SSM
Scuola Superiore Meridionale

Course title: Space Fluid Dynamics

Duration: 12 hours

PhD Program: SPACE

Name and Contact details of unit organizer:
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Course Description:
This course presents advanced research topics in fluid dynamics for space applications. This includes advanced gas dynamics, aerothermodynamics and plasma physics for hypersonic flight, space re-entry, and space propulsion, related thermal protection systems, and fluid dynamic research in microgravity conditions.

Syllabus:

1. **Fluid dynamics in microgravity:** capillarity, wetting, thermocapillary convection, multiphase flows, and heat and mass transfer. Experimental platforms and residual accelerations.
2. **High-temperature gas dynamics:** molecular excitation, dissociation, ionisation, and thermal and chemical non-equilibrium. Physical models and characteristic timescales.
3. **Hypersonic aerothermodynamics and thermal protection:** aerodynamic heating, gas–surface interactions, ablative and reusable thermal protection systems, high-temperature materials, and ground testing.
4. **Fluid dynamics of space propulsion:** reacting flows, mixing, heat transfer, and nozzle expansion. Selected multiphase and catalytic processes in hybrid and monopropellant thrusters.
5. **Plasma and rarefied-gas flows:** plasma physics and diagnostics, electric propulsion, rarefied-flow regimes, and gas–surface interactions in space applications.

Experimental techniques and numerical methods are introduced throughout the course.

Assessment:

To be defined

Suggested reading and online resources:

Lectures slides
Rodolfo Monti, Physics of Fluids in Microgravity, Rodolfo Monti (ed.), CRC Press, Earth Space Institute Book Series; 1st edition, 2001
John D., Jr. Anderson, Hypersonic and High-Temperature Gas Dynamics, Second Edition (AIAA Education).

G.P. Sutton, O. Biblarz O., Rocket Propulsion Elements, John Wiley & Sons Inc, 9th Edition, 2017, ISBN: 978-1118753651
Goebel D.M., Katz I., Fundamentals of Electric Propulsion: Ion and Hall Thrusters, John Wiley & Sons Inc
Erwin Mooij, Re-entry Systems, Springer Aerospace Technology, 2024
G.A. Bird, Molecular Gas Dynamics and the Direct Simulation of Gas Flows, Clarendon press (Oxford University press), 1994