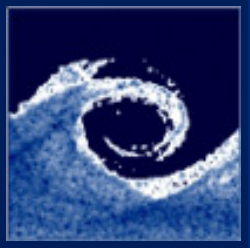


Stationary and transient flows

Lecture 4

Balogh Miklós

March 23, 2014

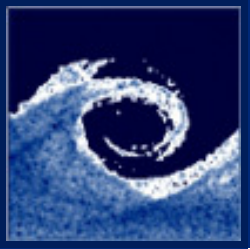


Table of Contents

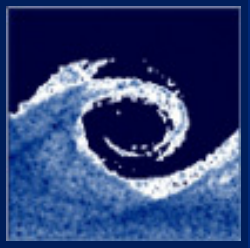
Steadyness

Block mesh

Analysis

Refining

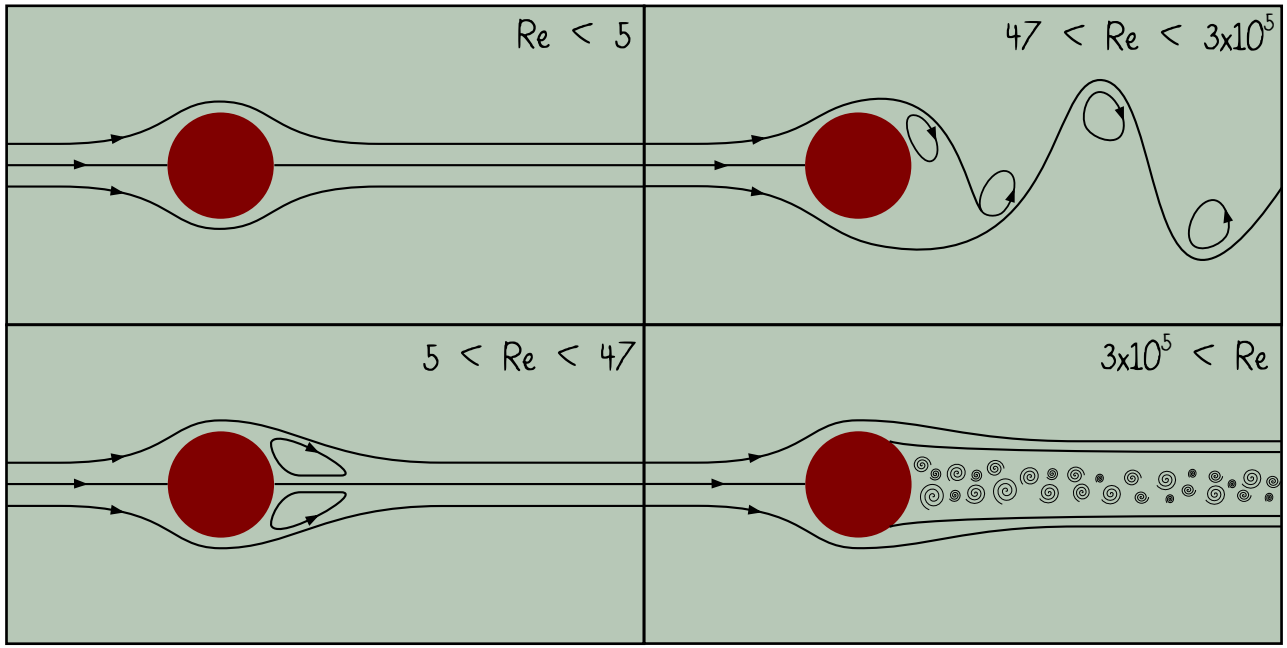
1. Steadyness
2. Block mesh
3. Analysis
4. Refining

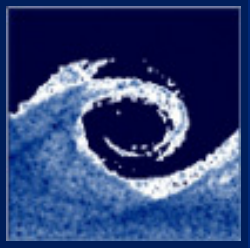


Stationary and transient flows

Steady vs. unsteady
Balogh Miklós
Steadyness
Block mesh
Analysis
Refining

- Transient (unsteady) flows
  - Every real flow in molecular sense
- Stationary (steady-state) flow refers to the condition
  - where the fluid properties do not change over time
  - all the time derivatives of a flow field vanish





