Physics Informed Neural Networks for Fluid Dynamics

NAPDE Project

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1 Unsteady problem in the Cavity

What is the strenght of the PINN?

In the unsteady case with noise on the boundary data, we analyzed the performances of:

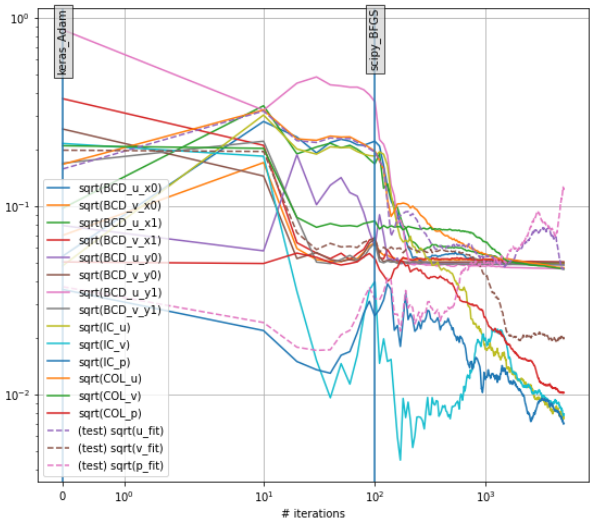
- a Neural Network trained for interpolation
- a Physics Informed Neural Network

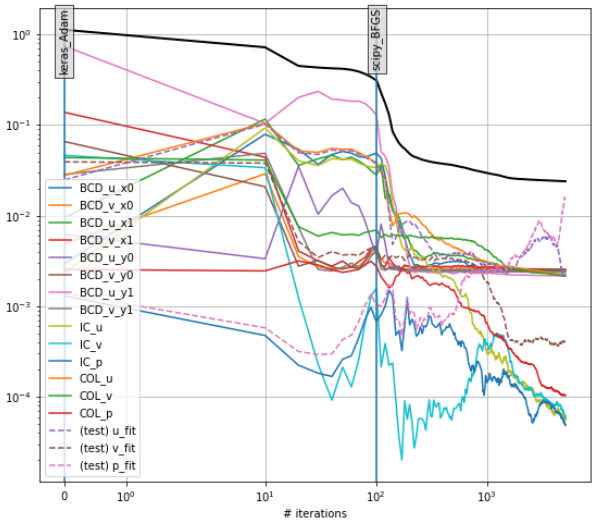
The noise is gaussian, with $\mu = 0$ and $\sigma = 0.05$ (5% of the measurement). We found that this value for the width is reasonable and suitable for the comparison; indeed, a stronger noise makes the interpolation unreliable.

Interpolation

The number of collocation points is:

