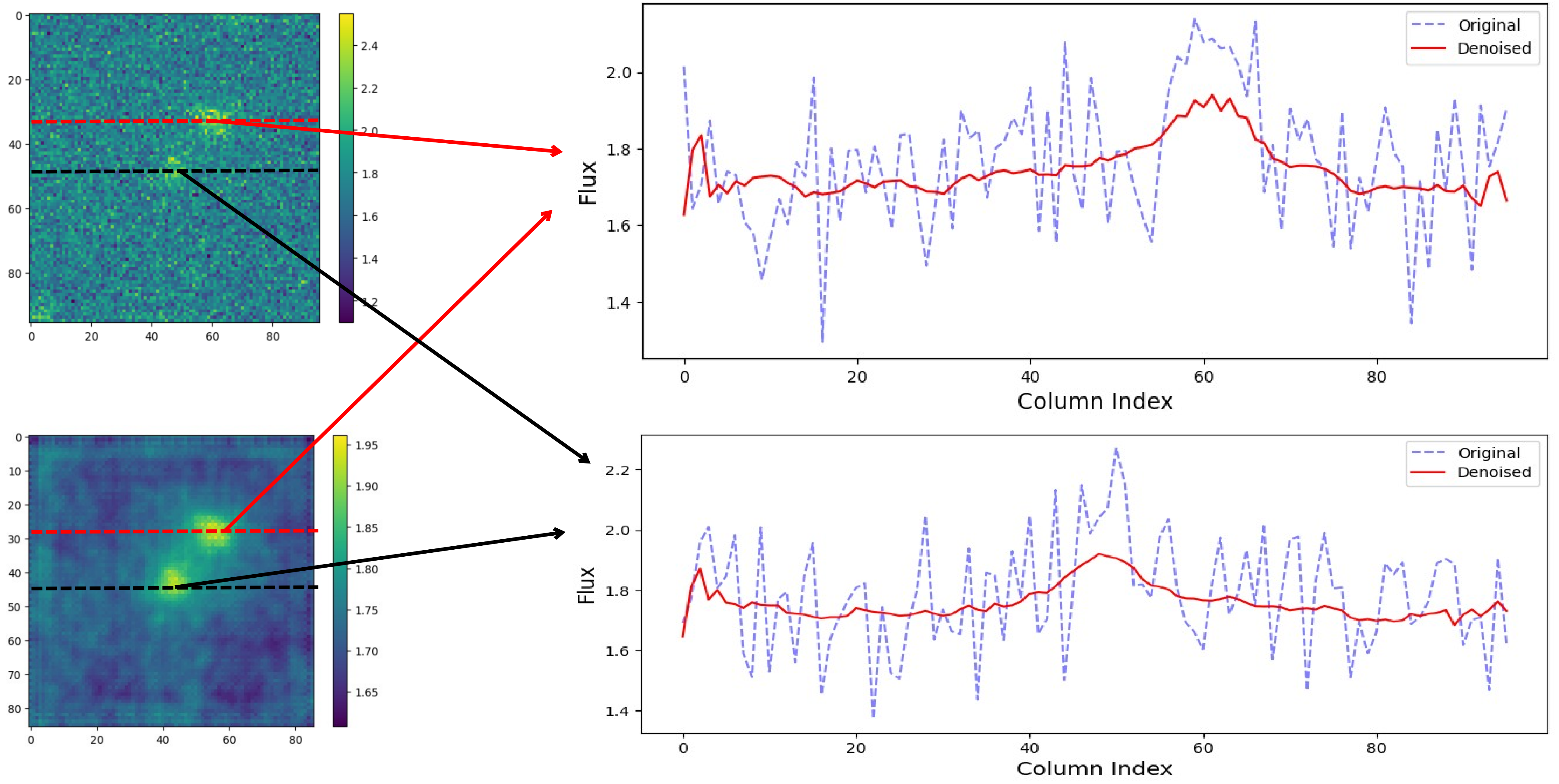


The original stamps↑

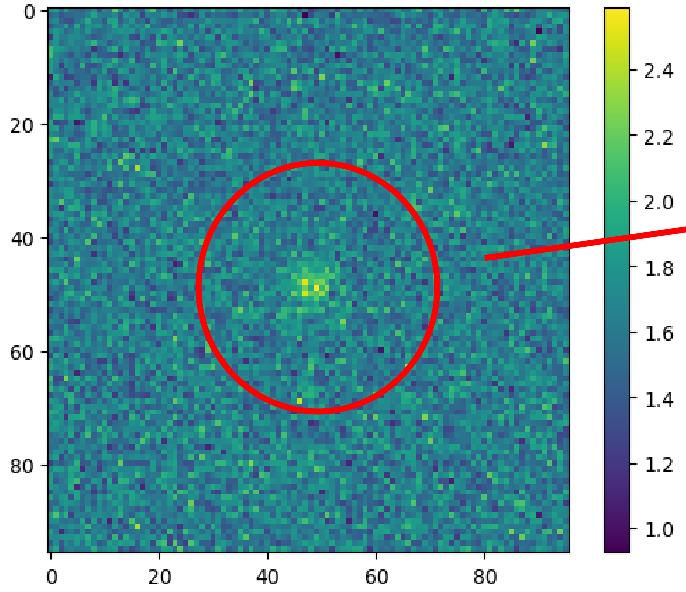
The denoised stamps↓

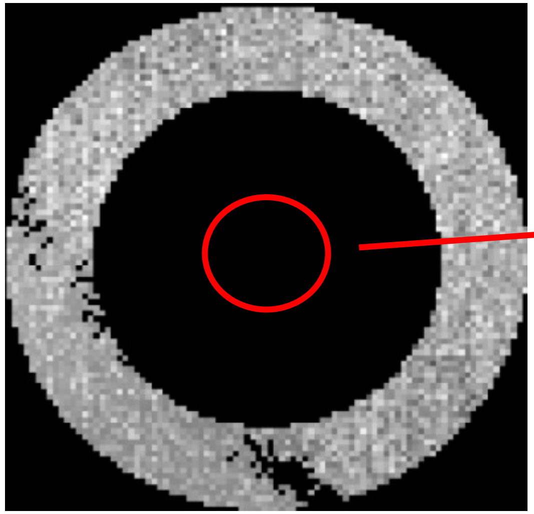


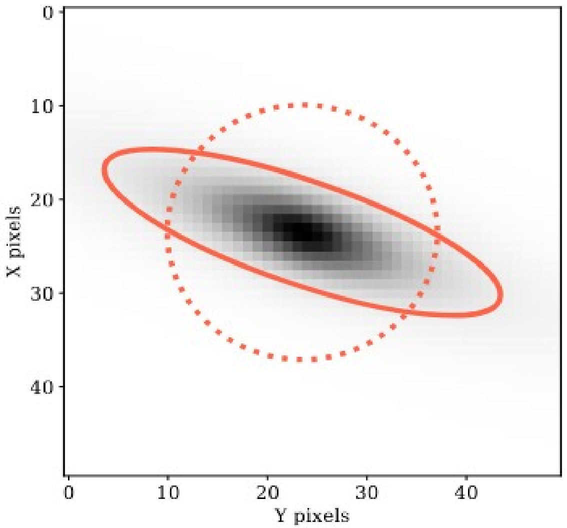
Profile (choose a line in the images)

