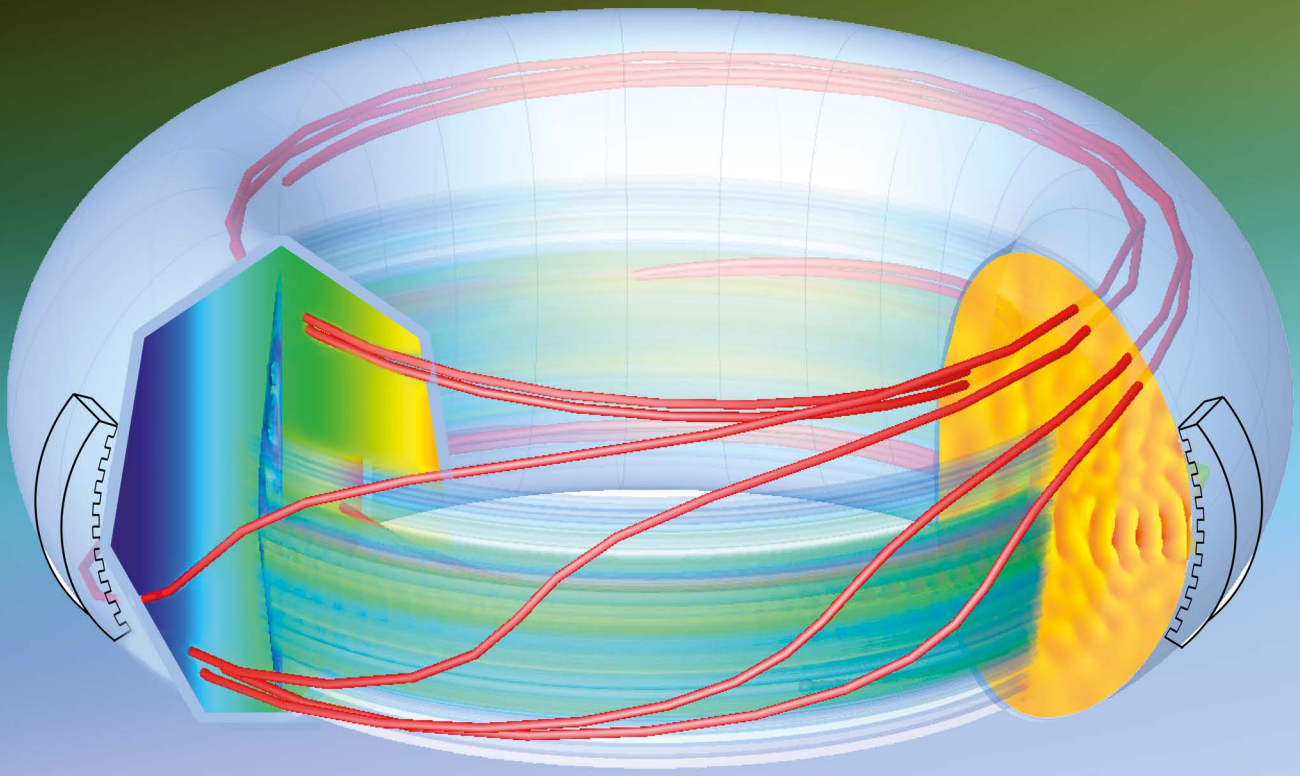
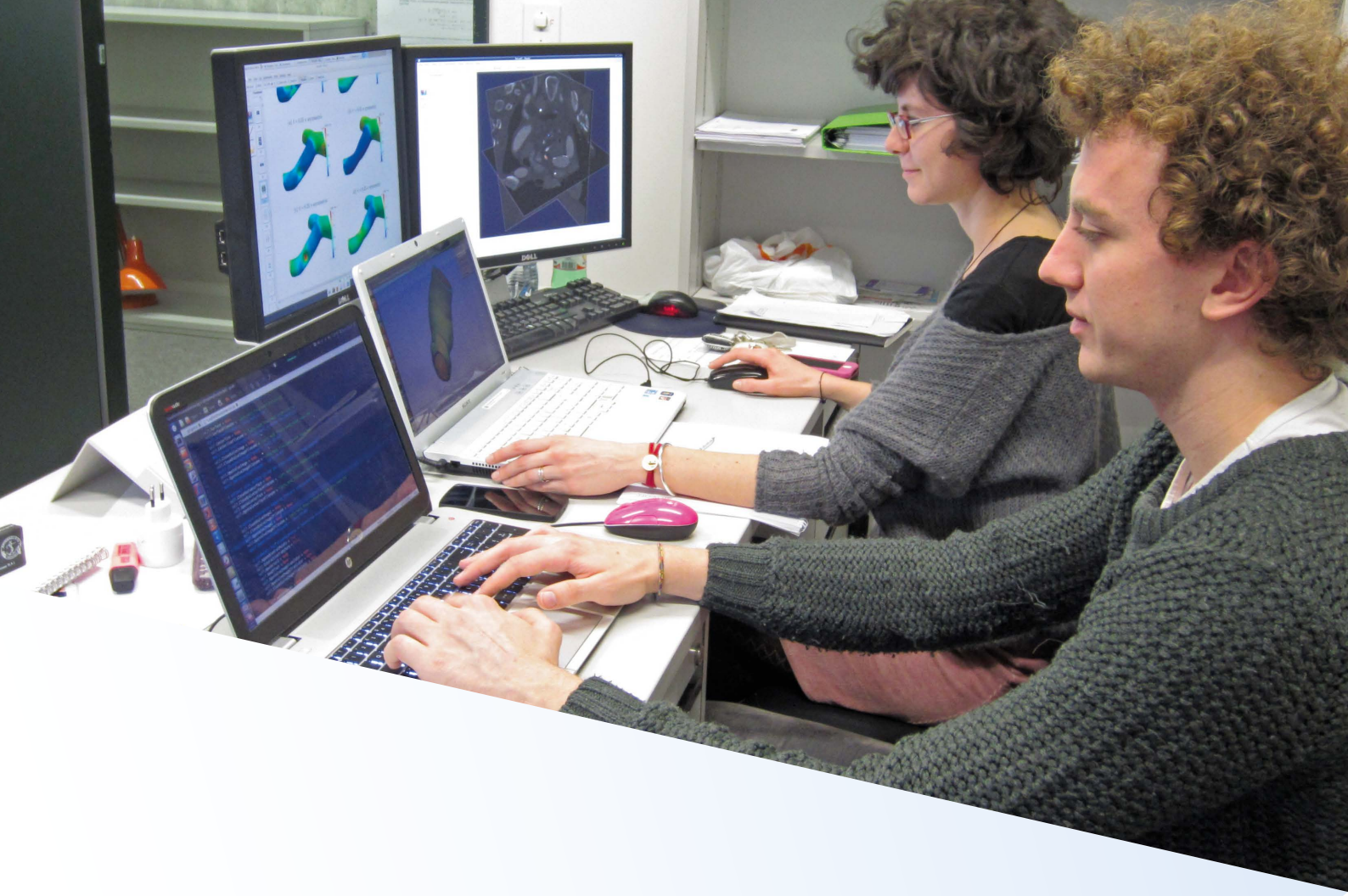
MASTER