Steps of the numerical analysis - Domain

Steady vs. unsteady

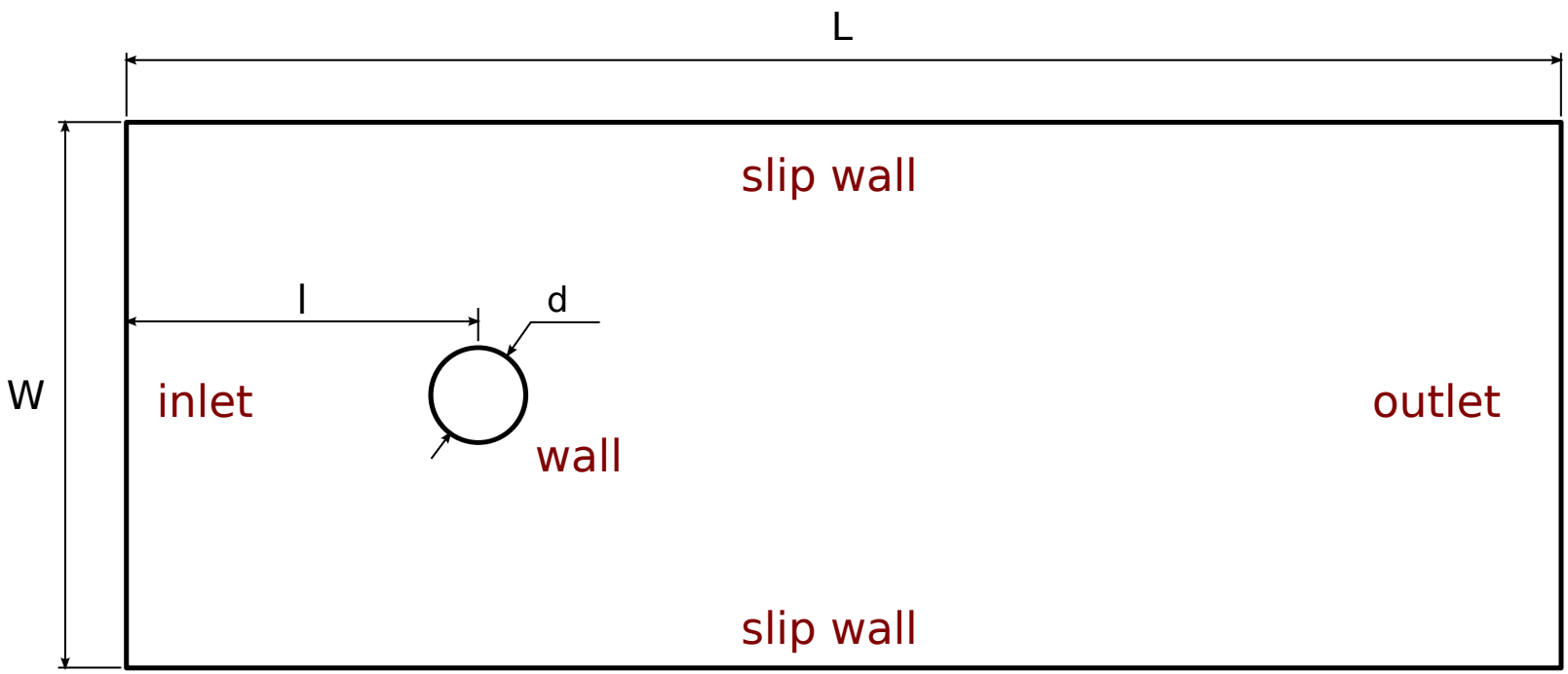
Balogh Miklós

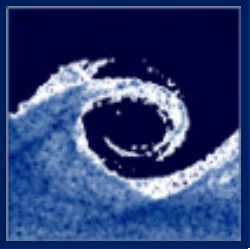
Steadyness

Block mesh

Analysis

Refining





Steps of the numerical analysis - Mesh blocks

Steady vs. unsteady

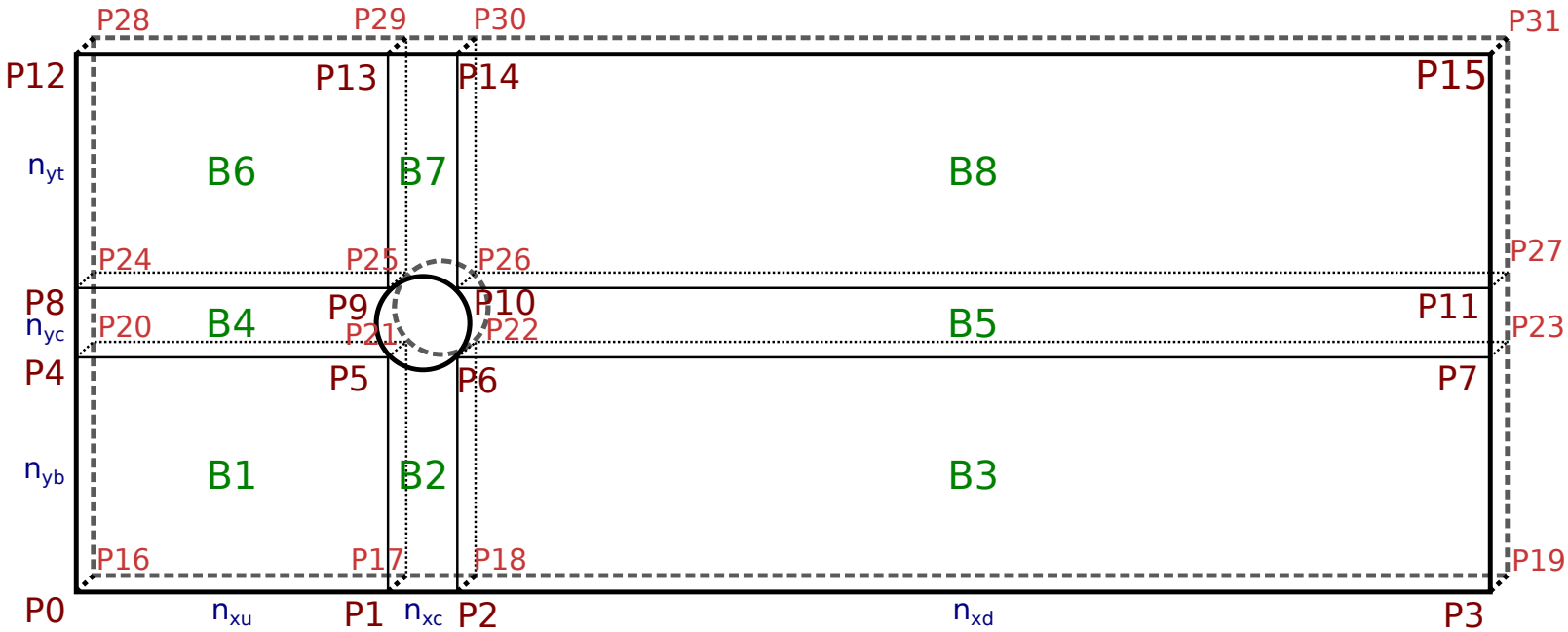
Balogh Miklós

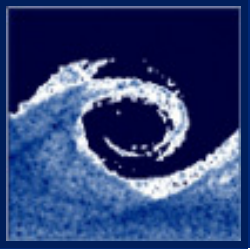
Steadyness

Block mesh

Analysis

Refining



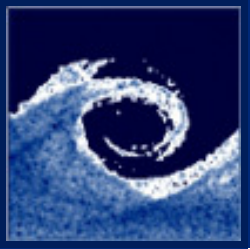


Steps of the numerical analysis - blockMeshDict

Listing coordinates of the block vertices:

Listing 1: vertices in blockMeshDict

```
1  convertToMeters 1.0;
2
3  vertices
4  (
5      (-10   -10  -1) // P0
6      (-1    -10  -1) // P1
7      ( 1    -10  -1) // P2
8      ( 30   -10  -1) // P3
9      ...
10 );
```



Steps of the numerical analysis - blockMeshDict

Listing the blocks, ordered list of vertex labels and mesh size:

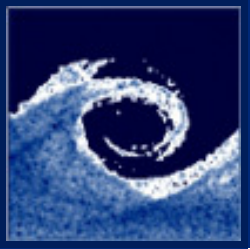
Listing 2: blocks in blockMeshDict

