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Study of Alfvénic vortex shedding past a cylindrical obstacle

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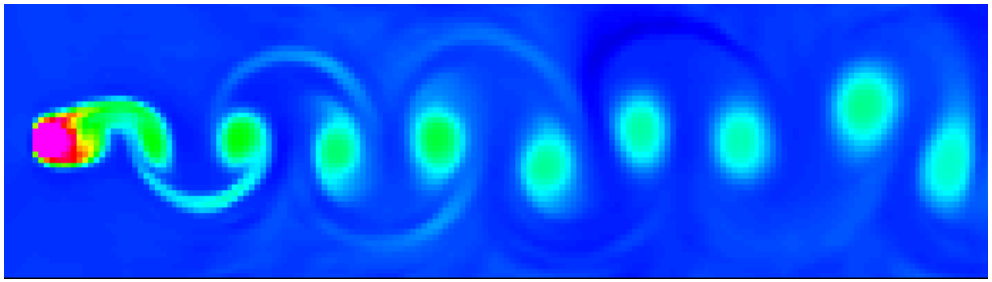
Introduction

- Fluid flow around a bluff obstacle may lead to periodical and alternate formation and disconnection of vortices from its each side (vortex shedding) and further formation of a chain of vortices (Kármán vortex street) – e.g. White (2006)



$$St = \frac{d \cdot f}{v}$$

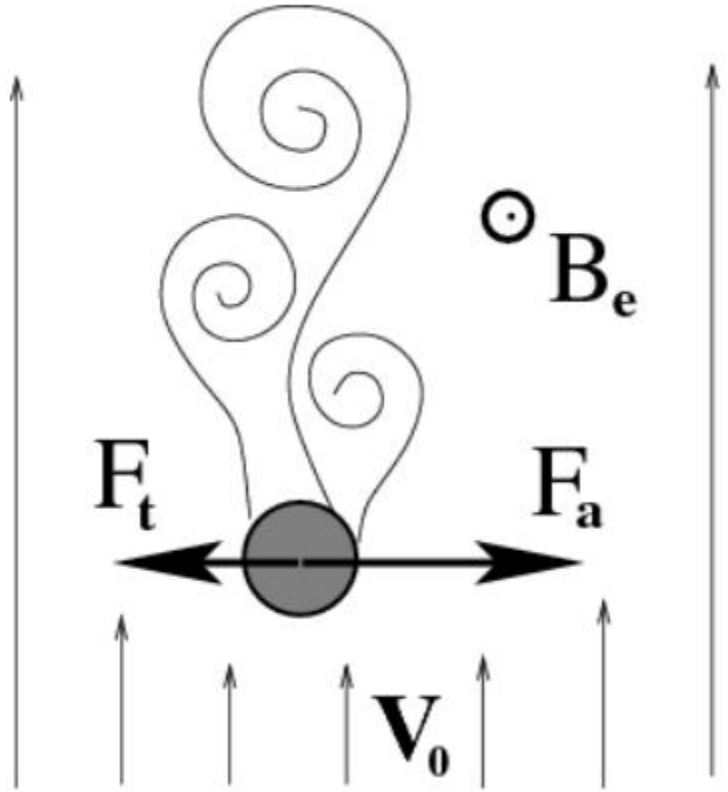
- Gruczecki et al. (2010) – vortex shedding has been widely studied in hydrodynamic conditions, but is less well understood in magnetohydrodynamic (MHD) conditions

- It has been studied in MHD conditions by a number of numerical simulations, mainly in 2D – e.g. Singha et al. (2006), Dousset and Pothérat (2008), Gruczecki et al. (2010)…
  - Karampelas and Van Doorsselaere (2021) – MHD simulations in 3D

