TIME TABLE

TIME	Monday May 25	Tuesday May 26	Wednesday May 27	Thursday May 28	Friday May 29
9.00 - 9.45	Registration	Spałek	Skoczeń	Boso	Russenschuck
9.45 - 10.30	Flükiger	Spałek	Skoczeń	Boso	Russenschuck
11.00 - 11.45	Flükiger	Spałek	Skoczeń	Boso	Russenschuck
11.45 - 12.30	Flükiger	Bottura	Skoczeń	Boso	Boso
14.00 - 14.45	Flükiger	Bottura	Skoczeń	Russenschuck	
14.45 - 15.30	Flükiger	Bottura	workshop	Russenschuck	
16.00 - 16.45	Spałek	Bottura	workshop	workshop	
16.45 - 17.30	Spałek	Bottura	workshop	workshop	
18.00	Welcome Aperitif				

ADMISSION AND ACCOMMODATION

The registration fee is 600.00 Euro + VAT*, where applicable (bank charges are not included). The registration fee includes a complimentary bag, four fixed menu buffet lunches (on Friday upon request), hot beverages, downloadable lecture notes and wi-fi internet access.

Applicants must apply at least one month before the beginning of the course. Application forms should be sent on-line through the following web site: http://www.cism.it. A message of confirmation will be sent to accepted participants. Applicants requiring assistance with the registration should contact the secretariat at the following email address: cism@cism.it.

Applicants may cancel their course registration and receive a full refund by notifying CISM Secretariat in writing (by email to cism@cism.it) no later than two weeks prior to the start of the course.

Cancellation requests received during the two weeks prior to the start of the course will be charged a 50.00 Euro handling fee. Incorrect payments are also subject to a 50.00 Euro handling fee.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered lodging and/or board, if available, in a reasonably priced hotel or student guest house.

Requests should be sent to CISM Secretariat by **March 25, 2020** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

Information about travel and accommodation is available on the web site www.cism.it, or can be mailed upon request.

* Italian VAT is 22%.

For further information please contact:
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ACADEMIC YEAR 2020
The Erwin Stein Session

Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

PHYSICALLY BASED MODELLING OF SUPERCONDUCTORS AND THEIR MOST ADVANCED APPLICATIONS

CISM ESOF Advanced School
coordinated by

Błażej Skoczeń
Cracow University of Technology
Kraków, Poland

proESOF
TOWARDS TRIESTE 2020
EUROSCIENCE OPEN FORUM
EuroScience

Udine *May 25 - 29* 2020

PHYSICALLY BASED MODELLING OF SUPERCONDUCTORS AND THEIR MOST ADVANCED APPLICATIONS

Modern low and high temperature superconductors are extensively used to build technologically advanced scientific instruments, including medical devices as well as means of mass transport or low-loss energy transmission lines. Typical type II low temperature superconductors, massively used to construct superconducting magnets operating in liquid (4.2 K) or superfluid (below 2.17 K) helium, are the niobium based alloys and intermetallic compounds, e.g. Nb-Ti, Nb3Sn, or more recent magnesium based compounds like the magnesium diboride MgB2. Another popular class of superconducting materials are the high temperature superconductors, like Rare-Earth (RE) based REBCO or Bismuth based BiSCCO, that are applied at much higher temperatures, up to the temperature of liquid nitrogen (77 K). Generally, low temperature superconductors are used to build superconducting coils, forming the most critical parts of complex superconducting magnets, and integrated in Magnetic Resonance Imaging (MRI) or nuclear magnetic resonance (NMR) instruments, or magnets for large science experiments such as superconducting particle accelerators and fusion devices. Though high temperature superconductors have extraordinary high-field properties, so far their application has been restricted to superconducting cables and current leads, transferring the current from ambient temperature to cryogenic conditions.