```
blocks
(
    // vertex numbers, number of intervals, interval grading
    hex ( 0  1  5  4 16 17 21 20) (48 48 1) simpleGrading ( 0.1075 0.1075 1)
    hex ( 1  2  6  5 17 18 22 21) (30 48 1) simpleGrading ( 1      0.1075 1)
    hex ( 2  3  7  6 18 19 23 22) (71 48 1) simpleGrading ( 28     0.1075 1)
    ...
);
```

Listing edges (line, polyLine, arc, simpleSpline, polySpline):

Listing 3: edges in blockMeshDict

```
edges
(
    // edge type, labels of end vertices, coord. of interpolation point(s)
    arc 5  6  ( 0 -1 -1)
    arc 6  10 ( 1  0 -1)
    ...
);
```



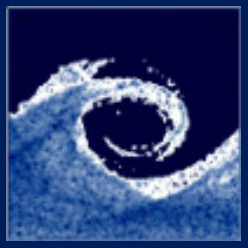
Steps of the numerical analysis - blockMeshDict

Listing boundaries (type, vertices of the faces):

Listing 4: boundaries in blockMeshDict

```
boundary
(
    inlet
    {
        type patch;
        faces
        (
            ( 0  4 20 16)
            ( 4  8 24 20)
            ( 8 12 28 24)
        );
    }
    ...
);


mergePatchPairs
(
);
```