Introduction

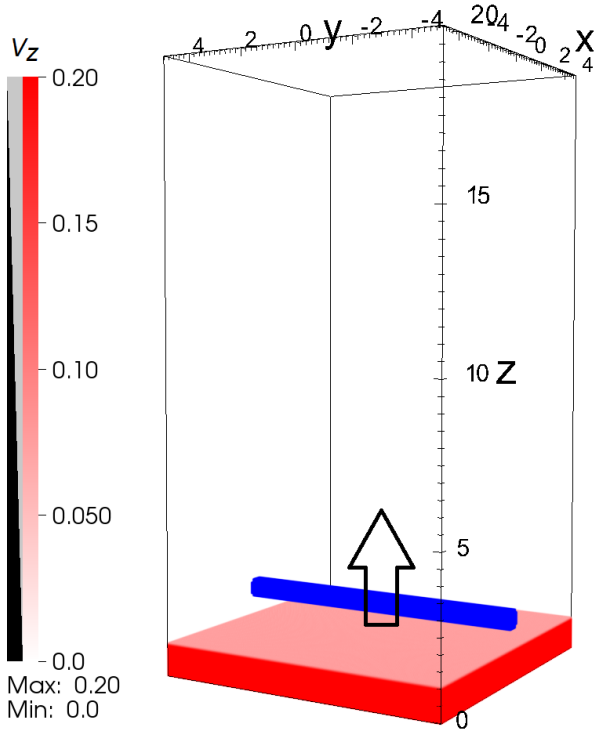
- E.g. Lee et al. (2015), Samanta et al. (2019) – observations suggest the possibility of its occurrence in the Sun's atmosphere

- Nakariakov et al. (2009) – it is a possible mechanism for excitation of kink mode oscillations in coronal loops:



