CEMRACS 2020

Numerical models and methods for particles and population dynamics

20th to 25th july : Summer school

27th july to 28th august : Five weeks of project

Luminy-Marseille, France

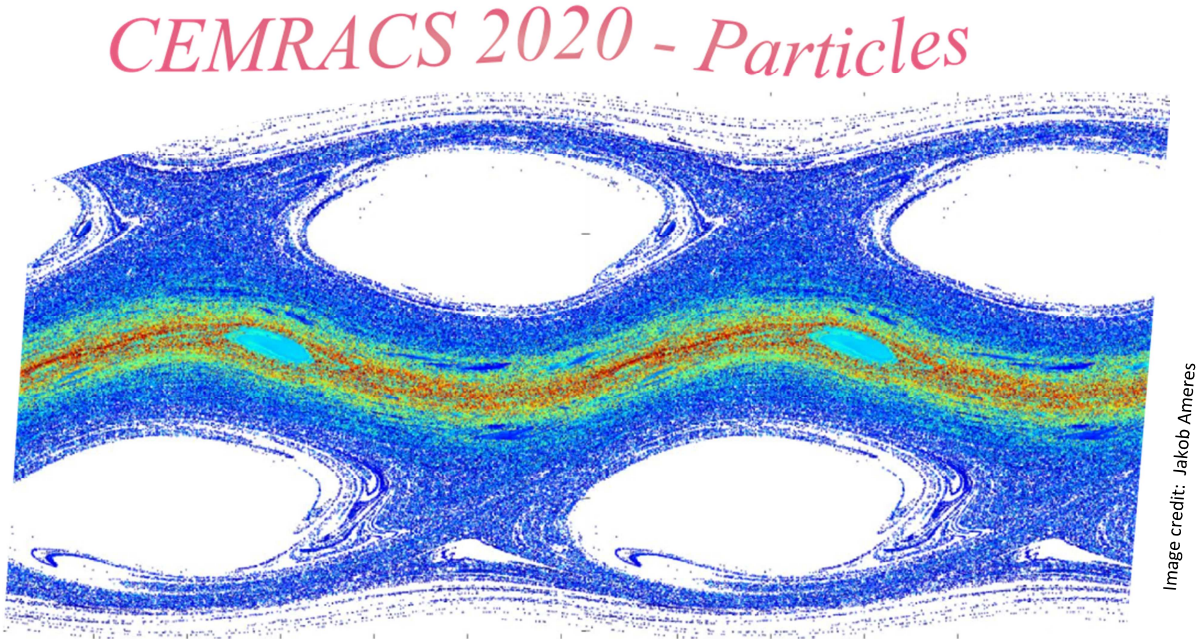

Image credit: Jakob Ameres

Aix*Marseille université

Organizers : E. Franck, H. Hivert, G. Latu, B. Maury ,
M. Mehrenberger , S. Merino- Aceituno, L. Navoret

Foreword

The CEMRACS (Mathematics summer school for advanced research in scientific computing) is a scientific event of the SMAI (the french Society of Applied and Industrial Mathematics). The concept was initiated in 1996 and takes place every year at CIRM (International Center for Mathematical Meetings) in Luminy-Marseille during 6 weeks from mid-july. The goal of this event is to bring together scientists from both the academic and industrial communities to work and discuss on focused topics. During the first week, a summer school is proposed. It consists of several lectures given by leading scientists and related to the main topic of the year. The remaining 5 weeks are dedicated to working on the research projects, possibly after a morning seminar.

This congress brings together about thirty senior international experts in applied mathematics, and related fields which are this year: plasma physics, biology, social science, parallel computing. The interdisciplinary endeavor and the six-weeks format have a triple purpose: to reinforce interdisciplinary collaborations, to train young high-level researchers, and to exchange on the most recent works by promoting new ideas.