Steps of the numerical analysis - Mesh

Steady vs. unsteady

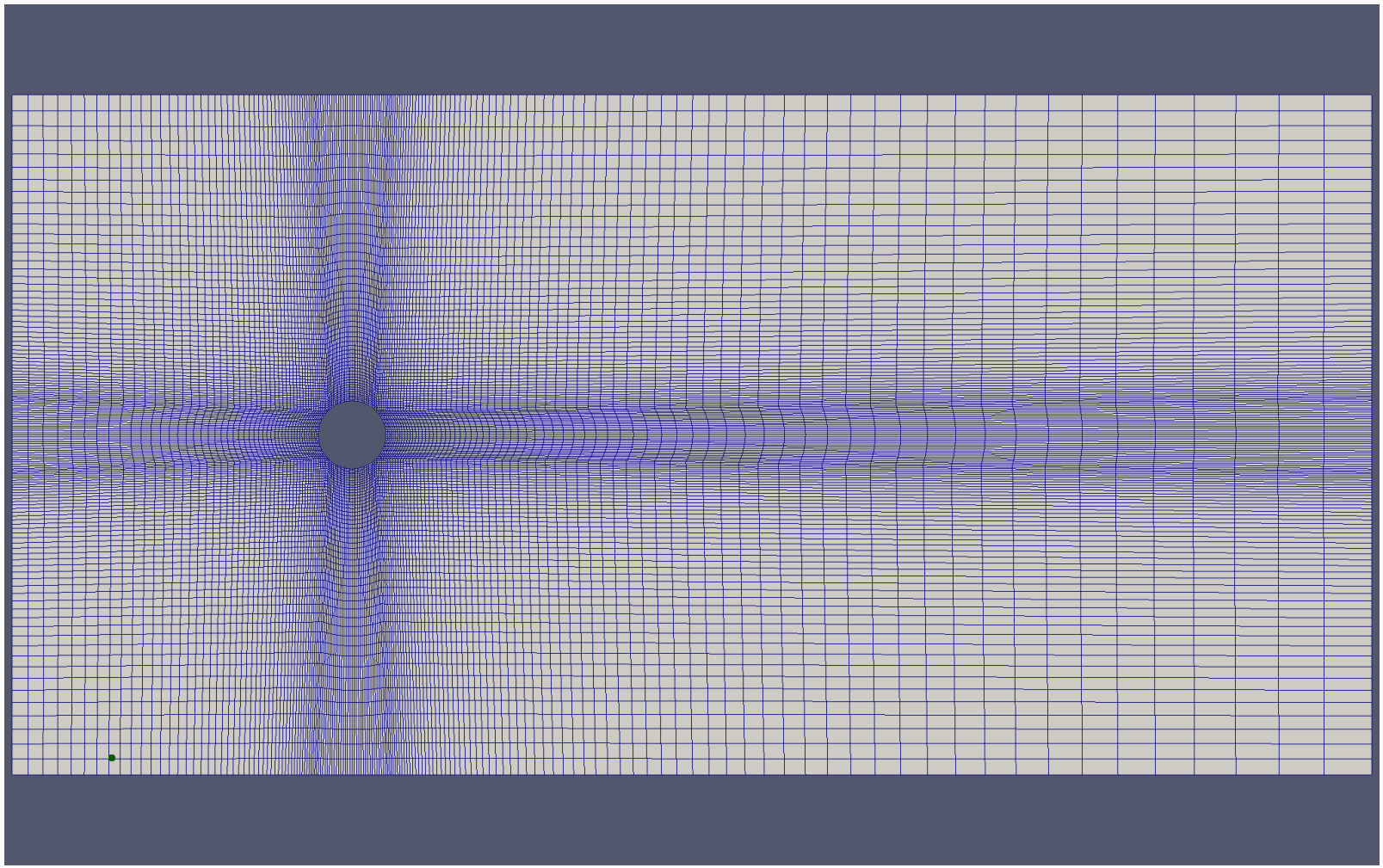
Balogh Miklós

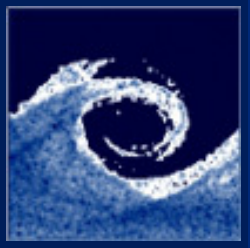
Steadyness

Block mesh

Analysis

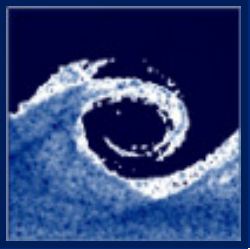
Refining





Steps of the numerical analysis - Boundaries

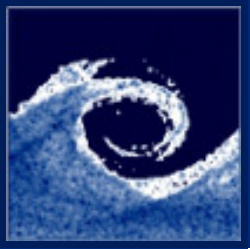
- Inlet (Dirichlet BC for U, Neumann BC for p)
  - fixed value for U ($U = U_{in} = 1\ ms^{-1}$)
  - zero gradient for p ($\partial p / \partial n = 0$)
- Outlet (Dirichlet BC for p, Neumann BC for U)
  - zero gradient for U ($\partial U / \partial n = 0$)
  - fixed value for p ($p = p_{ref} = 0\ Pa$)
- Walls
  - fixed value for U ($U = 0$)
  - zero gradient for p
- Front and back sides of a 2D domain
  - empty for both U and p
- Bottom and top sides
  - slip wall for both U and p



Steps of the numerical analysis - BC and IC for U

Listing 5: boundaries in 0/U

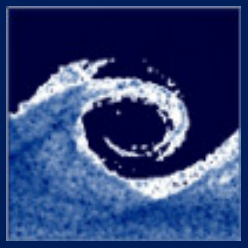
```
1  dimensions      [0 1 -1 0 0 0 0];
2  internalField   uniform (1 0 0);
3  boundaryField
4  {
5      inlet
6      {
7        type fixedValue;
8        value uniform (1 0 0);
9      }
10     outlet
11     {
12         type            zeroGradient;
13     }
14     cylinderWall
15     {
16         type            fixedValue;
17         value           uniform (0 0 0);
18     }
19     topWall
20     {
21         type            slip;
22     }
23     ...
24 }
```



