MS45: "Numerical methods and HPC challenges in Magneto Hydro Dynamics (MHD) modelling in plasma physics"

Marina Becoulet

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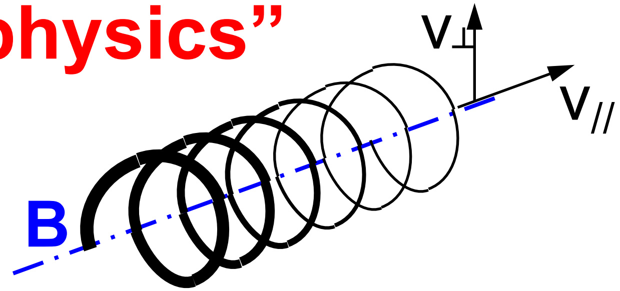


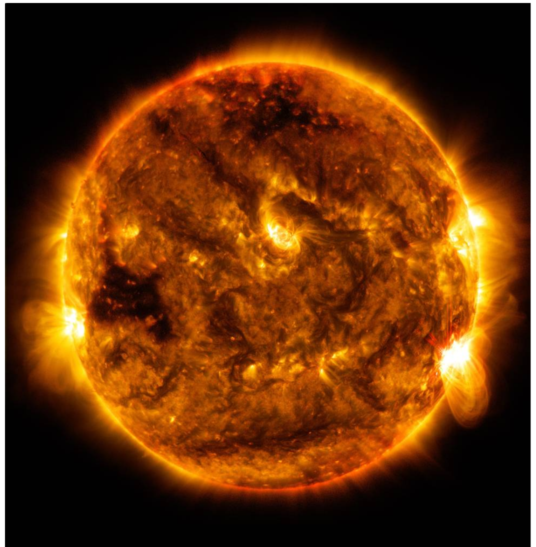
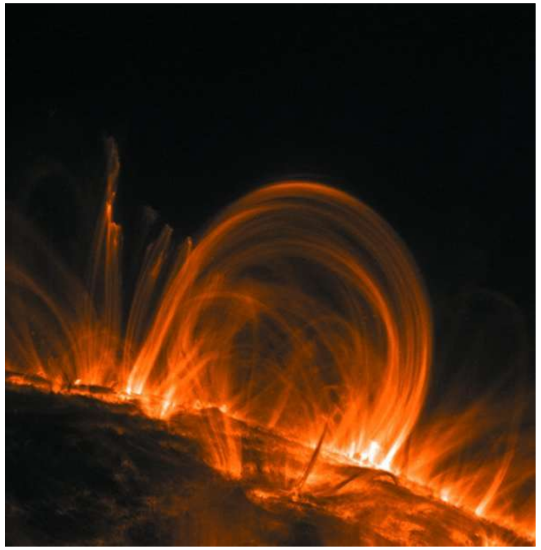
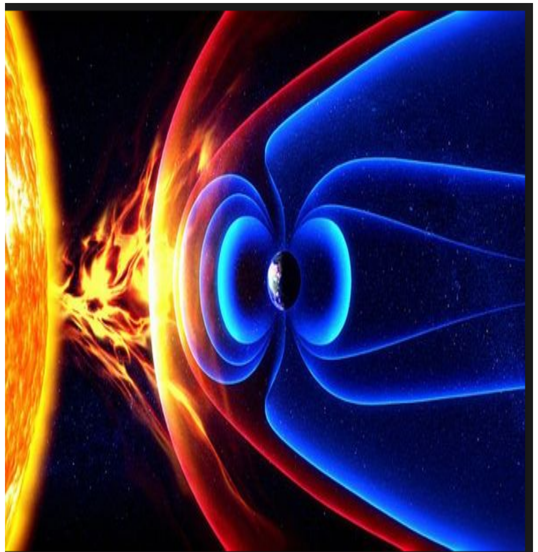
Plasma is the most common state of matter in the Universe.
Fully ionized: ions and electrons are not tied in atoms but freely moved as fluids.
Plasma is electrically quasi-neutral.
Plasma interacts with magnetic fields (following magnetic field lines with cyclotron motion).
Fluid and kinetic description.