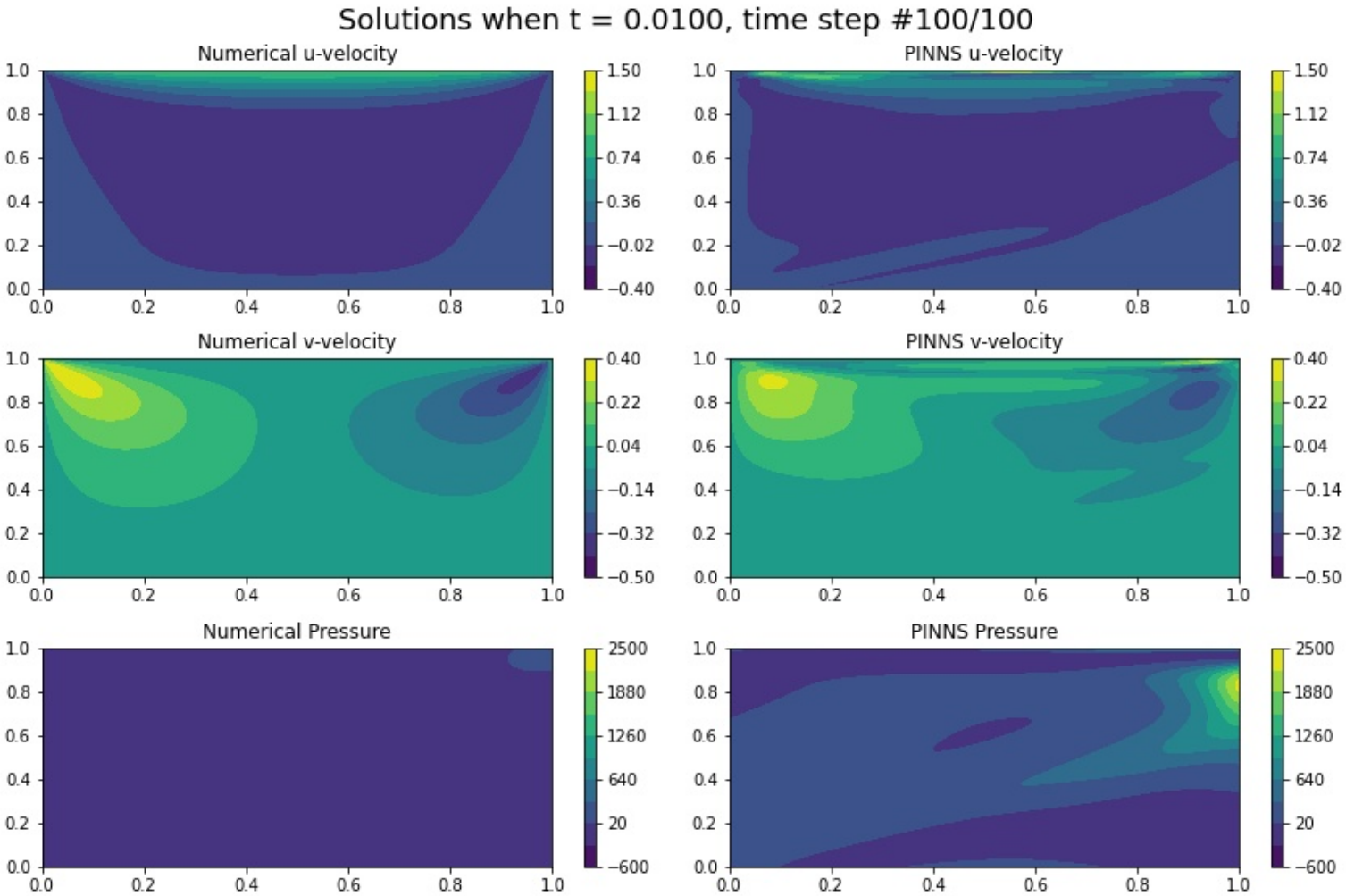
```
num_BC = 1000
num_IC = 1000
num_col_velocity = 500
num_col_pres = 10
```





We noted that there is **overfitting** for u and p.