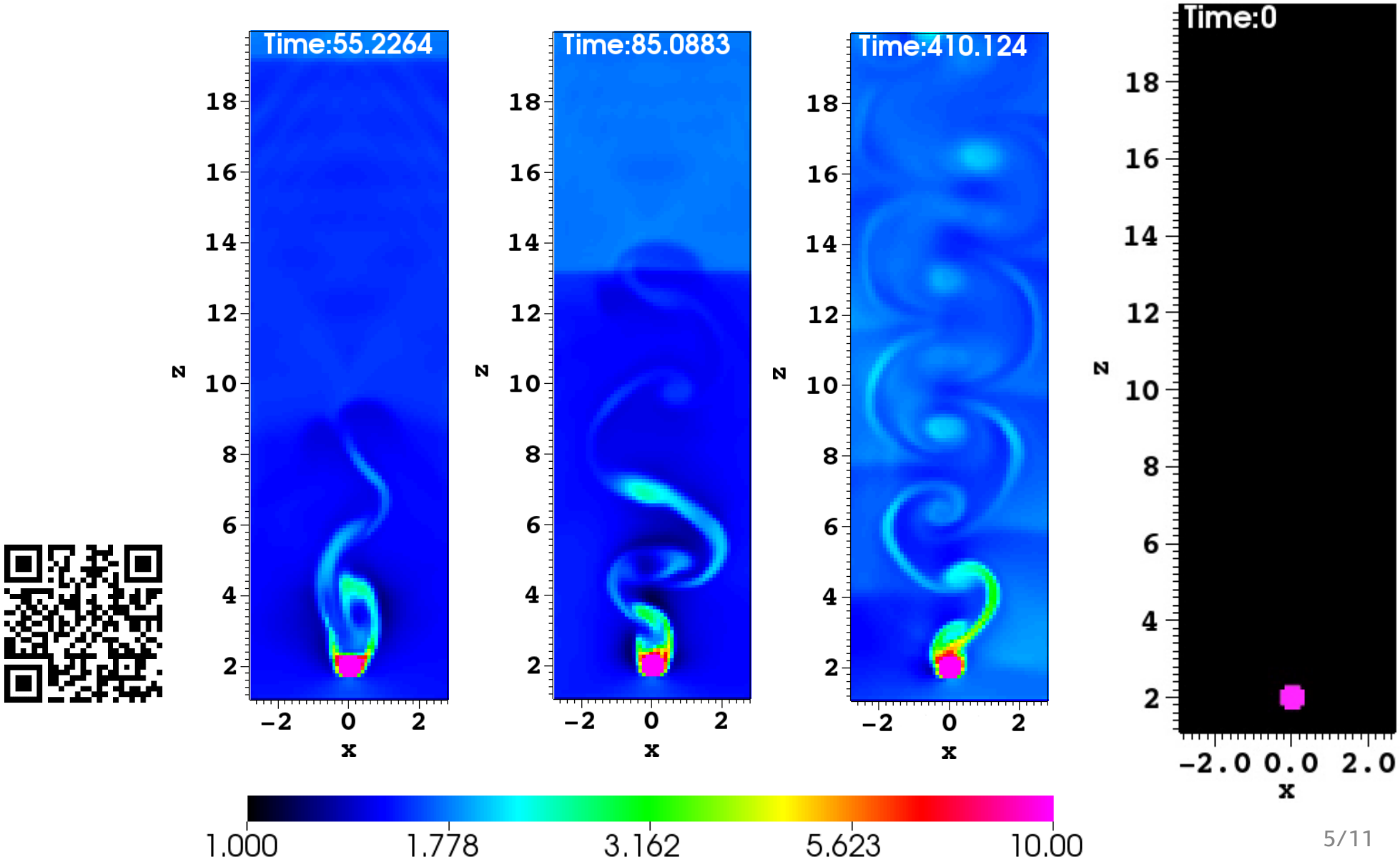
Numerical model

- Vortex shedding around a cylindrical obstacle was studied in MHD conditions in 3D using the numerical code Lare3d
- A parametric study was performed for different values of magnetic field (0, 5, 10 and 15 G) perpendicular to the plasma flow plane
- Gravitational field was not considered, ideal MHD equations were used