MHD in astrophysics plasmas:

Solar & Earth MHD: dynamo, solar cycles, flipping of poles, solar flares, magnetosphere, space weather directly impacts our life on Earth (electronics, satellites, electrical grids, health)

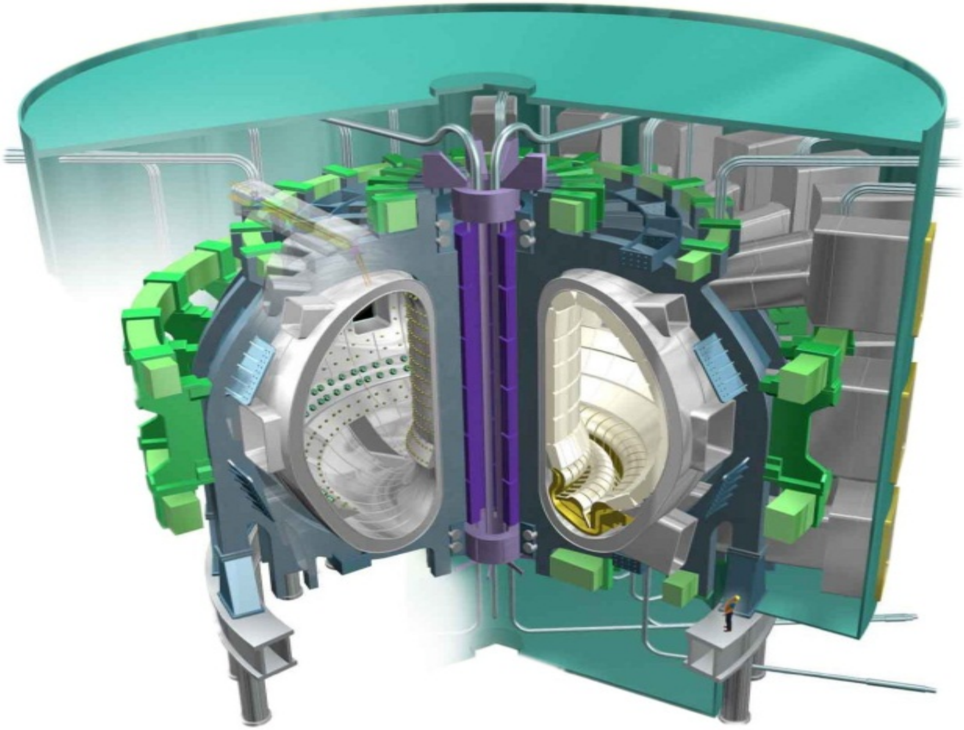
Interstellar MHD: filamentation, birth of stars