Steps of the numerical analysis - BC and IC for p

Listing 6: boundaries in 0/p

```
dimensions      [0 2 -2 0 0 0 0];
internalField   uniform 0;
boundaryField
{
    inlet
    {
        type            zeroGradient;
    }
    outlet
    {
        type fixedValue;
        value uniform 0;
    }
    cylinderWall
    {
        type            zeroGradient;
    }
    topWall
    {
        type            zeroGradient;
    }
    ...
}
```



Steps of the numerical analysis - Simulation

Steady vs. unsteady

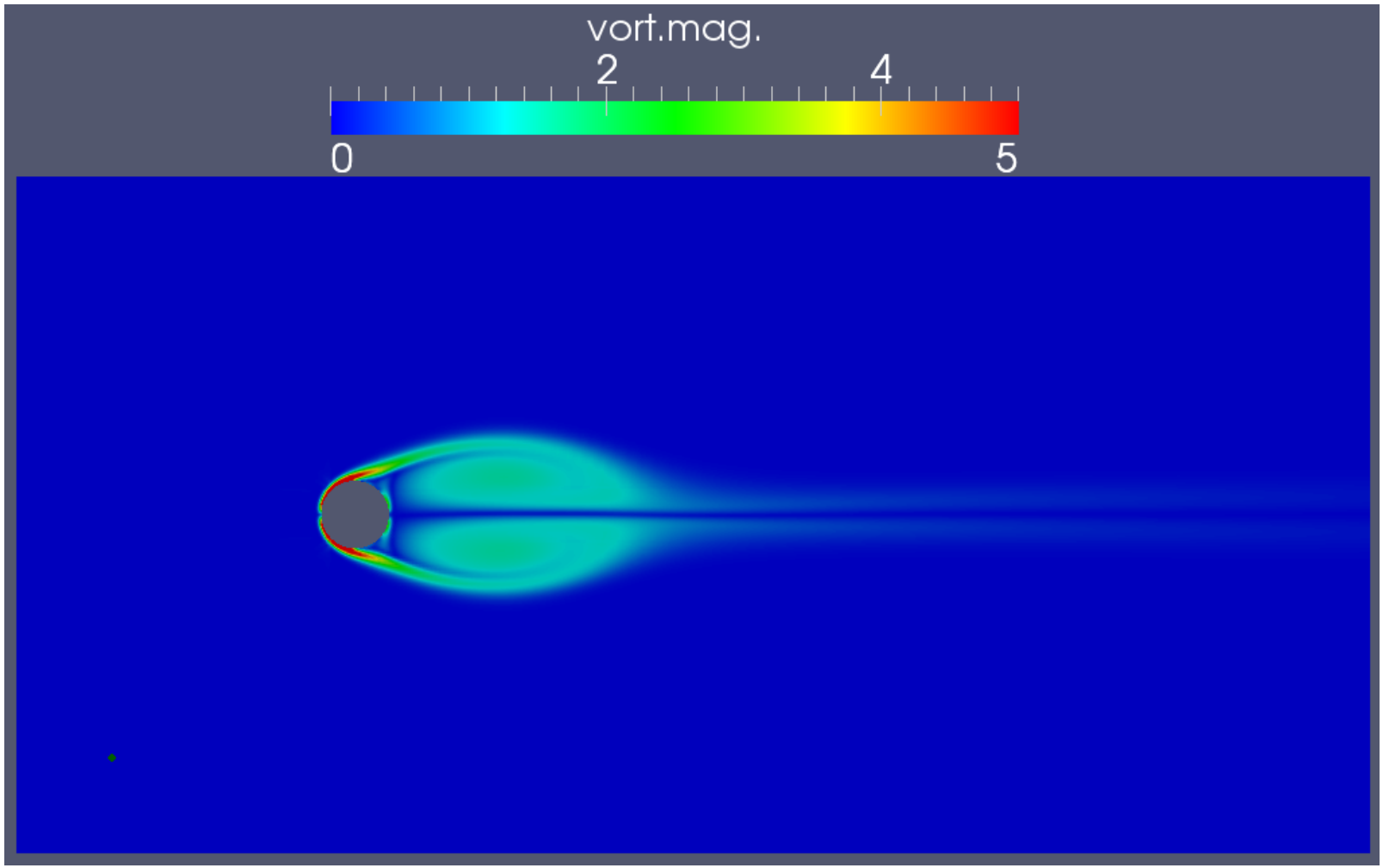
Balogh Miklós

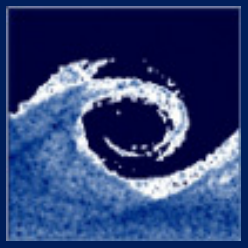
Steadyness

Block mesh

Analysis

Refining





Steps of the numerical analysis - Simulation