Interpolation - Solution at the final instant



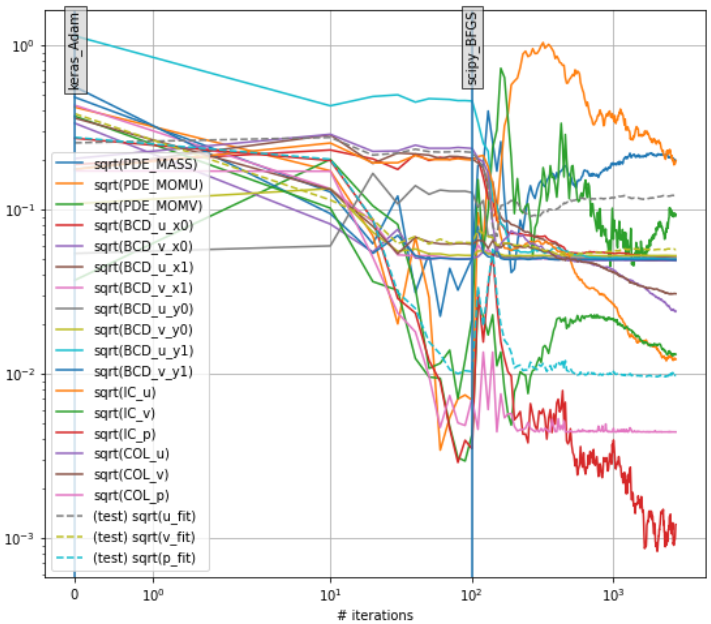
PINN

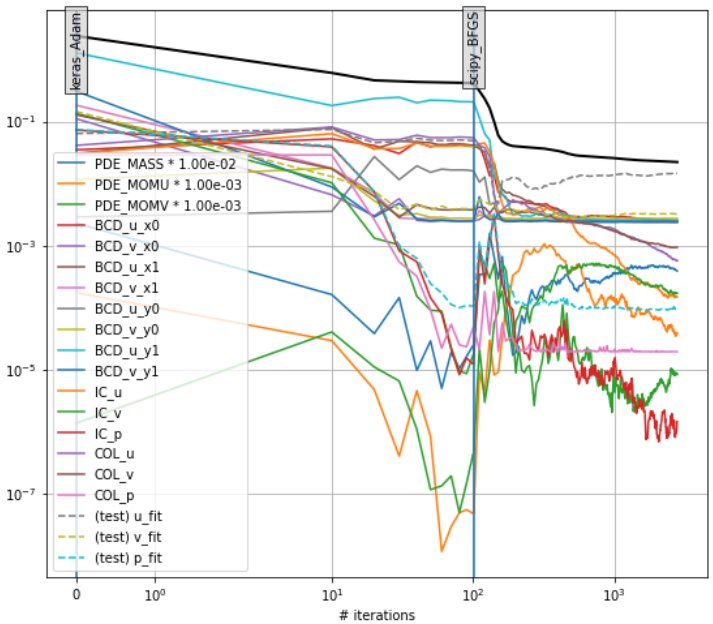
We noticed that the more we increased the weight of the physical losses, the better the result was, even with few points for pressure. The partition of points is the following:

```
num_PDE = 10000
num_BC = 1000
num_IC = 1000
num_col_velocity = 50
num_col_pres = 1
```