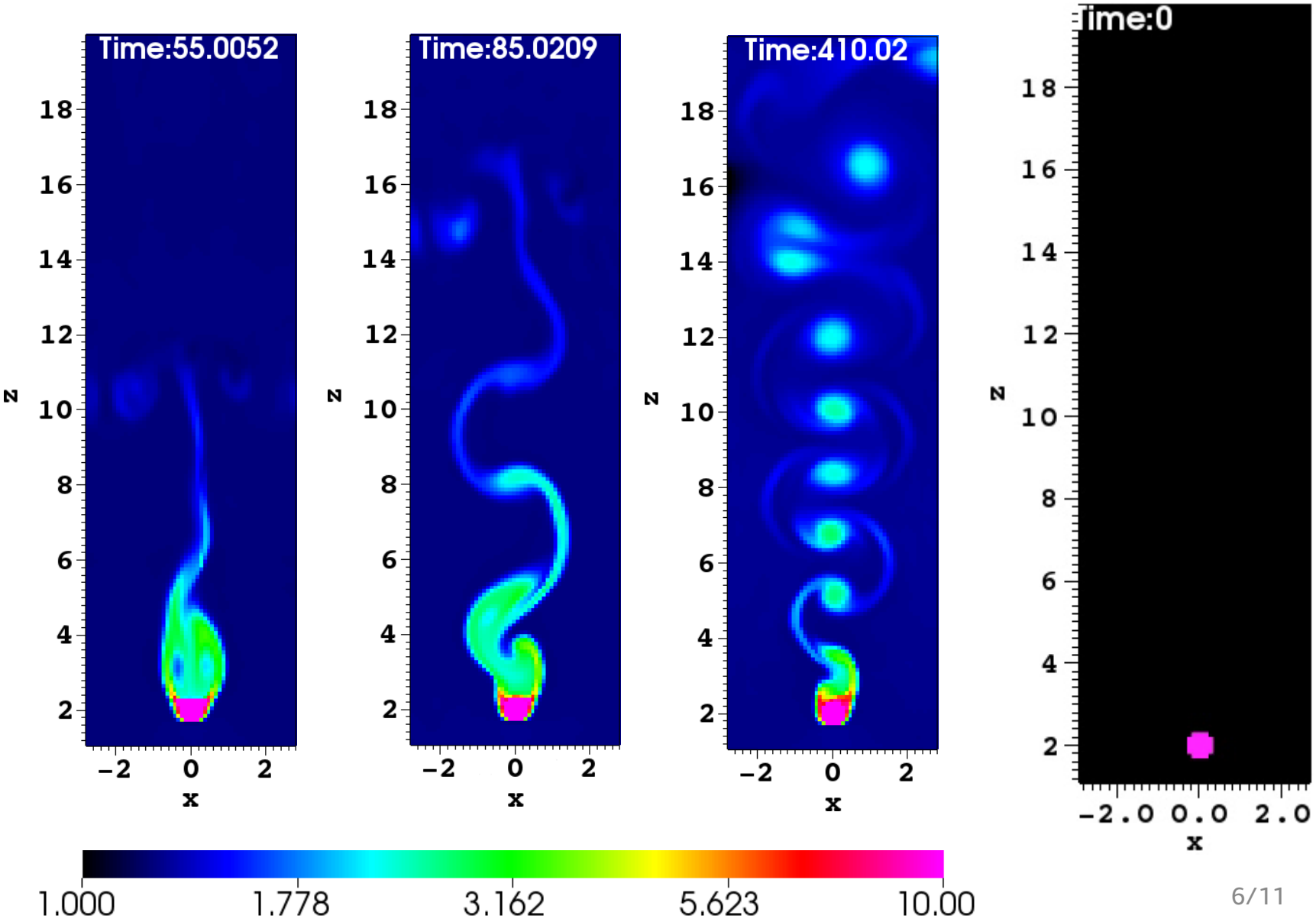
Results

- Time evolution of density – $B_y = 0$



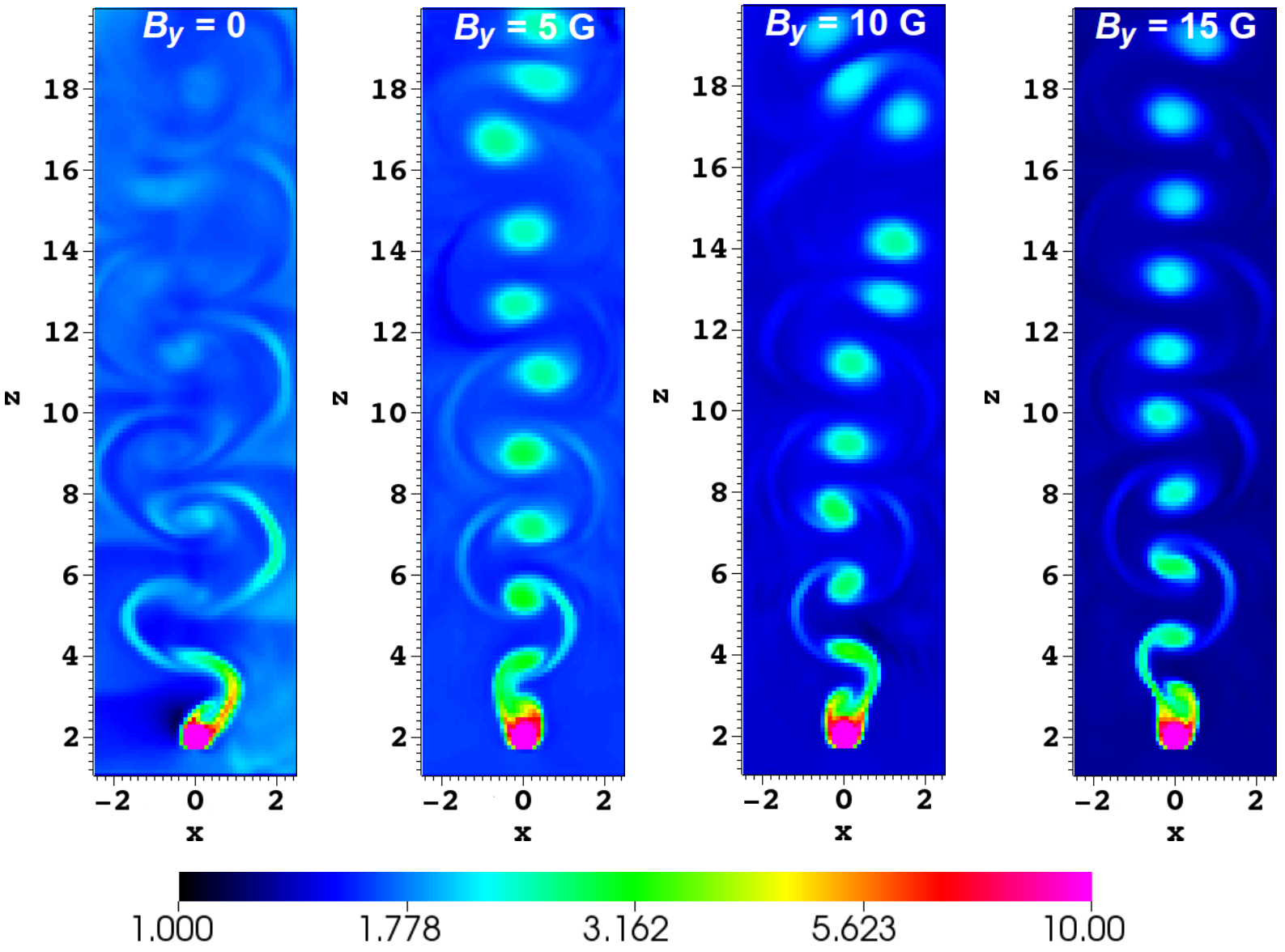
Results

- Time evolution of density – $B_y = 15$ G