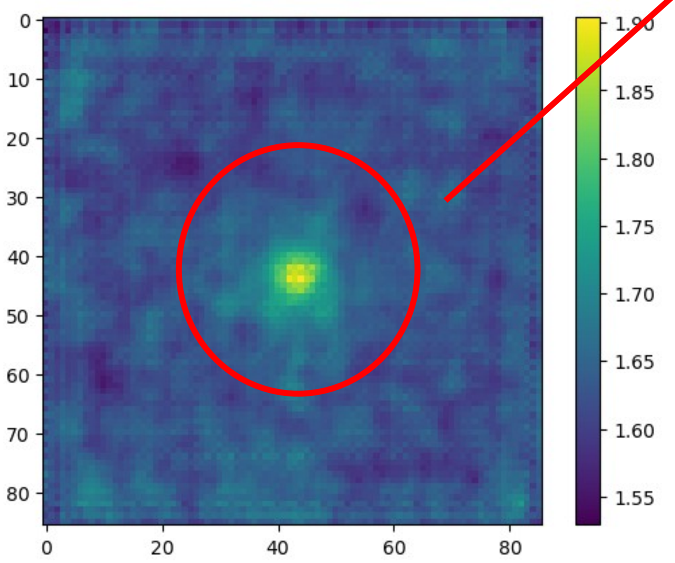


Calculate the flux of the galaxy









aperture_x	aperture_y	aperture_theta	aperture_a	aperture_b
1779.590	288.038	62.4898	0.922867	0.863632
1541.870	3963.350	-43.6940	1.280100	0.950191

