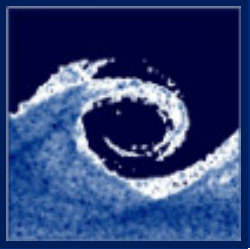
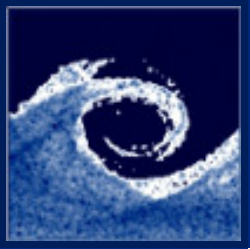


Stationary and transient flows

Lecture 4

Balogh Miklós

March 2, 2015



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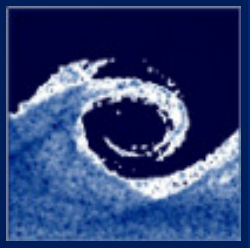
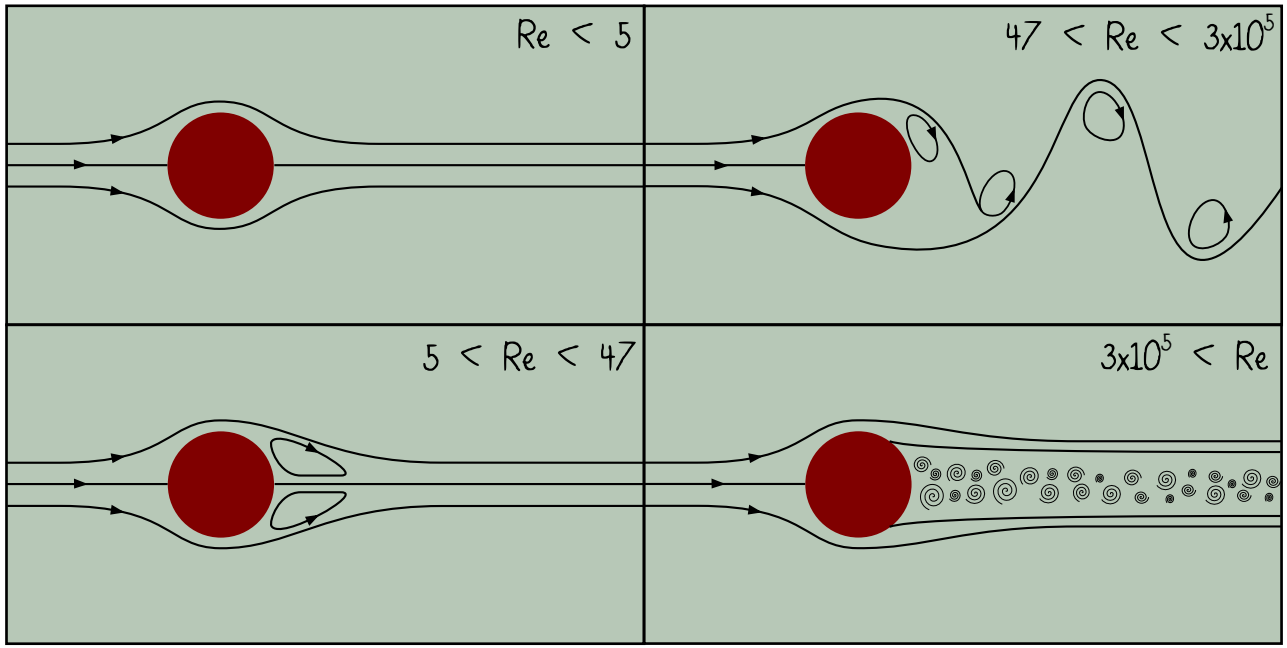
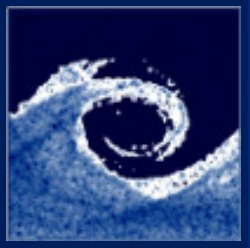