Luminy's venue

The theme chosen for CEMRACS 2020 is the study of large particle systems in various contexts: Physics, Biology and Sociology. We will be interested in the modeling aspects, the analytical study, and the numerical simulation. This type of particle approach raises many difficult mathematical and numerical issues; interdisciplinary interactions are important in this field to approach bottlenecks in a comprehensive manner. The CEMRACS 2020 edition aims to continue and develop these interactions and to promote new collaborations between mathematicians and industry. One main theme will be plasma physics, particularly around the description of magnetic fusion containment in connection with the ITER project. However, this summer school will also aim to promote many emerging and exploratory themes such as the theme of smart cities, in connection with collective movements (cars, pedestrians, crowds) and the current issues of optimization of transportation.

To understand these systems where thousands or even billions of particles interact with each other, it is often useful to try to describe the dynamics at large scale, as it is done in gas dynamics. These macroscopic models, of course, generally have limited range of validity. To numerically observe these dynamics, it will therefore require numerical methods that are not only efficient but also valid at different scales of description. The models rely tightly on the interactions involved: whenever possible, some comparisons with existing data will be made.

By participating, through the building of a project, you will strengthen your visibility to the community of applied mathematics in general and the community of students and actors in this field of study. It will also be an opportunity for you to discuss and exchange on your favorite topics.

General presentation

The scientific theme of CEMRACS is chosen by its organizing committee and changes every year. The purpose of this event is to bring together scientists from academia and industry to discuss the chosen topic. The first week is devoted to a summer school where several courses on the theme of CEMRACS are given by renowned scientists. After this week of classes, the remaining five weeks are devoted to research projects proposed by university or industrial scientists. Two to three students are assigned to each project. Every day, after a morning seminar, these young researchers work together on their project under the supervision of skilled researchers. The experience of previous years has shown the considerable positive impact of CEMRACS, not only on the development of these projects in the short term, but also on the interactions between mathematics, applied sciences and industry. The last CEMRACS had the following topics (http://smai.emath.fr/spip.php?article51) :

- CEMRACS 2019, Geophysical Fluids, Gravity Flows, A. Durand, B. Fabrèges, P. Latte, F. Lagoutière, F. Marche, F. Rousset
- CEMRACS 2018, Numerical and mathematical modeling for biological and medical applications: deterministic, probabilistic and statistical descriptions, V. Calvez, C. Grandmont, E. Locherbach, C. Poignard, M. Ribot, N. Vauchelet.
- CEMRACS 2017 Numerical methods for stochastic models: control, uncertainty quantification, mean-field, B. Bouchard, J.-F. Chassagneux, F. Delarue, E. Gobet, J. Lelong.
- CEMRACS 2016 Numerical challenges in parallel scientific computing, L. Grigori, C. Japhet, P. Moireau, P. Parnaudeau.
- CEMRACS 2015, Coupling Multi-Physics Models involving Fluids, E. Frenod, E. Maitre, A. Rousseau, S. Salmon, M. Szopos.
- CEMRACS 2014, Numerical modeling of plasmas, M. Campos-Pinto, F. Charles, H. Guillard, B. Nkonga.
- CEMRACS 2013, Modelling and simulation of complex systems: stochastic and deterministic approaches, N. Champagnat, T. Lelievre, A. Nouy.
- CEMRACS 2012, Numerical methods and algorithms for high performance computing, S. Descombes, B. Dussoubs, S. Faure, L. Gouarin, V. Louvet, M. Massot, V. Miele.

The main goals of CEMRACS are:

- presenting recent courses and works by renowned specialists and promote new ideas,
- initiating or pursuing interdisciplinary collaborations, mixing academia and industry,
- training young high-level scientists.

In previous editions, this event hosted 50 PhDs and post-docs over about 100 participants, and many nationalities were represented.

Organization and program of the school

Organization

Sterring committee :

- Emmanuel Franck (Tonus project, IRMA, INRIA and Université de Strasbourg)
- Hélène Hivert (Ecole centrale de Lyon, ICJ)
- Guillaume Latu (IRFM, CEA Cadarache)
- Bertrand Maury (Département de Mathématiques et Applications, Ecole Normale Supérieure, Paris and LMO, Université Paris-Sud)
- Sara Merino-Aceituno (University of Vienna, Austria)
- Michel Mehrenberger (I2M, Aix-Marseille Université)
- Laurent Navoret ((Tonus project, IRMA, INRIA and Université de Strasbourg)

Scientific committee :