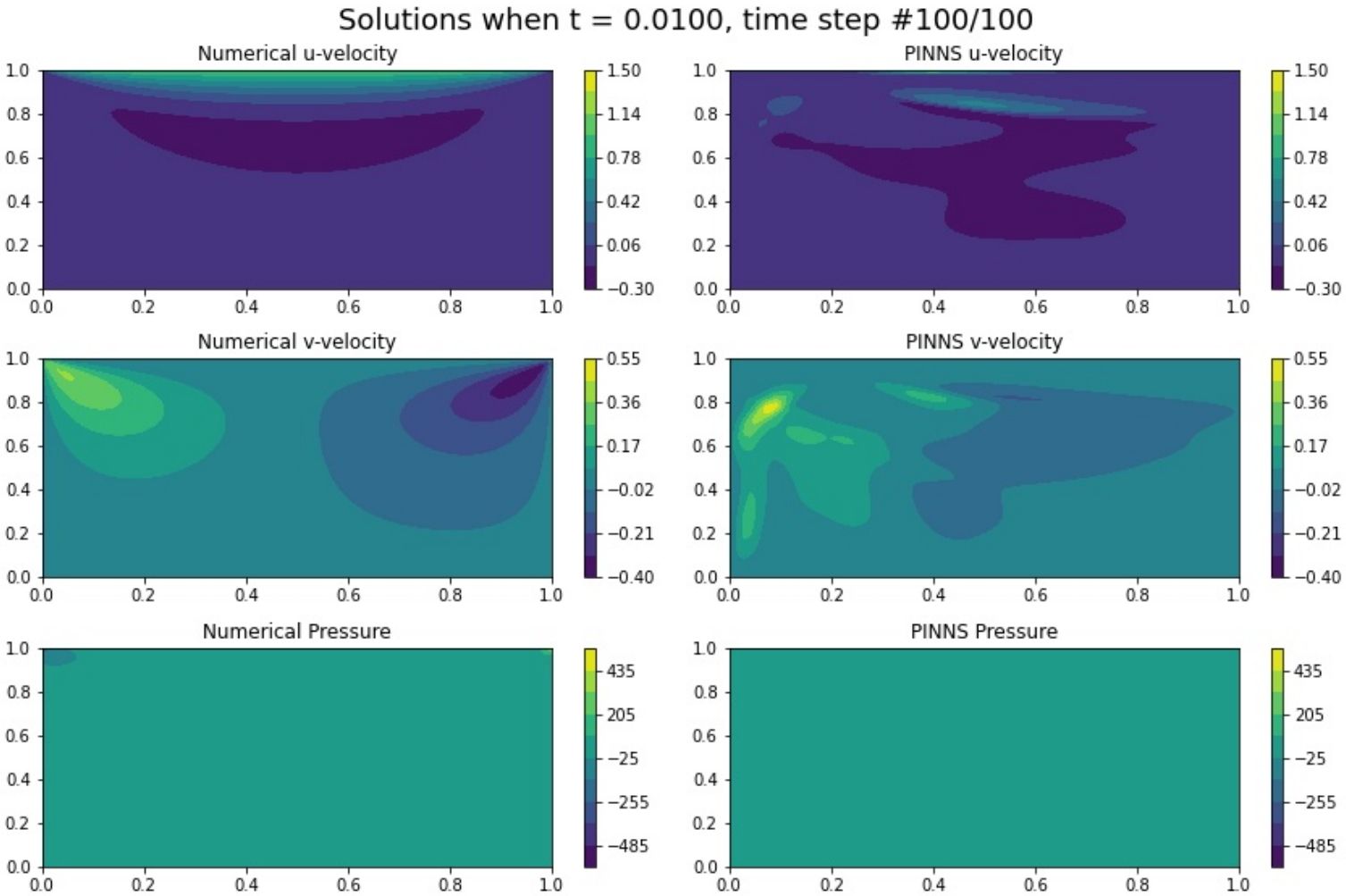
PINN - Losses

```
PDE_losses = [LMS('PDE_MASS', lambda: PDE_MASS(), weight = 1e-2),
              LMS('PDE_MOMU', lambda: PDE_MOM(0), weight = 1e-3),
              LMS('PDE_MOMV', lambda: PDE_MOM(1), weight = 1e-3)]
```