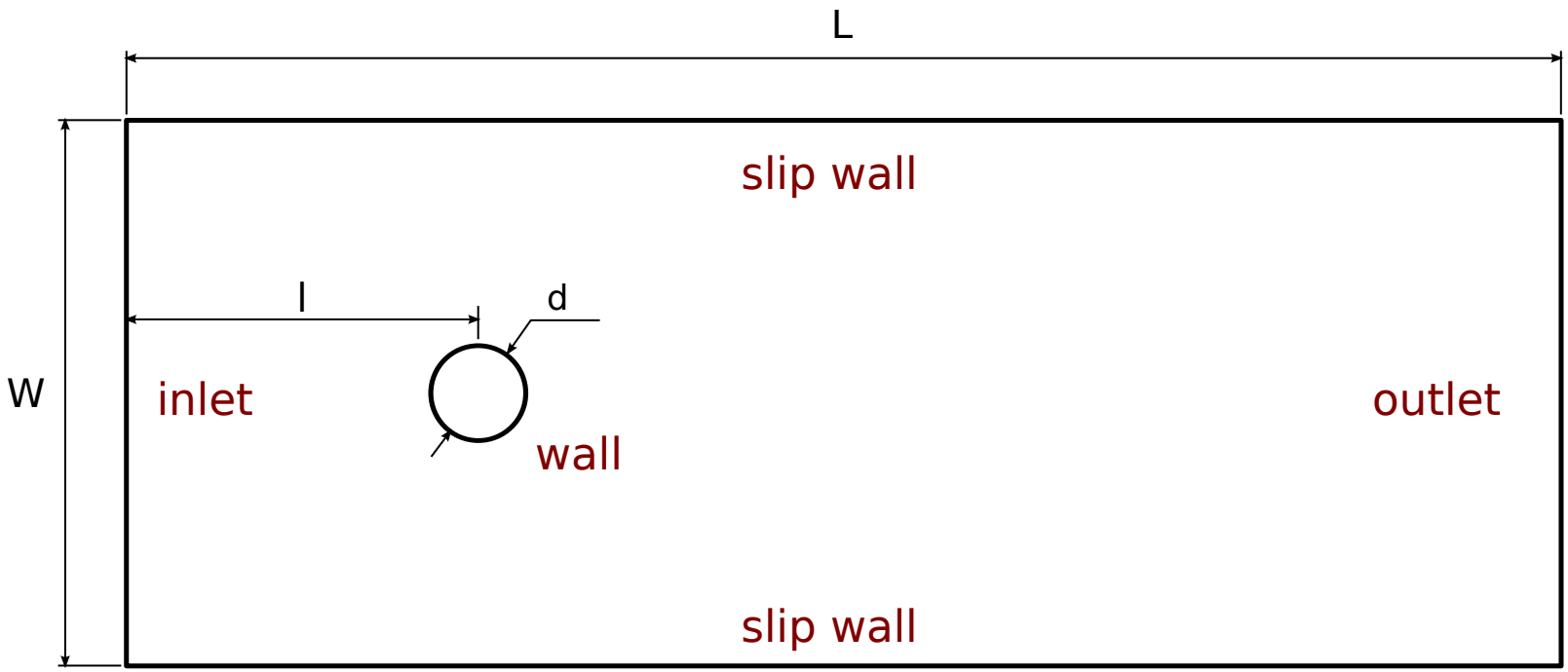
Stationary and transient flows

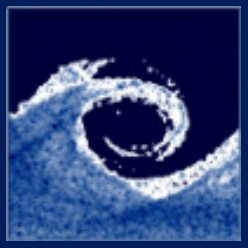
- Transient (unsteady) flows
  - Every real flow in molecular sense
- Stationary (steady-state) flow refers to the condition
  - where the fluid properties do not change over time
  - all the time derivatives of a flow field vanish