Steady vs. unsteady

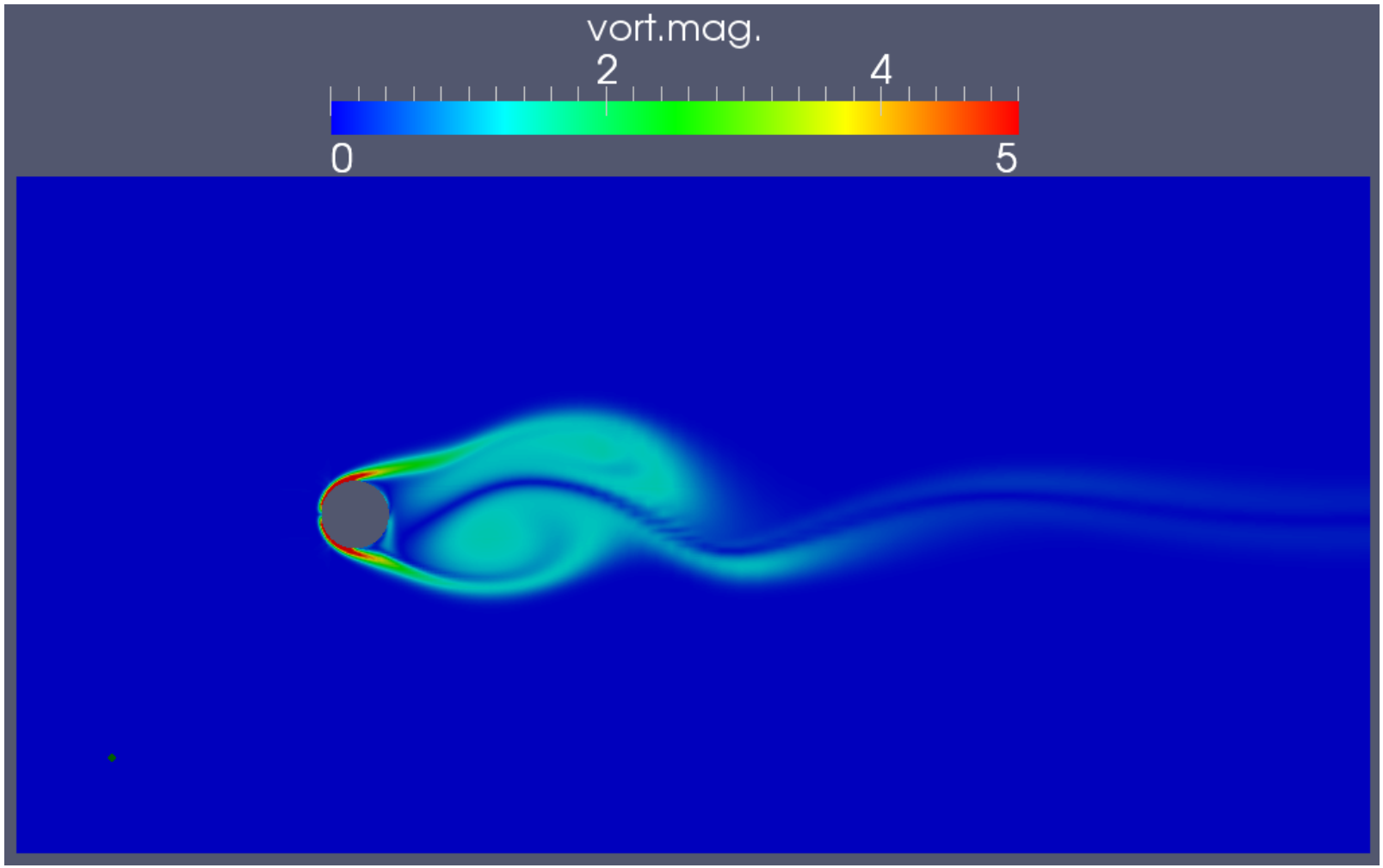
Balogh Miklós

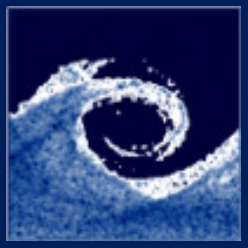
Steadyness

Block mesh

Analysis

Refining





Steps of the numerical analysis - Simulation

Steady vs. unsteady

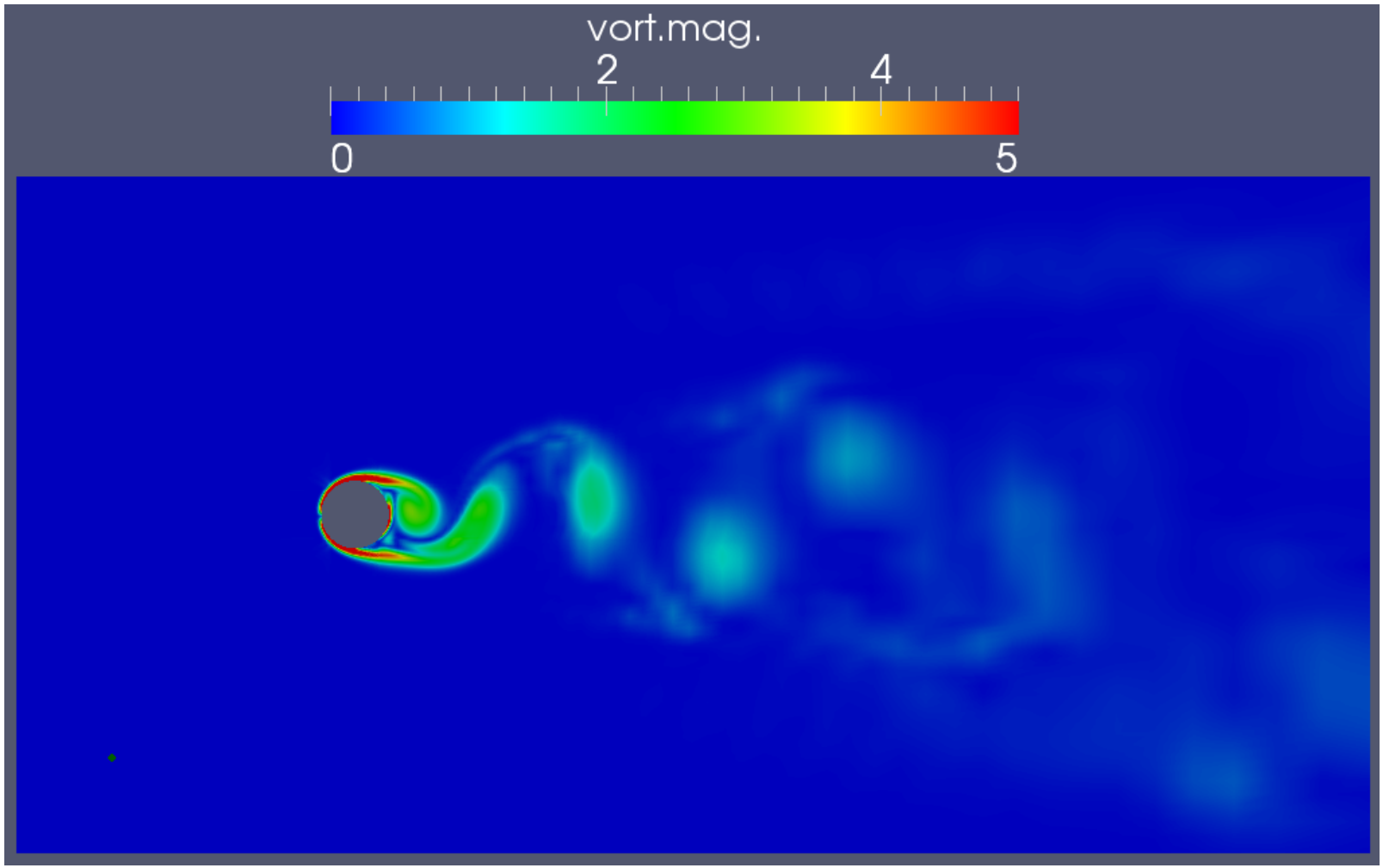
Balogh Miklós

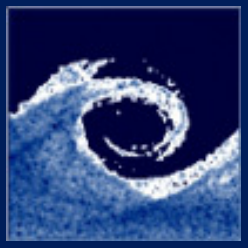
Steadyness