- The annulus used to estimate the background of a particular source. It can be seen how pixels present in the image mask are discarded from the annulus and will not enter into the sigma clipping statistics.
- Flux_galaxy=Flux_raw - Area_galaxy * Flux_background_mean.
- The package we use is “nayo”, can be found in GitHub

Calculate df

- Chose the same galaxies(pairs) in the different exposure,calculated calibrated flux with denoised source flux and the undenoised source flux, and calculated the difference. We keep the errores unchanged for the donised flux.

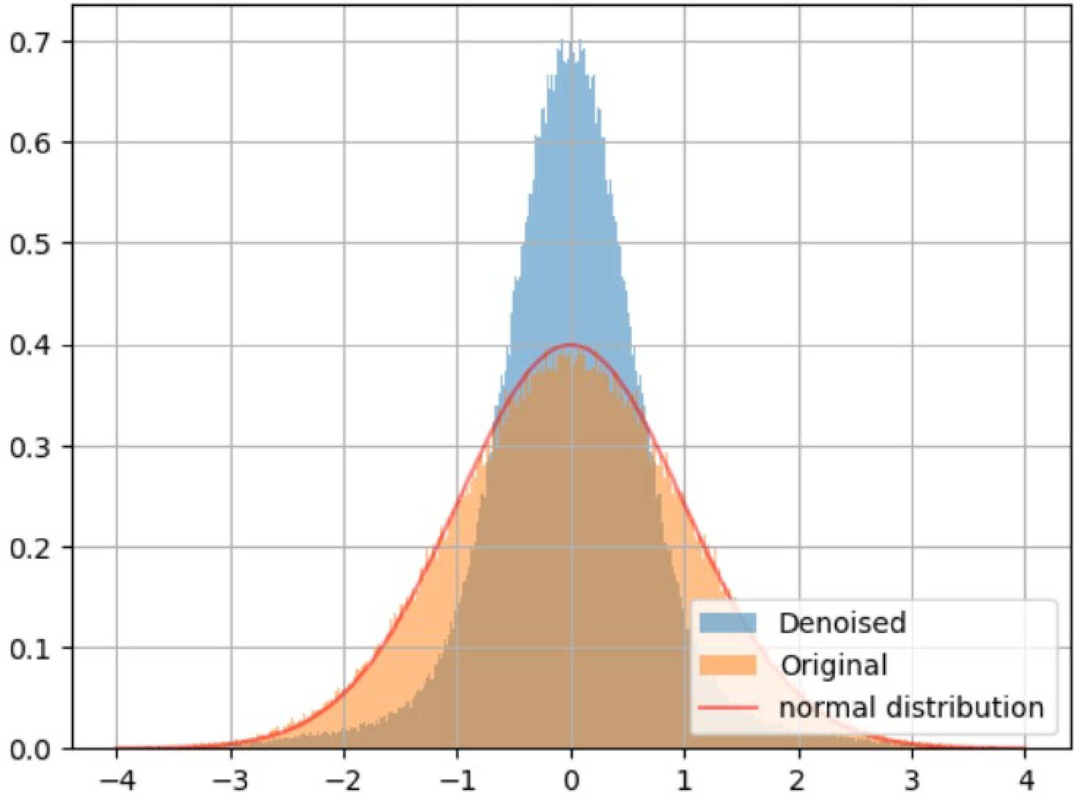
- The orange histogram: f1 and f2 mean the calibrated flux for the same galaxy in different exposure (with different zero-point).In general, the filled histograms of normalized differences follow a normal distribution.

- The blue histogram: f1 and f2 mean the denoised calibrated flux for the same galaxy in different exposure. The sigma68 is 0.69. We keep the error unchanged. The smaller sig68 and a sharper shape means the old errores are to large for the denoise fluxes.