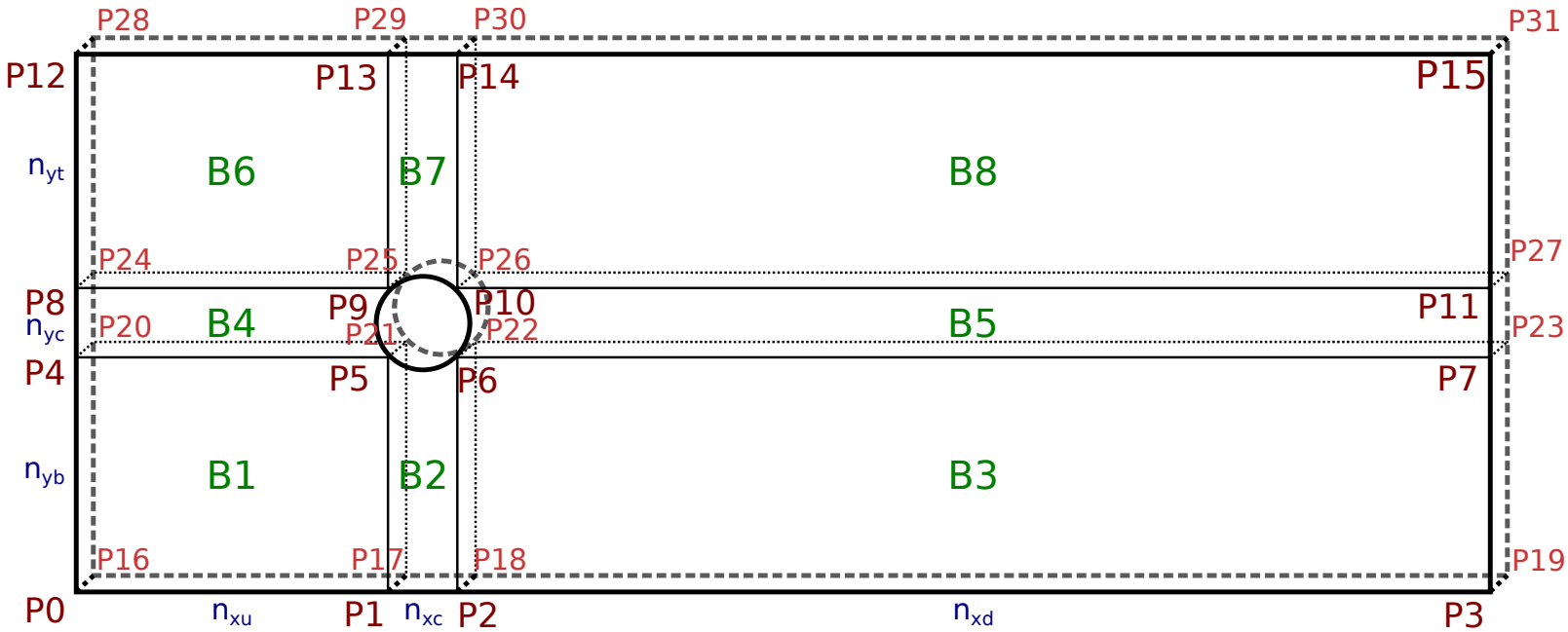


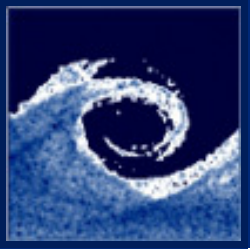
Steps of the numerical analysis - Domain





Steps of the numerical analysis - Mesh blocks





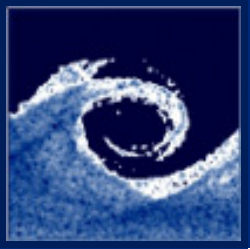
Steps of the numerical analysis - blockMeshDict

Listing coordinates of the block vertices:

Listing 1: vertices in blockMeshDict

```
convertToMeters 1.0;

vertices
(
    (-10   -10  -1) // P0
    (-1    -10  -1) // P1
    ( 1    -10  -1) // P2
    ( 30   -10  -1) // P3
    ...
);
```



Steps of the numerical analysis - blockMeshDict

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

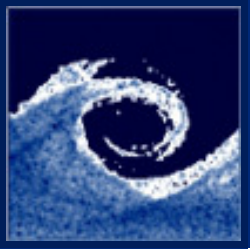
Listing 2: blocks in blockMeshDict

```
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)
    ...
);
```



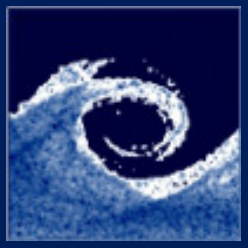
Steps of the numerical analysis - blockMeshDict

Listing boundaries (type, vertices of the faces):