Supernova, neutron star, accretion disk and jets

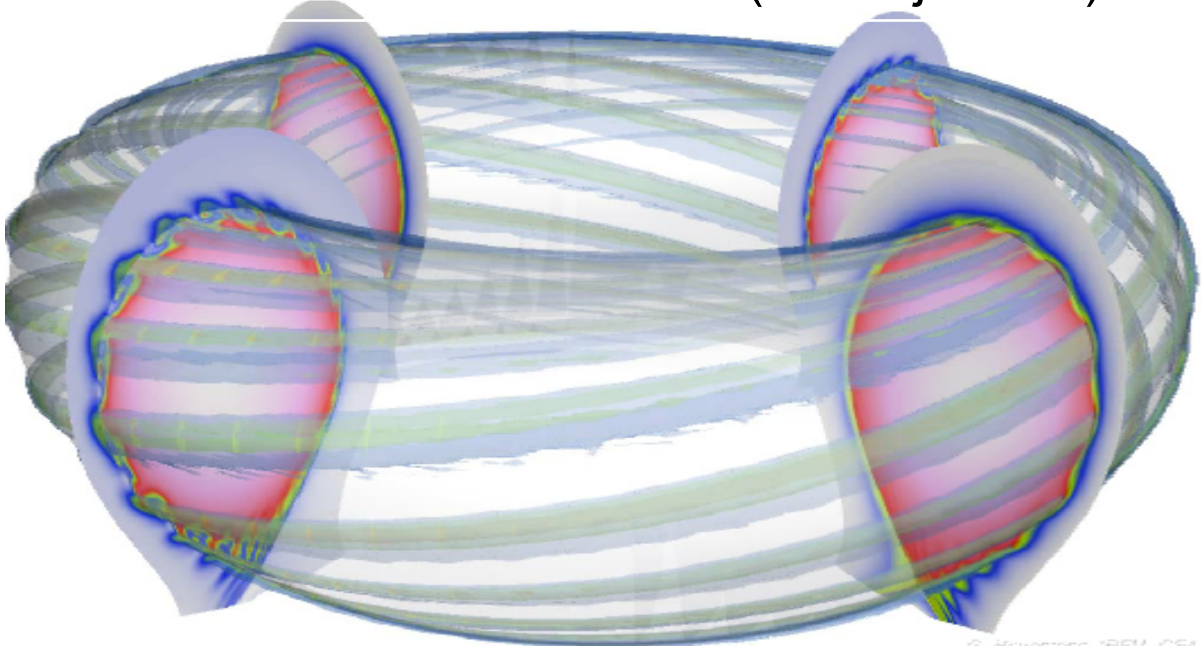




Carbon-free, unlimited energy source based on controlled nuclear fusion in magnetically confined plasma. Avoidance and control of MHD instabilities in fusion devices is crucial.

ITER –next step magnetic fusion device



Modelling of edge plasma MHD instabilities in tokamak with code JOREK (G. Huijsmans)



The numerical modelling and HPC challenges in plasma MHD can be extreme. In spite of specificity of applications the challenges have many common features: **strongly non-linear physics, involving MHD instabilities, complex geometry, wide range of spatial and time scales.** Combined effort of theoreticians, experimentalists, specialists in numerical methods, computational physics and computer science. This minisymposia is organized in this spirit with the goal to find synergy and discuss progress and issues in MHD plasma computing.

Title: “**Numerical methods and HPC challenges in Magneto Hydro Dynamics (MHD) modelling in plasma physics”.**

Scientific domain**s: Physics, Computer Science and Applied Mathematics**

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Presenter1 : Dr. Guido Huijsmans European Commission, Atomic Energy Commission, Institute for Magnetic Fusion Research, France, professor at the Eindhoven University of Technology, Netherlands, guido.huijsmans@cea.fr. **“Challenges in MHD modelling in fusion devices”**

Presenter 2: Dr. Jannis Teunissen, CWI, Amsterdam, The Netherlands and CmPA, KU Leuven, Belgium, jannis@teunissen.net, **“Highly parallel geometric multigrid solver suitable for adaptive mesh refinement (AMR) grids in plasma simulations”.**

Presenter 3: Boniface Nkonga, Nice University and INRIA Sophia Antipolis, France Boniface.Nkonga@unice.fr, **“A multidimensional analogue of the HLLI Riemann solver for conservative hyperbolic systems for astrophysical plasma applications ".**

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General discussion.

1. **How do you see future developments in plasma physics/MHD and in your research field in particular in view of Exascale ? What is on your "wishing list"? What kind of demands to HPC architectures ? What kind of "road map" you could propose?**
2. **General purpose vs application specific simulation codes?**
3. **Reusing computational tools from different application fields? (PASC and PRACE Days are good conferences to be informed, find contacts?)**
4. **What do you think about EuroHPC program? Funding/recognition for code development**?

The Scientific case 2018-26 (PRACE SSC) :"For Europe to achieve this, it is ***imperative to move beyond 3-5-year funding cycles****, primarily involving hardware, and* ***rather focus on what type of infrastructure and long-term collaborations are required****. While computational hardware accounts for a significant share of the cost, the long-term success and sustainability of a computational ecosystem is more dependent on our decisions about* ***how we invest in human infrastructure*** *to ensure the most creative and skilled individuals want to dedicate themselves to careers in computational infrastructure, academia, and industry. Despite the costs, it is critically important to recognize that not investing, or relying on national initiatives, is itself an active decision and one that will have direct, grave, consequences for Europe.* ***European academia and industry would be increasingly fragmented, uncompetitive, and irrelevant in an age where the US, Japan, and China are making gigantic investments in computing.*** *Much of the research would still be accomplished – possibly even by the same individuals working abroad – but it will be coupled with a massive brain-drain and loss of advanced European innovation in the most rapidly growing field of technology.*