# COMPUTATIONAL SCIENCE AND ENGINEERING



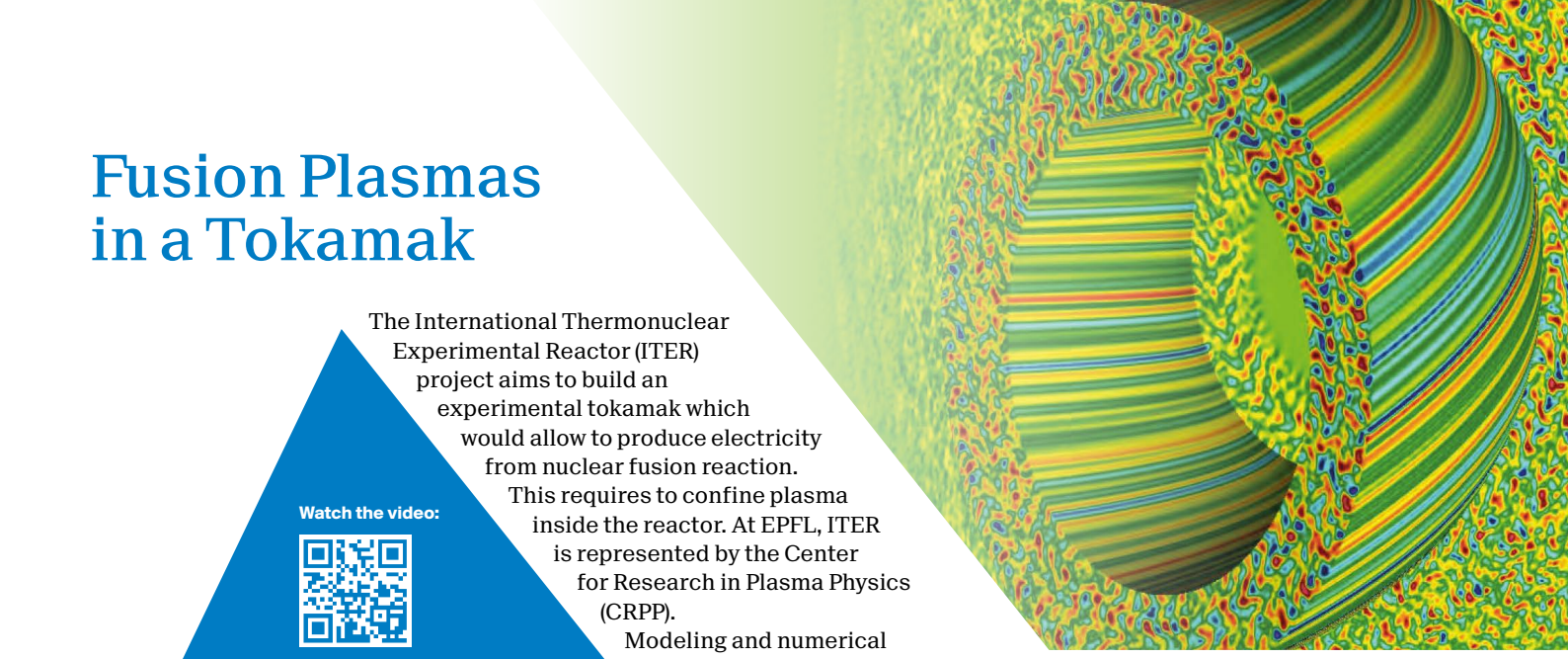
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE