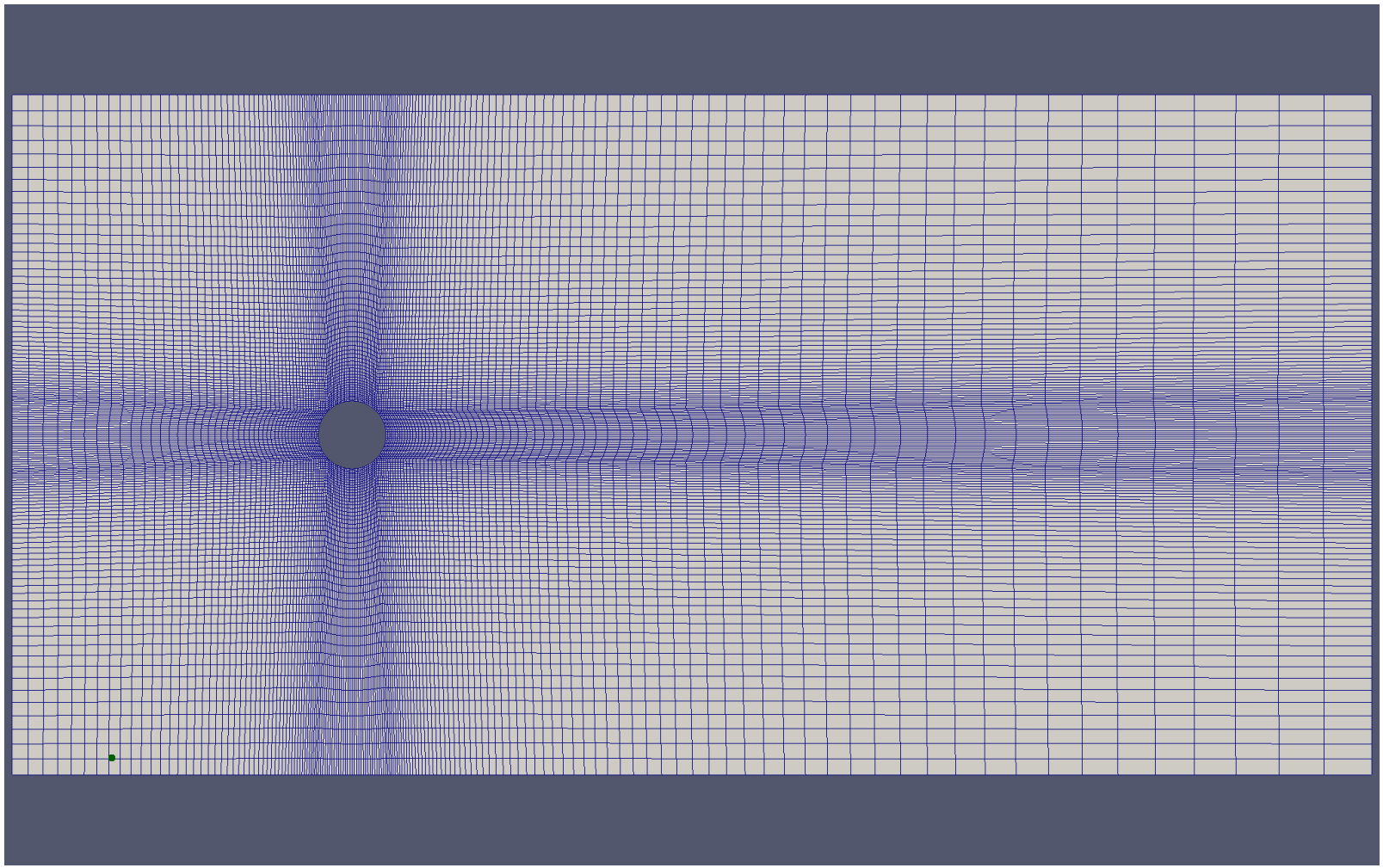
Listing 4: boundaries in blockMeshDict

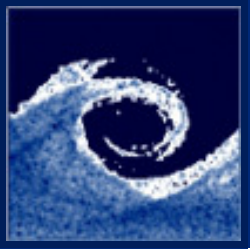
```
boundary
(
    inlet
    {
        type patch;
        faces
        (
            ( 0  4 20 16)
            ( 4  8 24 20)
            ( 8 12 28 24)
        );
    }
    ...
);


mergePatchPairs
(
);
```



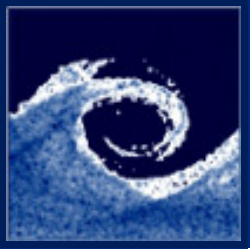
Steps of the numerical analysis - Mesh





Steps of the numerical analysis - Boundaries

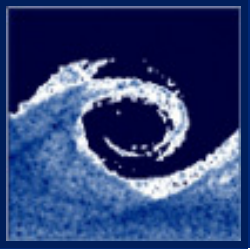
- Inlet (Dirichlet BC for U, Neumann BC for p)
  - fixed value for U ($U = U_{in} = 1\ ms^{-1}$)
  - zero gradient for p ($\partial p / \partial n = 0$)
- Outlet (Dirichlet BC for p, Neumann BC for U)
  - zero gradient for U ($\partial U / \partial n = 0$)
  - fixed value for p ($p = p_{ref} = 0\ Pa$)
- 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