The present course is focused mainly on low and high temperature superconductors. The contents stretch from the material microstructure and the constitutive description to real large-scale applications in the particle accelerators (e.g. Large Hadron Collider, LHC), or in the modern fusion devices (e.g. International Thermonuclear Experimental Reactor, ITER Tokamak). The course begins with a broad introduction to superconductors (materials, types of superconductors, flux pinning centers, parameters of critical surface, etc.), covers the physical background of superconductivity (phase transition, Meissner effect, BCS theory, Cooper mechanism, Josephson effect, etc.), the physical, mechanical and thermodynamic properties of low and high-temperature superconductors (e.g. the effect of strains on the critical surface). Next, the constitutive modelling of superconductors and related sheath and structural materials operating at extremely low temperatures is developed, including plastic strain induced phase transformation, discontinuous plastic flow and evolution of micro-damage fields (of technological and radiation origins). Finally, interaction of superconductors and magnetic fields is explained, and optimization of superconducting coils against the quality of magnetic field is discussed. The course is concluded by the most recent applications of modern superconductors in the technologically advanced instruments and devices (e.g. particle accelerators, medical imaging instruments, fusion based energy devices, etc.).

PRELIMINARY SUGGESTED READINGS

D.P. Boso, A simple and effective approach for thermo-mechanical modelling of composite supercoducting wires, Supercond. Sci.Technol. 26 (2013) 045006.

René Flükiger, MgB2 Superconducting Wires - Basics and Applications, World Scientific, 2016.

Stephan Russenschuck, Field Computation for Accelerator Magnets, Wiley-VCH, 2010.

B.Skoczen, J.Bielski, J.Tabin, Multiaxial constitutive model of discontinuous plastic flow at cryogenic temperatures, International Journal of Plasticity 55 (2014), 198–218.

M. Sitko, B. Skoczen, Modelling He I - He II phase transformation in long channels containing superconductors, International Journal of Heat and Mass Transfer 52 (2009), 1-2, pp.9-16.

B.Skoczen, A.Ustrzycka, Kinetics of evolution of radiation induced micro-damage in ductile materials subjected to time-dependent stresses, International Journal of Plasticity 80 (2016), 86-110.

Steven W. Van Sciver, Helium Cryogenics, Springer, 2012.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from the CISM web site. Instructions will be sent to accepted participants.

INVITED LECTURERS

Daniela Boso - University of Padua, Italy
5 lectures on: Numerical modelling of superconducting strands and composite materials.
Fundamental micro-macro concepts. Main approaches to modelling of composites. Finite element simulations of superconducting strands. Artificial Neural Network in multiscale analysis of composites. From the strand to the cable: the hierarchical structure of a bundle of wires. Superconductors for fusion applications: the on-going ITER and future DEMO.

Luca Bottura - CERN, Geneva, Switzerland
5 lectures on: Physical, mechanical and thermodynamic properties of superconductors.
Critical and engineering current density of technical superconductors. Superconductor stability at cryogenic temperature. Training and quench. Forces and stresses in superconducting coils. AC loss in superconducting wires and cables. Field quality of superconducting accelerator magnets.

René Flükiger- University of Geneva, Switzerland
5 lectures on: General introduction to superconductors.
Fundamentals of superconductivity. The systems NbTi and Nb3Sn. The system MgB2. HTS superconductors. Pnictides (Fe based compounds). Irradiation effects on the properties of Nb3Sn.

Błażej Skoczeń - Cracow University of Technology, Poland
5 lectures on: Constitutive modelling of superconductors and related materials for cryogenic temperatures.
Thermodynamics of lattice at extremely low temperatures. Physical phenomena occurring in the superconductors and structural materials at cryogenic temperatures. Constitutive modelling of superconductors and related structural materials. Prediction of lifetime of irradiated superconductors and sheath components.

Józef Spałek- Jagiellonian University, Cracow, Poland
5 lectures on: Physical background of superconductivity.
Basic properties of superconducting state. Concept of Cooper pairs and of BCS theory of superconductivity. Ginzburg-Landau and Gorkov-Abrikosov approaches. Unconventional superconductivity. Properties of high temperature superconductivity.

Stephan Russenschuck - CERN, Geneva, Szwitzerland
5 lectures on: Numerical modelling of superconducting magnets (ROXIE, 10 years after).
Integrating beam-physics simulations, field computation, and magnetic measurements. Post-processing techniques for magnetic measurements (harmonics, generalised gradients, boundary elements). The stretched-wire measurement technique (an example for solving partial differential equations)"

5 slots (equivalent lectures) reserved for half-day workshop dedicated to individual research projects of the participants.