## Simulation at the heart of science

Nuclear fusion. Climate evolution. Nanoscale piling. Mathematical developments. What do these four science topics have in common? Computer simulations, where human genius - in making models and shaping up algorythms - and supercomputers meet. The master in computational science provides students with all the basic skills that will make them most wanted specialists in scientific computing, numerical methods, algorithmic and software engineering, visualisation and multiscale-multiphysics modeling.

# Fusion Plasmas in a Tokamak



The International Thermonuclear Experimental Reactor (ITER) project aims to build an experimental tokamak which would allow to produce electricity from nuclear fusion reaction. This requires to confine plasma inside the reactor. At EPFL, ITER is represented by the Center for Research in Plasma Physics (CRPP).

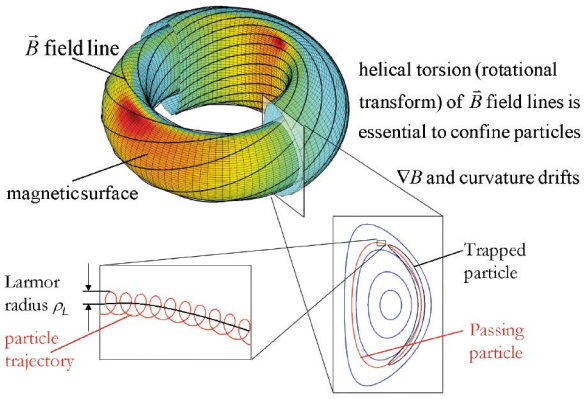
Modeling and numerical simulations of the plasma allow to study its behavior before the completion of the reactor and without the risks and costs inherent to the first real experiments. Therefore, efficient numerical methods that can be implemented for parallel simulation on supercomputer are essential for such complex simulations.

website: http://crpp.epfl.ch/research_TCV

*Magnetic confinement of plasma in a Tokamac. Boyancy and turbulence.*

Watch the video:

*Dana Christen:*
*"What I liked about EPFL is that it offered a good blend of theoretical courses and applied hands-on experiences."*



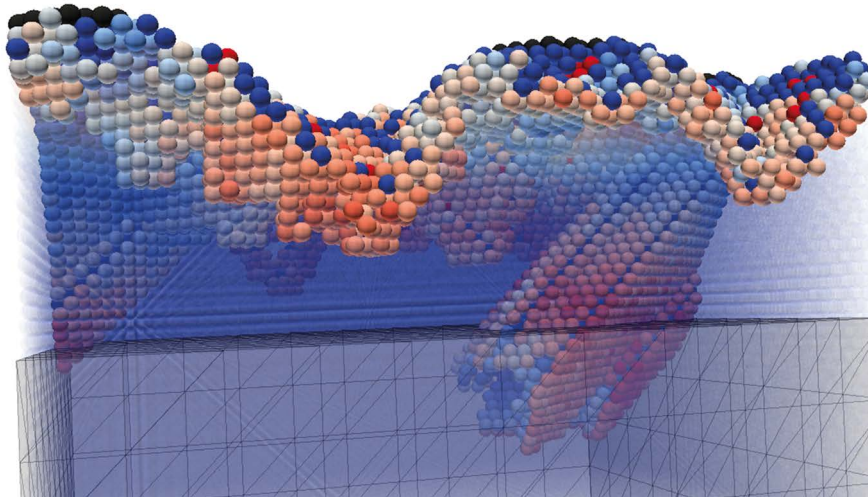

Watch the video:

*Vincent Zimmern:*
*"EPFL has now this worldwide reputation for being a computationally very active place, with a lot of research going on."*

# Multiscale Modeling of Materials

The mechanical deformation or the failure of a material, or the interaction between two objects, are characterized by phenomena at different space and time scales. The independent modeling of different scales has lead to important insights over the years. Thanks to modern supercomputers and advanced numerical schemes it is nowadays possible to better understand the interaction between scales. This relies on the coupling of continuum and discrete modeling and allows to understand involved mechanisms, for example, at the contact between two materials or at the origin of a fracture.