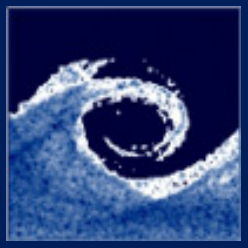
```
dimensions      [0 1 -1 0 0 0 0];
internalField   uniform (1 0 0);
boundaryField
{
    inlet
    {
      type fixedValue;
      value uniform (1 0 0);
    }
    outlet
    {
        type            zeroGradient;
    }
    cylinderWall
    {
        type            fixedValue;
        value           uniform (0 0 0);
    }
    topWall
    {
        type            slip;
    }
    ...
}
```



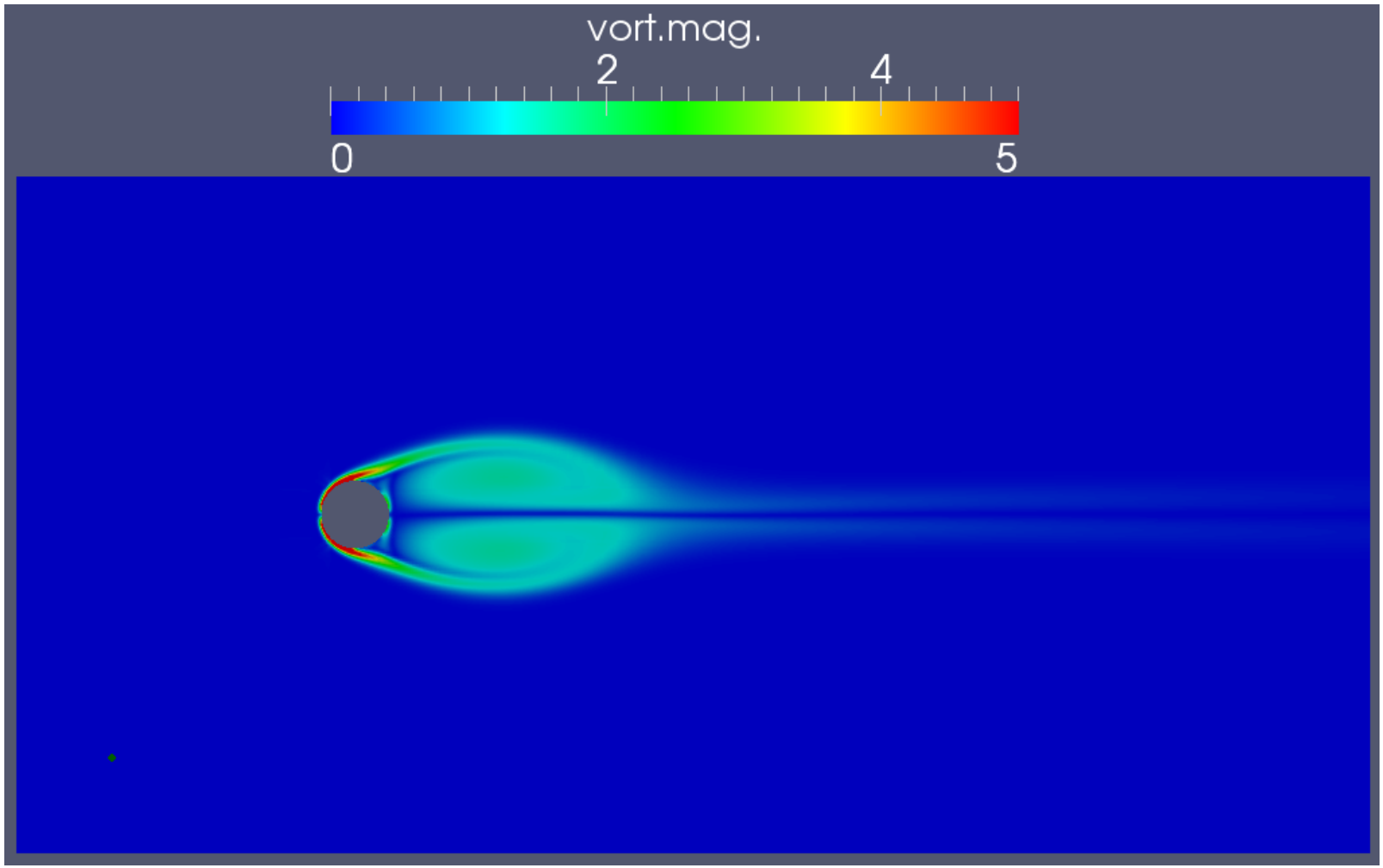
Steps of the numerical analysis - BC and IC for p