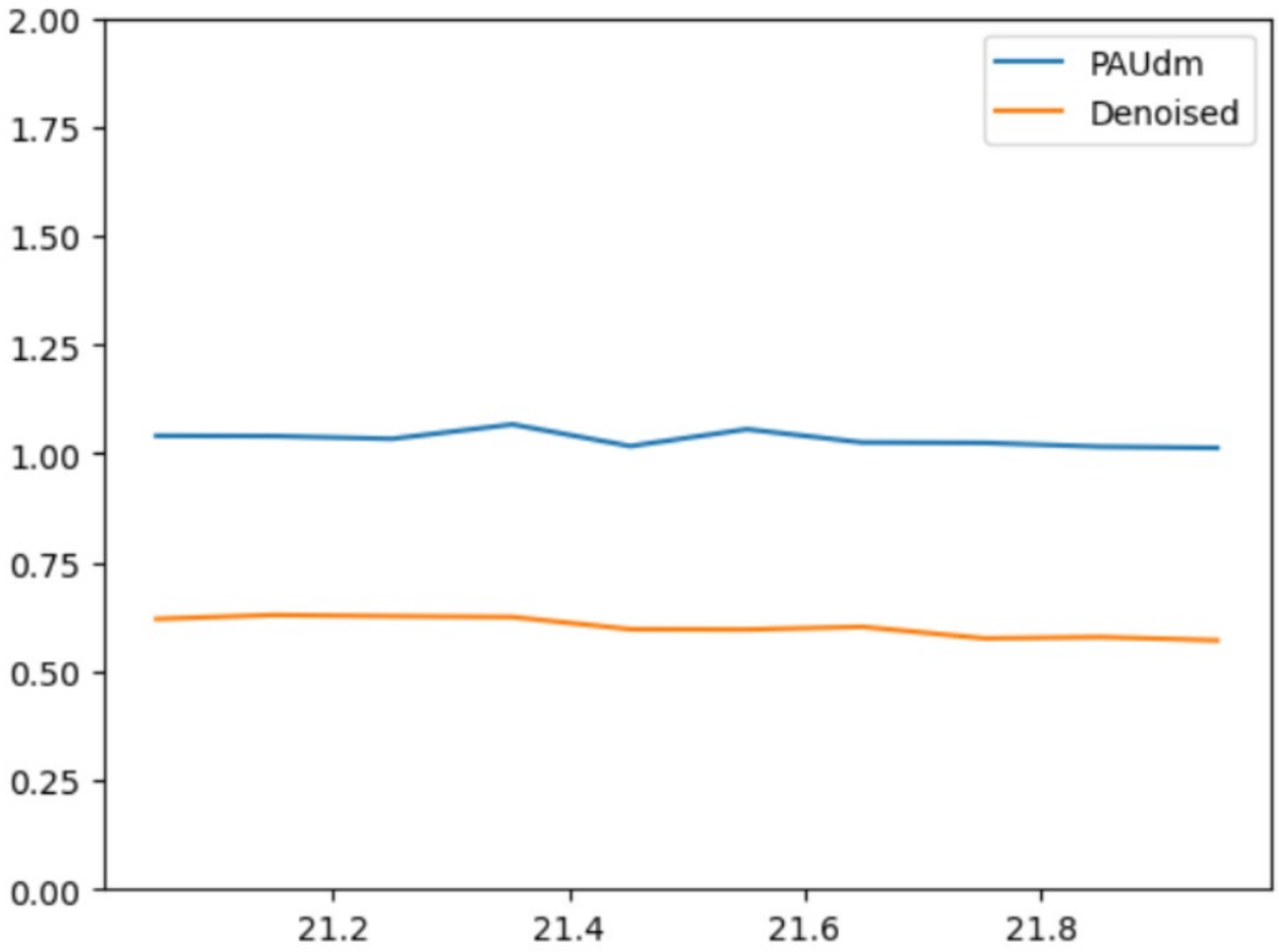
$$f_{\rm cal} = f_{\rm src} \cdot {\rm ZP}$$

$$\sigma_{\rm cal} = \sqrt{\sigma_{\rm src}^2 \sigma_{\rm zp}^2 + \sigma_{\rm src}^2 {\rm ZP}^2 + f_{\rm src}^2 \sigma_{\rm zp}^2}$$

$$df \equiv \frac{f_1 - f_2}{\sigma} = \frac{f_1 - f_2}{\sqrt{\sigma_1^2 + \sigma_2^2}}$$



sigma 68 in bins of I_auto (magnitude)



magnitude between (21,22)

conclusion

The denoise works nicely, we can use the denoised images in the further research.

next step

- using the denoised images to calculate the strong lense