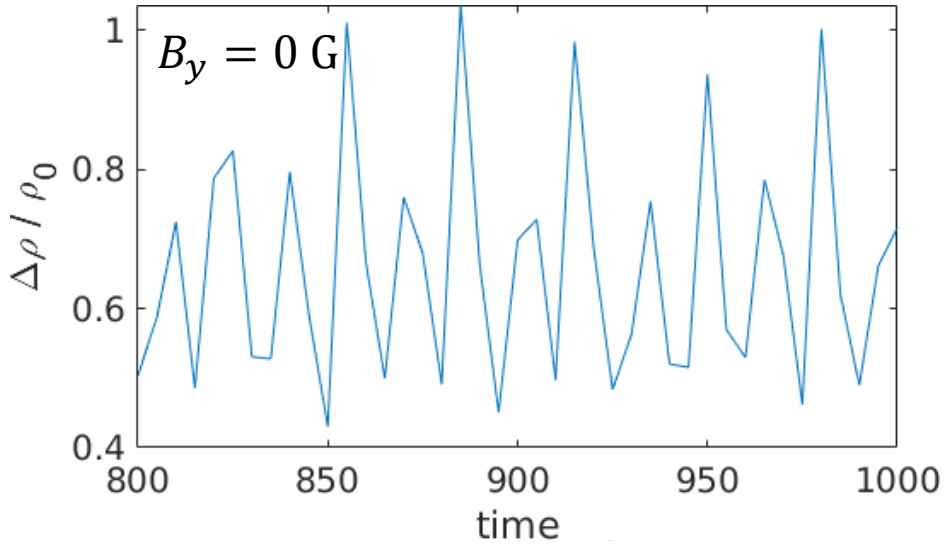
Results

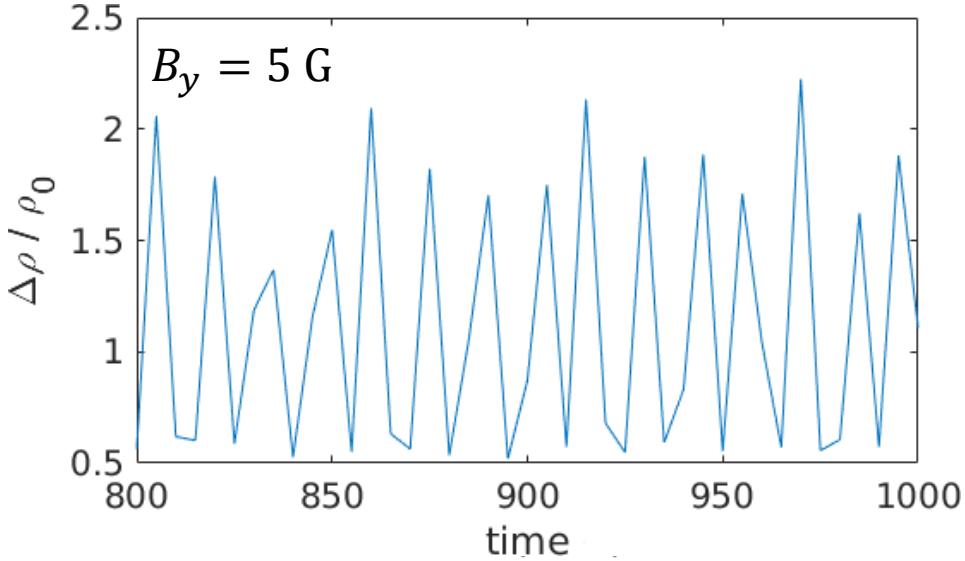
- Density distribution at the last timestep 1000 (1120 s) – comparation