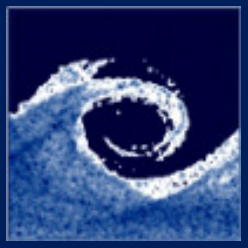
Listing 6: boundaries in 0/p

```
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;
    }
    ...
}
```

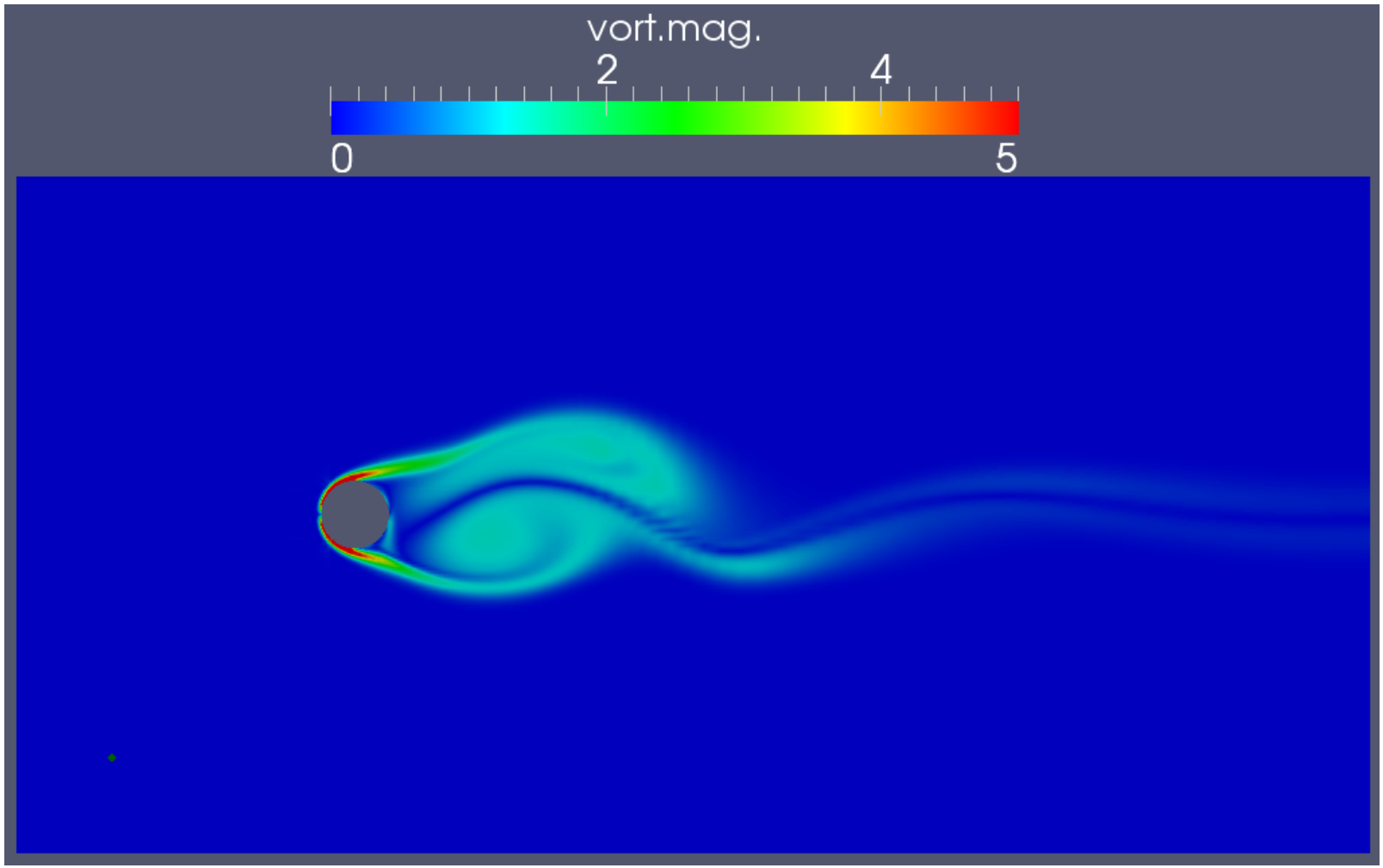


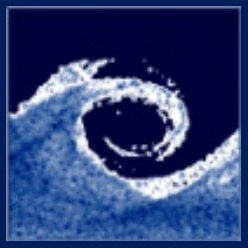
Steps of the numerical analysis - Simulation



