

CFCAM Sponsored Event

Solid Math 2020

Ecole des Ponts ParisTech, July 1-3, 2020

Organizers

Eric Cancès
Ecole des Ponts ParisTech and Inria Paris, France
eric.cances@enpc.fr

Horia Cornean
Aalborg University, Denmark
cornean@math.aau.dk

David Gontier
Université Paris-Dauphine PSL, France
gontier@ceremade.dauphine.fr

Gianluca Panati
Sapienza University, Roma, Italy
panati@mat.uniroma1.it

1. Proposal

1.1 Introduction and motivation

Recent discoveries in solid-state physics are challenging the mathematical physics and scientific computing communities, striving for ambitious goals:

- a mathematical understanding – based on fundamental models – of a variety of new phenomena, ranging from the anomalous transport in **aperiodic solids**, to the striking conductivity properties of **graphene and Weyl semimetals**, to the emergence of **topologically-ordered phases** of macroscopic matter;
- the development of new numerical methods for the **simulation of the electronic and optical properties of aperiodic solids** (disordered materials, multilayer 2D materials) at various levels of theory, from tight-binding models, to DFT, to embedding schemes and strongly-correlated methods.

1.2 State of the art

The pioneering investigations in these fields require the interplay of different mathematical techniques (including operator theory, C*-algebras, differential and non-commutative geometry, K-theory) and the development of new numerical methods and computational software.

In the past decade, the range of applicability of first-principle simulation methods based on Density Functional Theory (DFT) and Green function methods (GW, Bethe-Salpeter equation) has dramatically increased. It is now possible to compute *ab initio* a large part of the phase diagram of a crystalline material, the diffusion rate of a vacancy in a crystal, the band gap of a semiconductor, or its absorption spectrum as a function of the temperature. However, many challenging problems remain, as for instance the first-principle simulation of solids with correlated electrons, of shallow point defects, of extended defects (dislocations, grain boundaries), and more generally of strongly disordered systems. Another interesting question at the interface of mathematical physics and scientific computing is the design of discretisation methods and numerical algorithms compatible with some algebraic structure (e.g. the C*-algebra associated with a model of aperiodic solid), or some topological or geometrical properties (e.g. smooth Bloch bundles).

Joint effort from the mathematics, physics and scientific computing communities is needed to address these very difficult problems.

1.3 Objectives

Following the tradition of the first three editions (SOLID MATH 2014, Trieste, Italy; SOLID MATH 2016, Aalborg, Denmark; SOLID MATH 2018, Montreal, Canada), we are planning a focused international conference, with a twofold aim:

- (a) encourage the exchange of ideas and methods between experts in the field from various disciplines (physics, mathematics, scientific computing);
- (b) disseminate the recent results and techniques, making them accessible, by informal talks, to **Ph. D. students and young postdoctoral fellows**.

Without any claim of completeness, in the 2020 conference we will focus on the following topics:

- Topological aspects of quantum transport (Quantum Hall effect, Quantum Spin Hall effect)
- C^* -algebraic approach to quantum transport (aperiodic solids, disordered systems)
- Adiabatic and time-dependent methods in solid-state physics
- Localization of electrons in solids, including localization of Wannier functions
- Mathematical results on Density Functional Theory (DFT) and Green function methods

Targeted audience:

The list of speakers (see below) includes some of the leading researchers in the field of the mathematical and numerical methods for solid state physics. Therefore, we expect participants ***both from the mathematical physics and from the theoretical and computational solid-state physics community***. To stimulate a fruitful exchange of ideas and methods between the two communities, some researchers in solid-state physics will be invited.

Participation of ***Ph.D. students and young post-doc fellows*** will be encouraged by planning additional financial support for young participants and an adequate number of ***Junior Talks***, namely shorter talks devoted to promising young people.

The conference website is available at the address:

<https://www.ceremade.dauphine.fr/~gontier/Solid-Math-2020/>

Webpages of past editions:

Solid Math 2018 (Montreal, Canada)

<http://people.math.aau.dk/~cornean/Solid-Math-2018/>

Solid Math 2016 (Aalborg, Denmark):

<http://people.math.aau.dk/~cornean/SOLID-MATH-2016/>

Solid Math 2014 (Trieste, Italy):
<https://sites.google.com/site/solidmath2014/>

1.4 Participant List (confirmed)

Senior speakers

- J. Bellissard (GeorgiaTech, Atlanta USA)
- C. Fermanian Kammerer (Créteil, France)
- G.M. Graf (ETH Zürich, Switzerland)
- V. Jaksic (McGill, Montreal, Canada)
- M. Lewin (Paris-Dauphine, France)
- C.-A. Pillet (Toulon, France)
- M. Porta (Tübingen, Germany)
- E. Prodan (Yeshiva, New York, USA)
- R. Purice (Bucarest, Romania)
- H. Schulz-Baldes (Erlangen, Germany)
- S. Teufel (Tübingen, Germany)

Junior speakers

- P. Cazeaux (Kansas University, USA)
- A. Drouot (Columbia, New York, USA)
- A. Levitt (Ecole des Ponts et Inria, France)
- G. Marcelli (Tübingen, Germany)
- D. Monaco (La Sapienza, Rome, Italy)
- J. Shapiro (Columbia, New York, USA)
- C. Tauber (Cergy, France)

2. Financial Support

We request a 2k€ financial support from CFCAM.

The overall provisional budget is as follows:

Expected expenses: 13.5 k€

- accommodation for 12 speakers: 4.8 k€
- grants for 10 PhD students and postdoctoral fellows: 4 k€
- lunches for all 40 participants during the 3 days of the workshop: 2 k€
- coffee breaks: 0.7 k€
- social dinner: 2 k€

Funding requests: 13.5 k€

- ERC Synergy EMC2: 3.5 k€ (secured)
- Annales Henri Poincaré: 2 k€ (secured)
- Labex Bézout: 2 k€ (secured)
- CFCAM: 2k€
- CNRS: 2k€
- International Association of Mathematical Physics: 1 k€
- Journal of Mathematical Physics: 1 k€