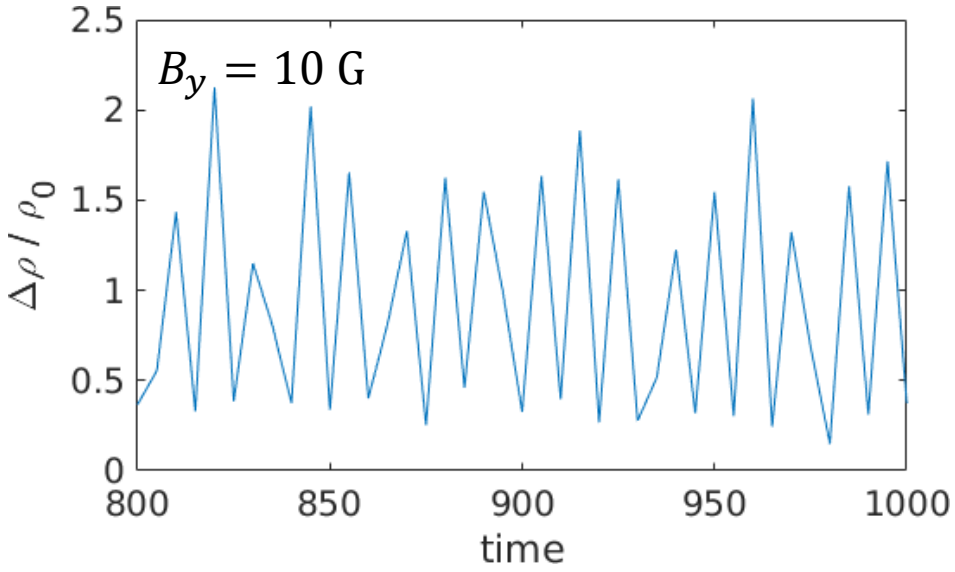


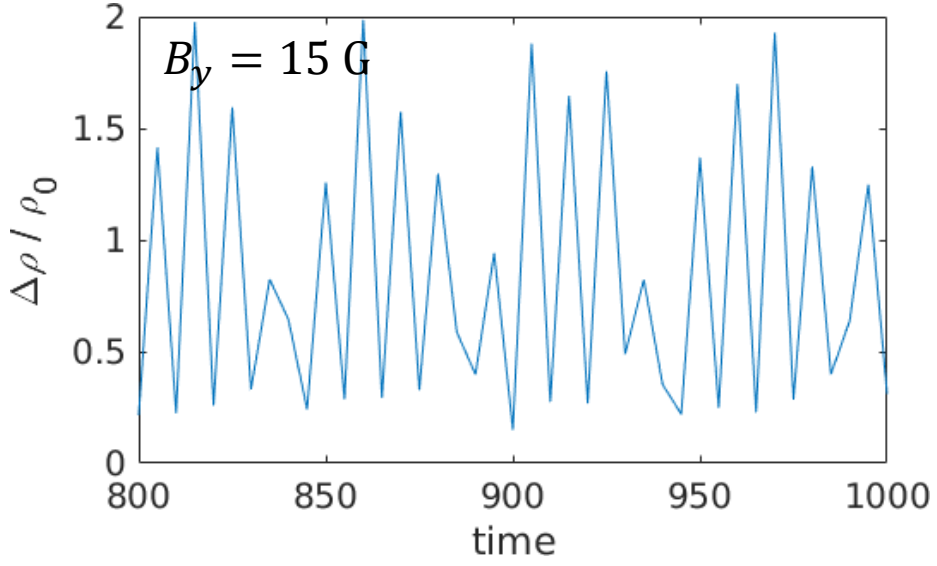
Results

- Relative density change – comparation









Results

- Values of period obtained from the time evolution of $\Delta\rho/\rho_0$ using wavelet analysis (Torrence and Compo, 1998)

B_y	0	5 G	10 G	15 G
P	12.701	10.830	9.428	8.736

Conclusion

- The presence of magnetic field perpendicular to the flow plane:
  - makes the vortices denser
  - makes the vortex shedding frequency increase
  - causes higher periodical density changes
- In the future we intend to use stronger magnetic field inside the obstacle and extend the problem on gravitational field to approximate it more to the solar corona

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