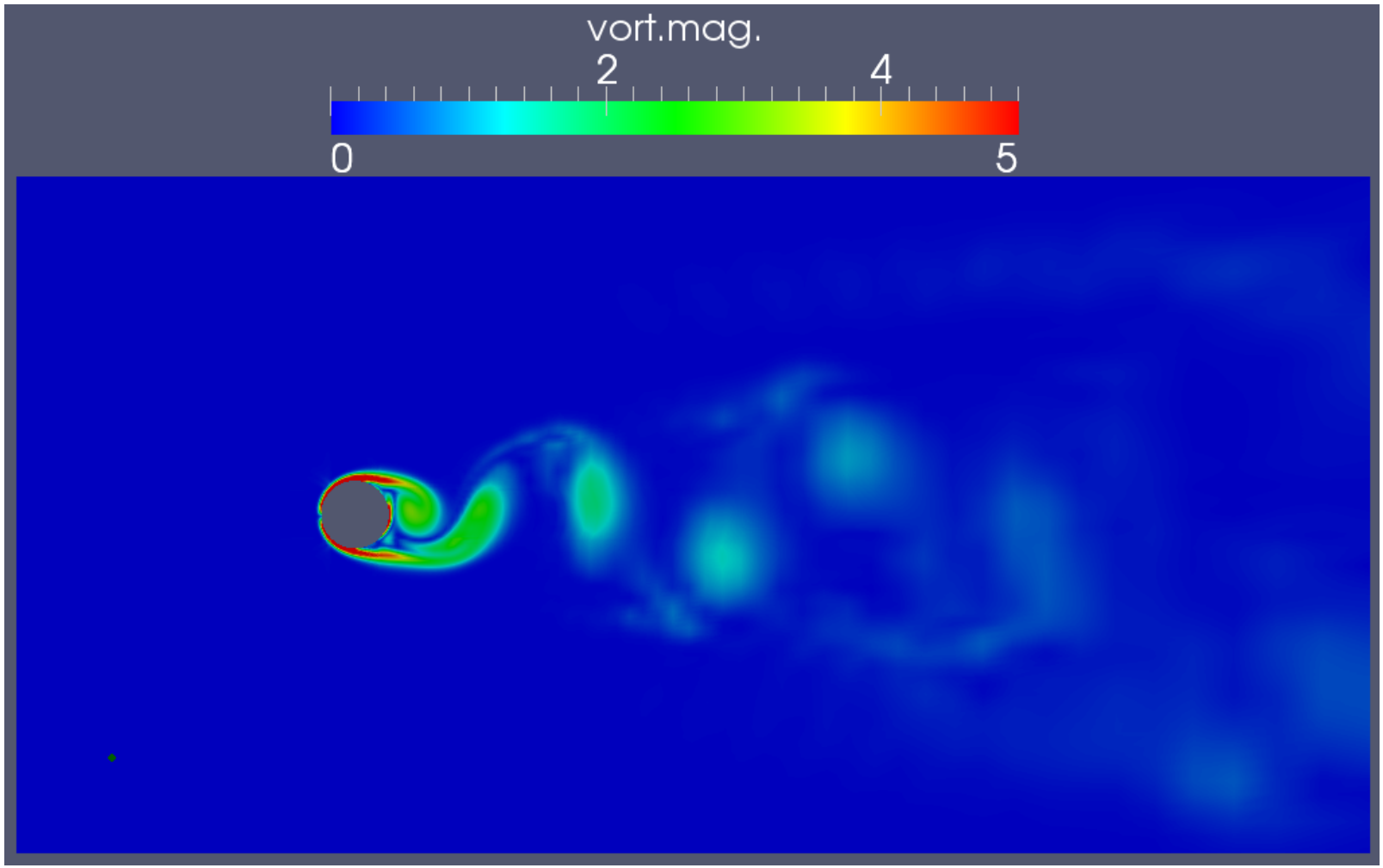


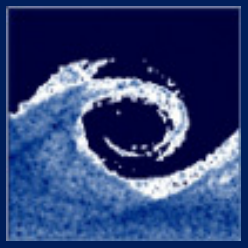
Steps of the numerical analysis - Simulation



