TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

Dipartimento di Fisica

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# *Seminar*

Tuesday, 26 September 2023 - h. 14:00

*Fisica della Materia room (Department of Physics)*


## Dr. Hugo Saraiva TAVARES

*Instituto de Física, Universidade Federal do Rio de Janeiro, Brasil*


# "Some advances in lattice Boltzmann methods for magnetohydrodynamic flows under the presence of curved boundaries and non-uniform magnetic fields"


### *Abstract*

We propose a single-step simplified lattice Boltzmann algorithm capable of performing magnetohydrodynamic (MHD) flow simulations in pipes for very small values of magnetic Reynolds numbers $R_m$. In some previous works, most lattice Boltzmann simulations are performed with values of $R_m$ close to the Reynolds numbers for flows in simplified rectangular geometries. One of the reasons is the limitation of some traditional lattice Boltzmann algorithms in dealing with situations involving very small magnetic diffusion time scales associated with most industrial applications in MHD, which require the use of the so-called quasi-static (QS) approximation. Another reason is related to the significant dependence that many boundary conditions methods for lattice Boltzmann have on the relaxation time parameter. In this work, to overcome the mentioned limitations, we introduce an improved simplified algorithm for velocity and magnetic fields which is able to directly solve the equations of the QS approximation, among other systems, without preconditioning procedures. In these algorithms, the effects of solid insulating boundaries are included by using an improved explicit immersed boundary algorithm, whose accuracy is not affected by the values of $R_m$. Some validations with classic benchmarks and the analysis of the energy balance in examples including uniform and non-uniform magnetic fields are shown in this work. Furthermore, a progressive transition between the scenario described by the QS approximation and the MHD canonical equations in pipe flows is visualized by studying the evolution of the magnetic energy balance in examples with unsteady flows. In addition, we explore advancements in some other lattice Boltzmann methods, such as Central Moments-based and Multiple-Relaxation-Time (MRT) schemes.



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