PINN - Solution at the final instant



PINN - Losses

```
PDE_losses = [LMS('PDE_MASS', lambda: PDE_MASS(), weight = 1e-1),
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```
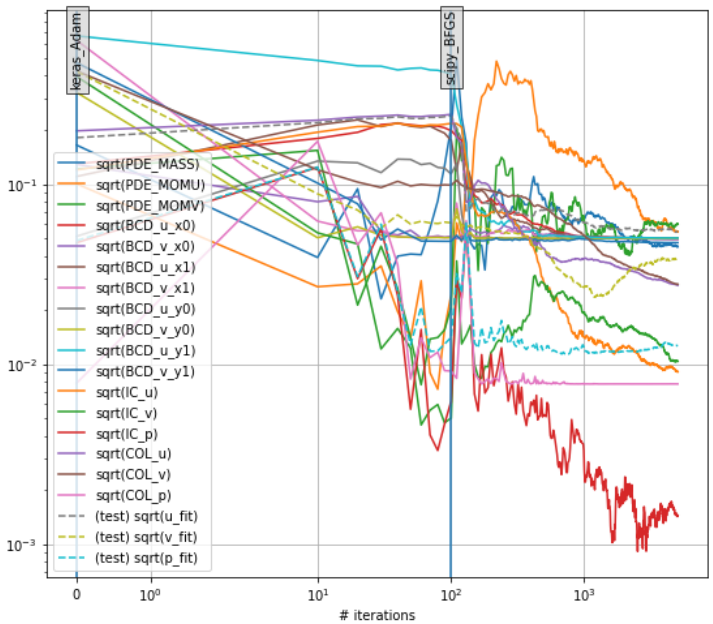
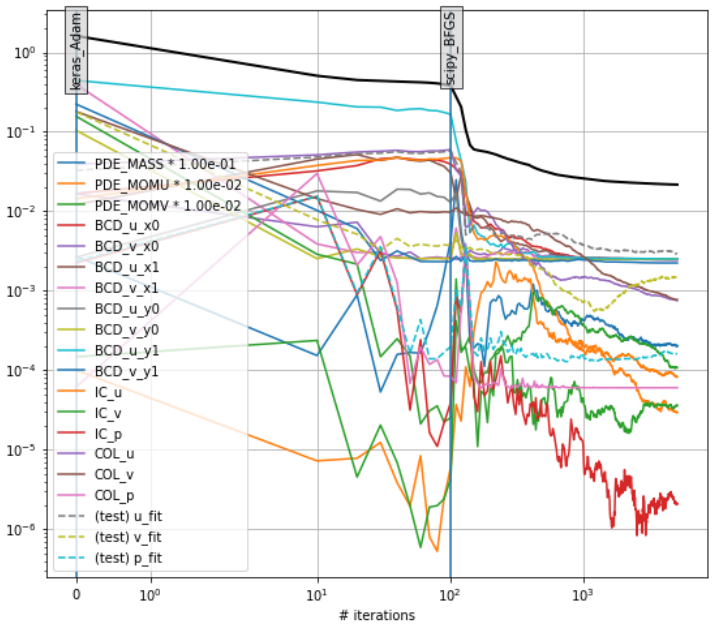
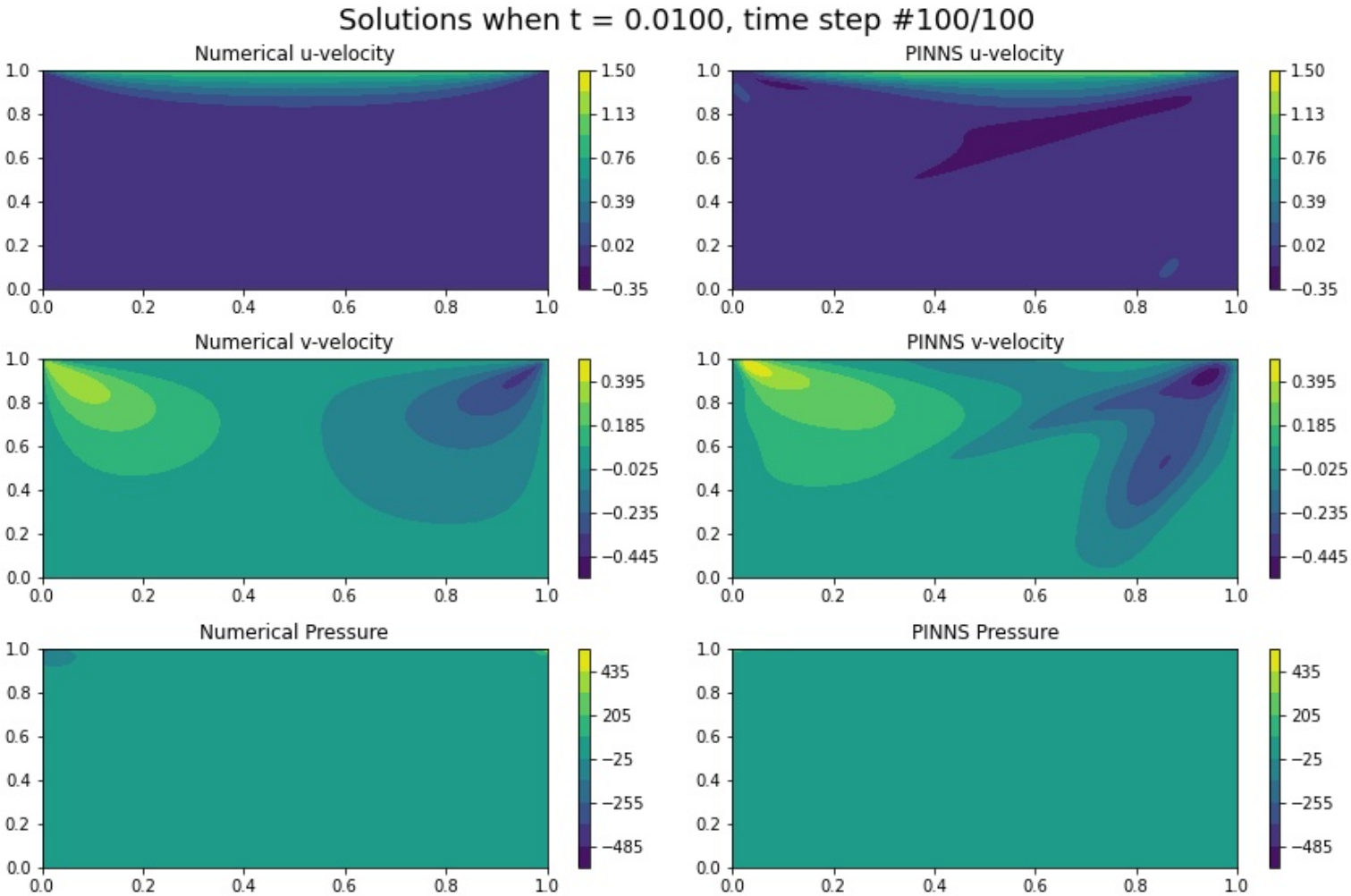





PINN - Solution at the final instant



PINN - Losses