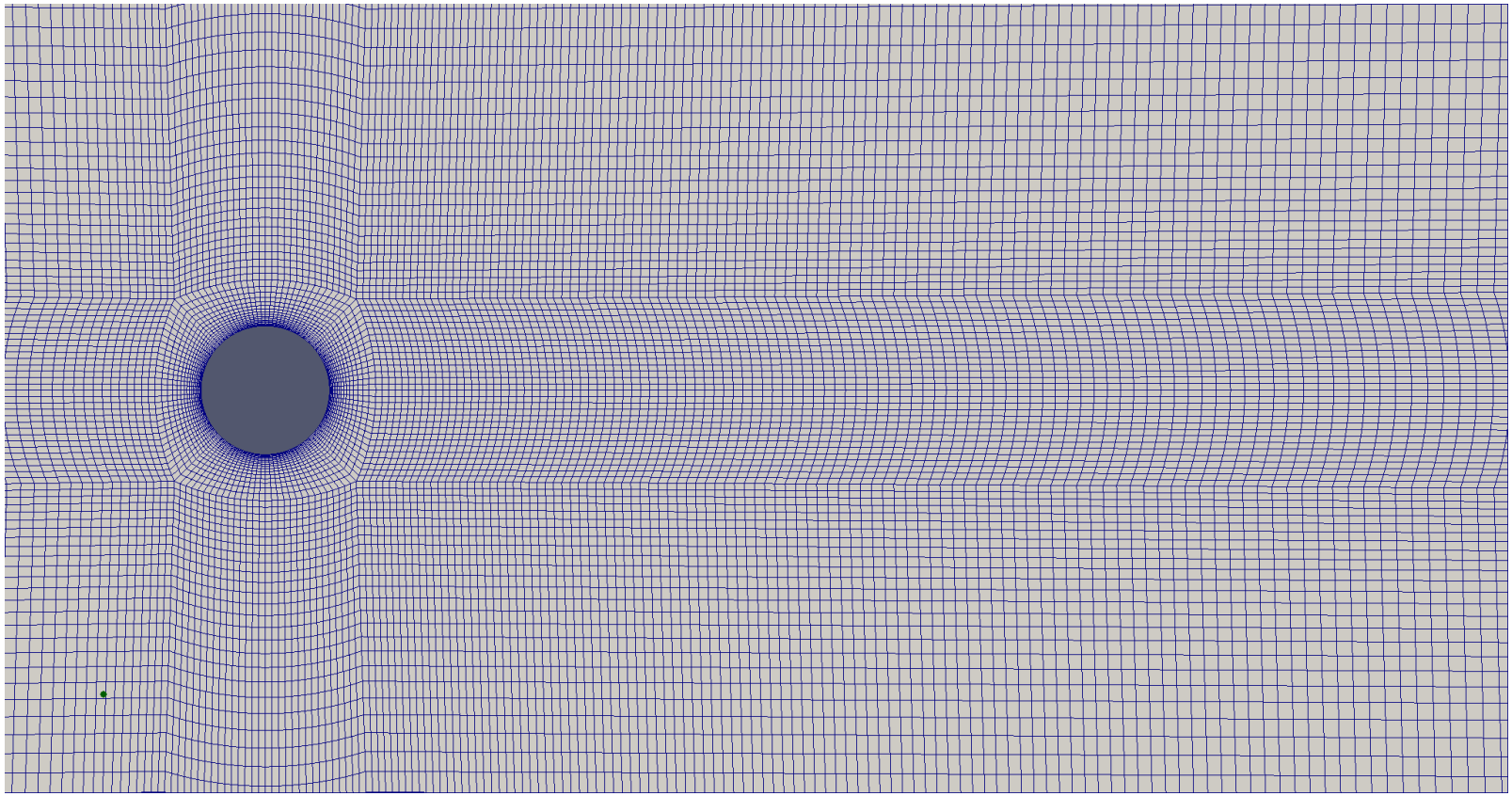


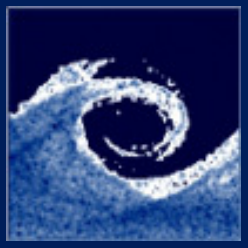
Steps of the numerical analysis - Simulation





Steps of the numerical analysis - Refined mesh





Steps of the numerical analysis - Fine simulation