- Pierre Degond, Imperial College London, GB
- Irène Gamba, University of Texas, Austin, USA
- Virginie Grandgirard, CEA Cadarache, France
- Eric Sonnendrücker, Max-Planck Institute for Plasma Physics, Munich, Germany

The members of the organizing committee have a wide range of skills: numerical, modeling, high-performance computing, kinetic models, fluid-particle models, asymptotic preserving methods, multi-scale methods, application to plasma physics, application to biology, application to social systems, etc. Michel Mehrenberger is in charge of coordination. The steering committee takes care of the management of the conference at the logistical level: reservation and management of the conference venue, organization of the timetable and scientific animation, management of participants and accommodation, dissemination of information to participants and accounting:

- Coordination: M. Mehrenberger
- Website: L. Navoret, E. Franck, M. Mehrenberger
- Catering, accounting: H. Hivert, E. Franck, G. Latu
- Attendee contact: H. Hivert
- Proceedings of the conference: B. Maury, M. Mehrenberger, S. Merino-Aceituno
- Discussion with the scientific committee: M. Mehrenberger, G. Latu
- Choice of program and speakers: all members of the organizing committee
- Search for funds and participants: all members of the organizing committee

The scientific committee ensures the scientific coherence of the summer school program and the quality of the event.

Program of the week of classes

Wishing to encourage the emergence of new interdisciplinary collaborations while focusing on certain promising applications, we organized the CEMRACS2020 "Numerical models and methods for particle and population dynamics" around two main applications: magnetic fusion and collective movements. The courses will be given by internationally recognized researchers. They will be divided into three parts, an introductory part, a main part and a part dedicated to recent progress and perspectives. The four main courses are:

- Isabelle Gallagher (ENS Paris): Derivation of the Boltzmann equation and hydrodynamic limit which makes it possible to summarize how to build kinetic models and their fluid approximation.
- Giacomo Dimarco (University of Ferrara, Italy): Monte Carlo methods, kinetic patterns with collisions.
- José A. Carillo (Imperial College, London, England): Collective movement of active quantities and Cucker-Smale models. Mathematical approach to collective movements.
- Cécile Appert-Rolland (Laboratory of Theoretical Physics, University Paris-Sud): Modeling of crowd movements; models of the social force type and cellular automata; experimental aspects. Physicist point of view on collective movements.

Figure 1 Crowd modelling

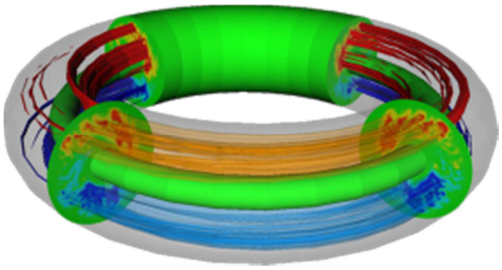

Figure 2 Turbulence modelling within a Tokamak plasma

In addition, four shorter courses (1h30) including a description of concrete applications using particle-based models will be given:

- Emmanuel Frénod (University of Vannes), Data assimilation, concrete examples from industry where models of partial differential equations are fed with data,
- Lénaïc Chizat (Paris-Sud University), Optimal Transport and Techniques in Machine Learning: Monitoring Individuals by Eulerian Observation,
- Martin Campos Pinto (LJLL, Paris & IPP Max-Planck, Germany), Particle Methods for Plasma Physics,
- Xavier Besseron (University of Luxembourg) High performance calculation for particles, parallelization of DPM (Discrete Particle Method) for industrial problems.

The objective of the four main courses is to present the methodological aspects and the theoretical and practical tools. We wanted to focus on relatively long courses (4-5 hours) to allow treating a subject in depth. On the other hand, the four complementary courses aiming at concrete applications make it possible to put the main courses in perspective and also to put the topics approached in relation with some industrial problems. Thanks to these courses, doctoral students and young researchers in particular, will be prepared and will have the bases necessary to calmly tackle the research projects that