```
PDE_losses = [LMS('PDE_MASS', lambda: PDE_MASS(), weight = 1e0),
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              LMS('PDE_MOMV', lambda: PDE_MOM(1), weight = 1e-1)]
```
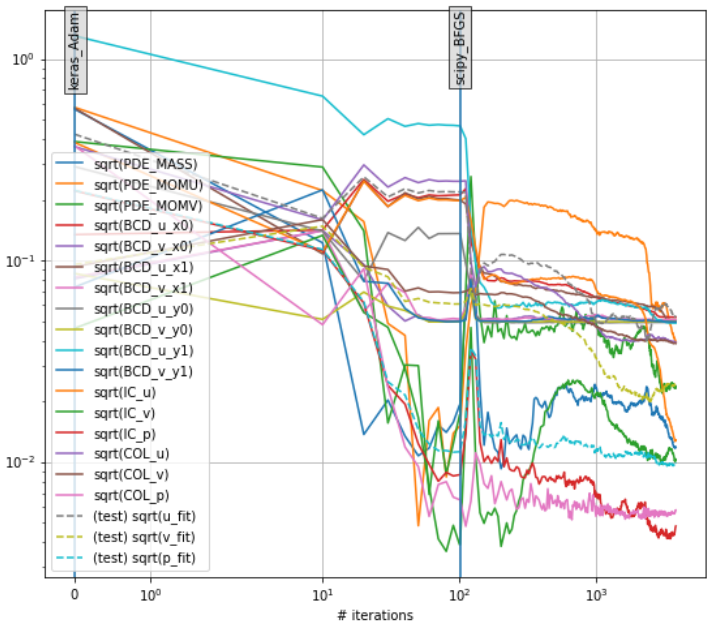
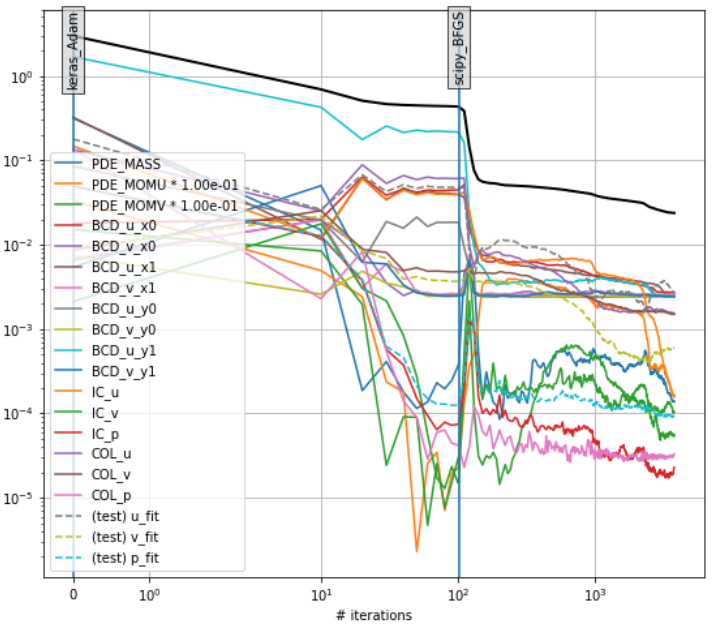
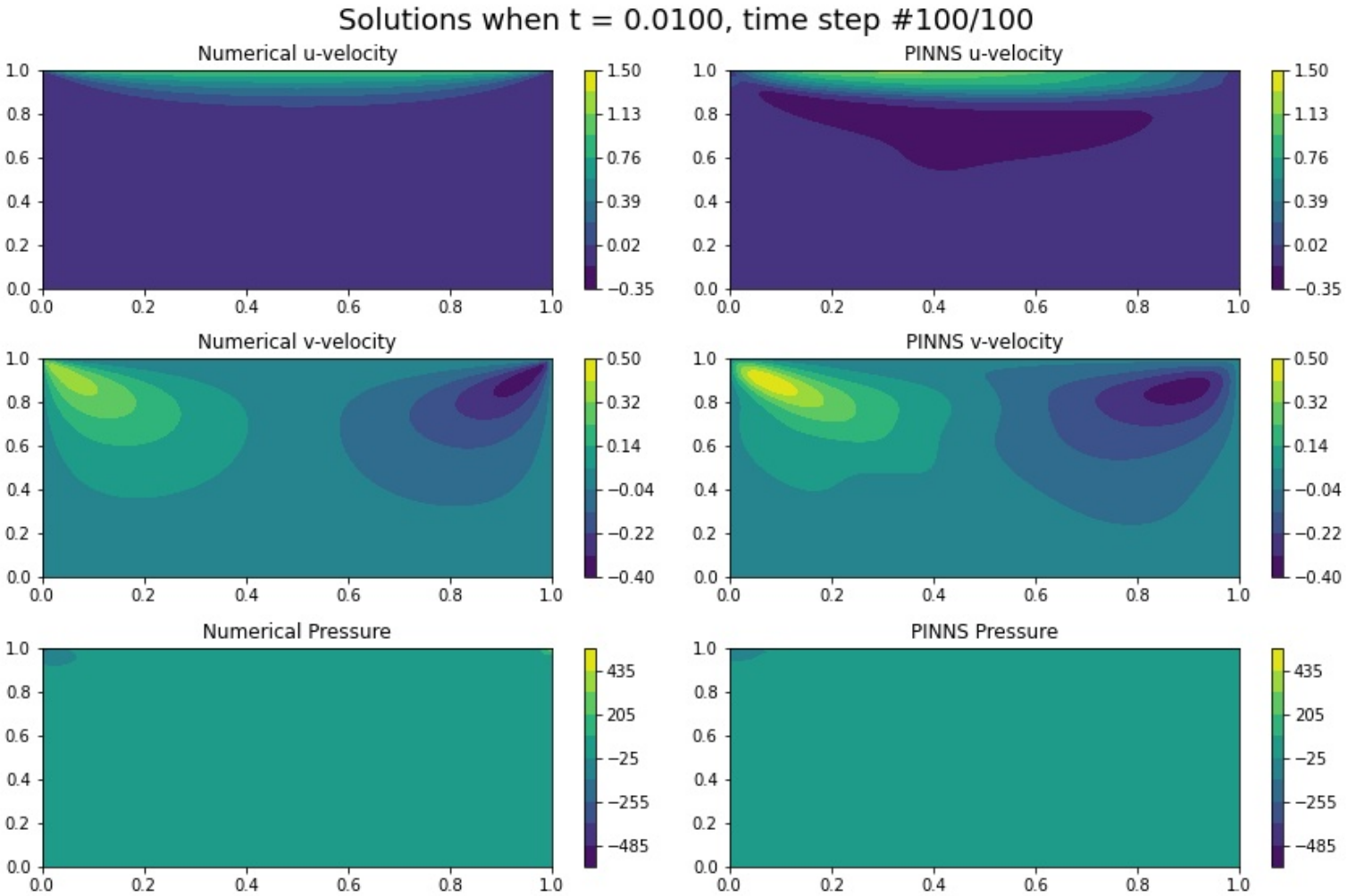





PINN - Solution at the final instant



PINN - Losses