Labs: LAMMM+LSMS
website: http://lsms.epfl.ch/

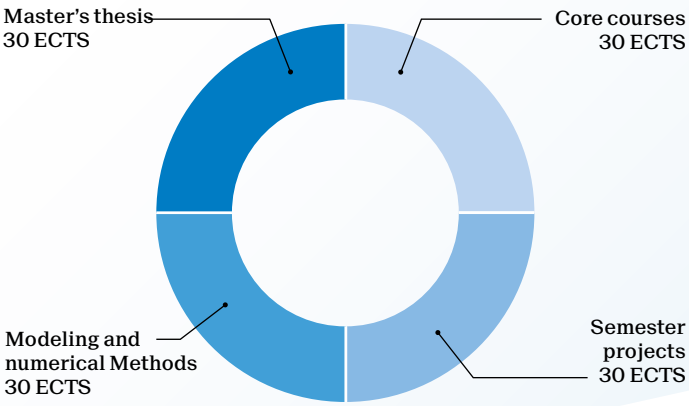


*Dislocation emission during the normal contact loading of a nanoscale rough surface. The model benefits from a coupled method to reduce the computational cost involved in handling many atoms.*

Master of Science in

# COMPUTATIONAL SCIENCE AND ENGINEERING

2-year program - 120 ECTS




| | Credits |
|---|---|
| **Core courses** | **30** |
| Advanced numerical analysis | 5 |
| Algorithms | 6 |
| Computational physics III | 3 |
| Computer simulation of physical systems I | 4 |
| Dynamique moléculaire et simulations Monte Carlo | 2 |
| Image processing I | 3 |
| Introduction to the finite elements method | 5 |
| Numerical analysis and computational mathematics | 4 |
| Numerical integration of dynamical systems | 5 |
| Parallel computing and pthreads | 4 |
| Programming concepts in scientific computing | 4 |
| Software Engineering | 6 |

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| **Semester projects** | **30** |
| Project in computational science and engineering I, II | 16 |
| Industrial internship | 8 |
| Project in human and social sciences | 6 |

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| **Modeling and numerical Methods** | **30** |
| Computational Modeling Based on Differential Equations | 8 min. |
| Advanced methods in computational solid mechanics | 3 |
| Atomistic and quantum simulations of materials | 4 |
| Biological modeling of neural networks | 4 |
| Dynamical system theory for engineers | 4 |
| Environmental transport phenomena | 5 |
| Hydrodynamics | 5 |
| Instability | 5 |
| Numerical flow simulation | 5 |
| Numerical methods in heat transfer | 3 |
| Particle-based methods | 4 |
| Principles and applications of systems biology | 3 |
| Quantum simulations of materials: Properties and spectroscopies | 4 |
| Turbulence | 3 |

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| Computational Modeling Based on Discrete Systems | 8 min. |
| Applied molecular quantum chemistry | 4 |
| Biomolecular structure and mechanics | 4 |
| Computational methods in molecular quantum mechanics | 4 |
| Computer simulation of physical systems II | 4 |
| Digital 3D geometry processing | 5 |
| Distributed Intelligent Systems | 5 |
| Image processing II | 3 |
| Introduction to electronic structure methods | 4 |
| Mathematical foundations of signal processing | 6 |
| Mathematical modelling of behavior | 4 |
| Molecular quantum dynamics | 2 |
| Signal processing for communications | 6 |
| Water quality modeling | 4 |

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| Numerical Methods, Algorithms, High Performance Systems | 8 min. |
| Advanced Algorithms | 7 |
| Advanced multiprocessor architecture | 6 |
| Convex optimization and applications | 4 |
| Computational Finance | 5 |
| Computational linear algebra | 5 |
| Mathematical modeling of DNA | 5 |
| Computer algebra | 5 |
| Numerical approximation of partial differential equations I | 5 |
| Numerical approximation of partial differential equations II | 5 |
| Numerical integration of stochastic differential equations | 5 |
| Numerical methods for conservation laws | 5 |
| Numerical methods for electromagnetics | 5 |

### Simulation based engineering

EPFL is a world leader in computing, engineering and fundamental sciences.
A Master in Computational Science and Engineering from EPFL opens the door to top employment with computational skills in high demand in a broad spectrum of industries, not only in all branches of engineering, but also in emerging and vibrant market sectors including energy, financial and pharmaceutical R&D.
It is also a strong asset for a PhD in Computational Science.

# Career prospects

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Contact: cse@epfl.ch

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