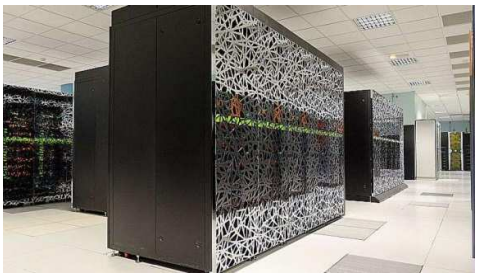

Figure 3 Irene Joliot-Curie supercomputer - CEA

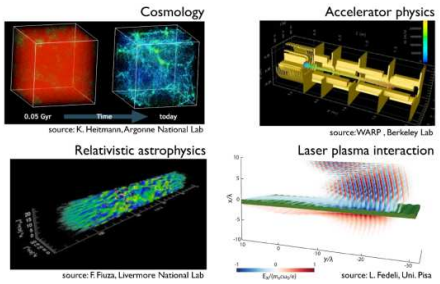

Figure 4 Using particles within several application fields

take place over the next 5 weeks. The combination of various aspects related to particle transport makes it possible to have different points of view while enriching each other.

Program of the five weeks dedicted to project

During the second phase of CEMRACS, each participant works within a specific team on a project proposed by a leader coming from industry or university. The teams are composed of young researchers supervised by one or two confirmed scientists. A short daily seminar is organized in the morning in order to encourage exchanges between the participants and to allow receiving recent knowledge.

The CIRM (International Center for Mathematical Meetings) is unique in the world. CIRM is located in Luminy, in the heart of the *Calanques* and on the scientific Marseille campus. It was designed to welcome researchers and allow them to work on mathematical issues, but also to disseminate their knowledge to young researchers and PhD students. It has a renowned library that can help much. During the five weeks of the workshop, each participant is integrated into a project financed by an industry or academy partner. A special feature of this summer school: researchers sleep, eat and work at CIRM, which promotes synergies.

Twelve to twenty projects are typically implemented during each CEMRACS. Each will be published in a booklet. The publication has been published in recent years in the ESAIM proceedings https://www.esaim-proc.org/.

Spin-off

We expect from this edition of CEMRACS several important spin-offs. First, it will gather between young and experienced researchers from very different backgrounds. This will strengthen the links between academia and industry.

The courses focusing on “Mathematics applied to particle systems“ will be taught by mathematicians but also by a physicist. The two axes of the thematic school were chosen to cover a broad spectrum of applications, one of the aims being to train young researchers on relevant topics targeting both academic subjects and industrial issues. Links with the data science, a booming field, can open doors for attending students. We expect CEMRACS will strengthen existing links and create new collaborations and synergies.

Finally, this school was also thought of as a starting point for long-term research projects related to particle systems.

The support and proximity of ITER and CEA are assets for examining critical issues of magnetic fusion. This CEMRACS will help build or consolidate bridges between industry partners and the community of applied mathematics at local and international level.

Building a scientific project

To propose a project, simply send a short description (including a summary of a dozen sentences typically) to cemracs20@smai.emath.fr. The project should be supervised by an experienced person (from industry or academia), whose presence on the spot can be either punctual or during a significant fraction of the project time. The commitment of this experienced researcher is meant to ensure the organization and progress of the project, i.e. to precisely specify the milestones and supervise the project participants. Science visitors who are interested in some specific projects can be associated with these for shorter periods and are, of course, welcome. A team of two or three young researchers will work on the topic for the duration of the research session. Each project will have free access to regional parallel computing resources (meso-center of Aix-Marseille University). The number of projects proposed in previous CEMRACS sessions was in the range of 11 to 17.

CEMRACS takes place at the CIRM, in Marseille on the Luminy campus. Participants are accommodated on site at the rate of 96 euros per day in double room and 108 euros in single room (night and meals included). A meal can also be booked without associated accommodation for 16 euros. Project funding should be considered as soon as the proposal is submitted. Classically, submitting and funding a project requires a budget of 12 000 euros which covers at least the costs of accommodation for all participants involved in the project. Do not hesitate to contact the organizers to discuss with them and obtain extra info cemracs20@smai.emath.fr .

Interested persons are invited to submit a **draft project**, presented in the form of a title and some descriptive lines by **31 December 2019** to cemracs20@smai.emath.fr. The more complete description of one or two pages accompanied by a financing proposal will then be required for 1st May 2020.