```
PDE_losses = [LMS('PDE_MASS', lambda: PDE_MASS(), weight = 1e1),
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              LMS('PDE_MOMV', lambda: PDE_MOM(1), weight = 1e0)]
```

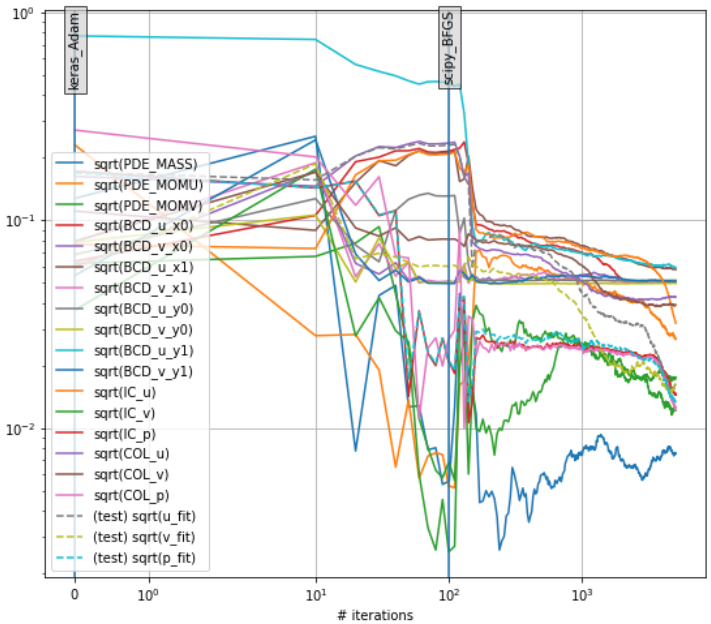

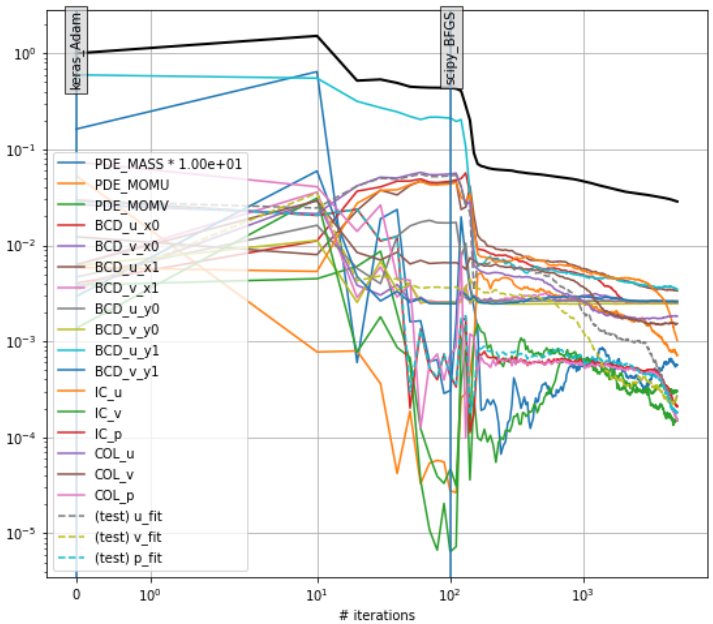

PINN - Losses

In this case, even if boundary losses are stuck due to the presence of noise, the test loss keep going down and there is no overfitting.

PINN - Solution at the final instant