Block mesh

Analysis

Refining





Steps of the numerical analysis - Refined mesh

Steady vs. unsteady

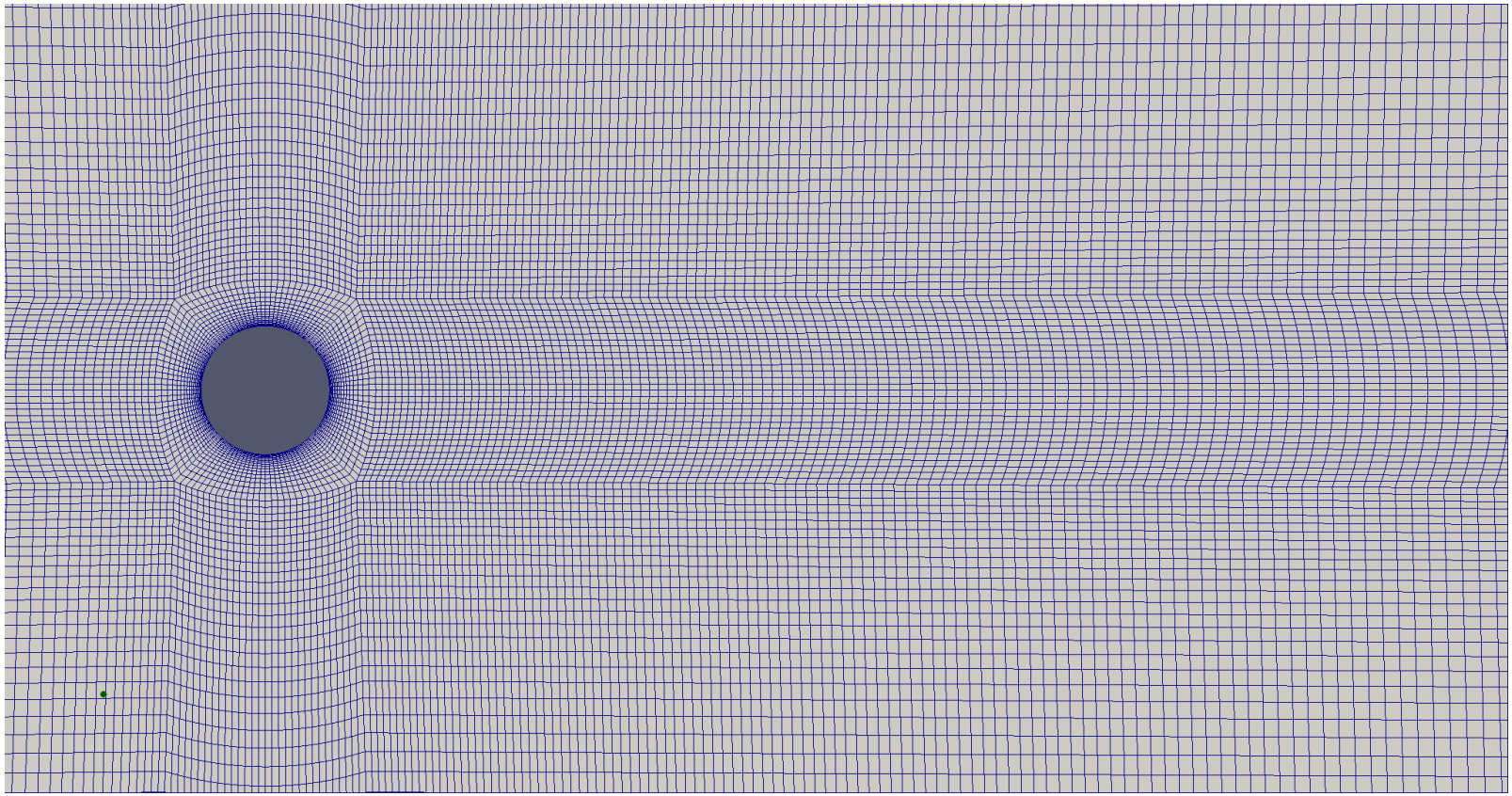
Balogh Miklós

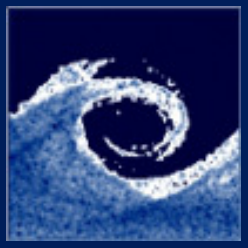
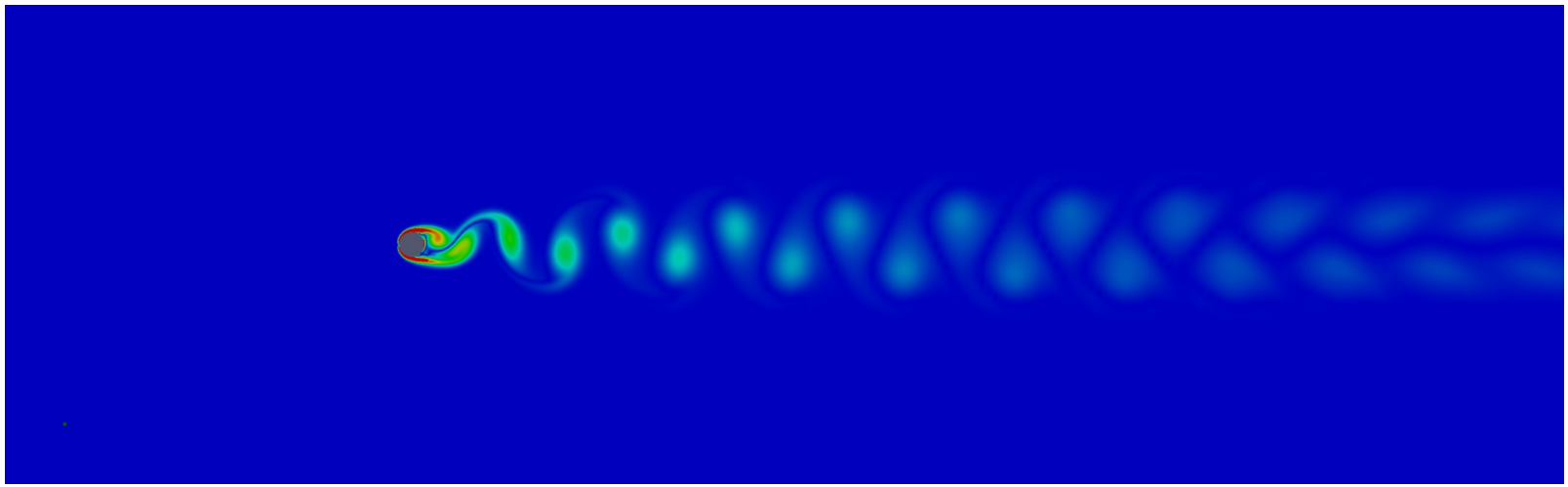
Steadyness

Block mesh

Analysis

Refining





Steps of the numerical analysis - Fine simulation