Mathematical Frontiers in the Analysis of Many-particle Systems

Cambridge, July 1-5, 2019

Invited Speakers

Aymeric Baradat
Claude Bardos
François Bolley
Didier Bresch
Tristan Buckmaster
Frédérique Charles
Laurent Desvillettes
Francis Filbet
Olivier Glass
François Golse
Megan Griffin-Pickering
Daniel Han-Kwan
Pierre-Emmanuel Jabin
Zeinab Karaki
Lisa Maria Kreusser
Laurent Laflèche
Matthieu Léautaud
Fabricio Macia
Antoine Mellet
Sergio Polidoro
Mario Pulvirenti
Frédéric Rousset
Luis Silvestre
Martin Taylor
Camille Tardif
Alexis Vasseur

To register for the conference, please visit:

https://mafran2019.sciencesconf.org/

Organisers

Emeric Bouin
Jessica Guerand
Clément Mouhot
Ivan Moyano

This conference is funded by the European Research Council (ERC) MAFRAN grant under the European Union's Horizon 2020 research and innovation programme (grant agreement No 726386)

MAFRAN Conference

Centre for Mathematical Sciences, University of Cambridge
1-5 July 2019

European Research Council
Established by the European Commission

Conference Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
09:00-09:40	Registration and coffee	**MELLET**	**HAN-KWAN**		**POLIDORO**
09:40-09:50	Welcome	Short break			
09:50-10:30	**BARDOS**	**GLASS**	**BRESCH**	**FILBET**	**TAYLOR**
10:30-11:00	Coffee break				
11:00-11:40	**VASSEUR**	**BOLLEY**	**GRIFFIN-PICKERING**	**JABIN**	**DESVILLETTES**
11:40-12:20	**KREUSSER**	**BARADAT**	**GOLSE**	**SILVESTRE**	
12:20-14:30	Lunch time				
14:30-15:10	**BUCKMASTER**	**LAFLECHE**	*Free afternoon*	**TARDIF**	
15:10-15:20	Short break			Short break	
15:20-16:00	**ROUSSET**	**LEAUTAUD**		**PULVIRENTI**	
16:00-16:30	Coffee break		*Quidditch Game*	Coffee break	
16:30-17:10	**MACIA**	**CHARLES**		**KARAKI**	

On Monday to Wednesday the conference will be held at the Centre for Mathematical Sciences in room MR3.

Centre for Mathematical Sciences
University of Cambridge
Wilberforce Road
Cambridge CB3 0WA

Google maps (Train Station to CMS): https://goo.gl/maps/zD8xxh4MUdk7K62G7

On Thursday and Friday the conference will be held at Trinity Hall WYNG Gardens.

Trinity Hall WYNG Gardens
Thompsons Lane
Cambridge CB5 8AQ

Google maps (CMS to WYNG Gardens): https://goo.gl/maps/3rwuxHiRwykdGRLu5

Conference Dinner

A conference dinner will take place at Wolfson College on Wednesday 3 July. A drinks reception at 7:00pm will be followed by dinner at 7:30pm.

Monday 1 July – Centre for Mathematical Sciences

9:00am	Registration and Coffee in the Central Core
9:40am	Welcome remarks
9:50am	**Claude Bardos (Univ. Paris 7, France)** **A baby version of the Landau damping with scalings. Application to the quasilinear approximation** Considering the solution of the Vlasov equation on a finite time interval and introducing some convenient and may be physical scalings one obtains an elementary version of the Landau Damping and a road map to the proof of the quasilinear approximation.
10:30am	Coffee break
11:00am	**Alexis Vasseur (Univ. of Texas, USA)** Title and abstract TBC
11:40am	**Lisa Maria Kreusser (Univ. Cambridge, UK)** **Rigorous Continuum Limit for the Discrete Network Formation Problem** Motivated by recent physics papers describing the formation of biological transport networks we study a discrete model proposed by Hu and Cai consisting of an energy consumption function constrained by a linear system on a graph. We study the existence of solutions to this model, propose an adaptation so that a macroscopic system can be obtained as its formal continuum limit and show the global existence of weak solutions of the macroscopic gradient flow. For the spatially two-dimensional rectangular setting we prove the rigorous continuum limit of the constrained energy functional as the number of nodes of the underlying graph tends to infinity and the edge lengths shrink to zero uniformly. This is joint work with J. Haskovec and P. Markowich.
12:20pm	Lunch
2:30pm	**Tristan Buckmaster (Univ. Princeton, France)** **Shock wave formation for the 2D isentropic compressible Euler equations** In joint work with Steve Shkoller, and Vlad Vicol, we provide a new, elementary constructive proof of shock formation for the 2D isentropic compressible Euler equations in the presence of non-trivial vorticity.

3:10pm	Short break
3:20pm	**Frédéric Rousset (Univ. Paris-Sud, France)** **Asymptotic stability of homogeneous equilibria for screened Vlasov-Poisson systems** We shall describe a recent alternative proof of the result obtained by Bedrossian, Masmoudi and Mouhot on the Landau damping in the whole space. This approach is based on the characteristic method and the derivation of pointwise in time dispersive estimates for the linearized equation. Joint work with D. Han-Kwan (Polytechnique) and T. Nguyen (Penn State).
4:00pm	Coffee break
4:30pm	**Fabricio Macia (UPM, Spain)** **Effective Hamiltonians and long-time semiclassical dynamics** Effective Hamiltonians are an important tool in solid state physics; here, effective Hamiltonians are derived for the the dynamics of an electron in a crystal in the asymptotic regime of small wave-length comparable to the characteristic scale of the crystal. By means of a Floquet-Bloch decomposition we reduce the dynamics to those of an infinite family of pseudo-differential dispersive equations, for which the scaling limit under consideration amounts to performing simultaneously the semiclassical and the long-time limit. Our approach to this problem is based on the quantification of dispersive effects via a two-microlocal analysis on critical points on the Bloch energies. In particular, we are able to deal with degenerate critical points and codimension-one crossings. This is joint work with V. Chabu and C. Fermanian-Kammerer.

Tuesday 2 July – Centre for Mathematical Sciences

9:00am	**Antoine Mellet (Univ. Maryland, US)** **A free boundary problem for cell motility** We derive a new free boundary problem to model the crawling motion of cells on a substrate. Our starting point is a system of equations coupling a fourth order diffuse interface approximation of Cahn-Hilliard type to a second order parabolic equation modelling some chemo-repulsive effects (which account for the formation on protrusions along the membrane of the cell). The resulting free boundary problem is of Hele-Shaw type. It combines the (regularizing) effects of surface tension with the (destabilizing) effects of the chemo-repulsive potential. It exhibits interesting properties (e.g. symmetry breaking and hysteresis phenomena) which are in good agreement with observations.
9:40am	Short break
9:50am	**Olivier Glass (Univ. Paris-Dauphine, France)** **Vortex models as limits of the evolution of solids in a perfect incompressible fluid** We consider the evolution of N solids in a perfect incompressible fluid in a two-dimensional domain. The fluid is driven by the incompressible Euler equation, while the solids evolve according to Newton's laws, under the influence of the the pressure on their boundary. This generates a well-posed system as long as no collision occurs. We investigate the asymptotic limit of this system as the solids shink to points, while their mass either goes to 0 or is fixed. We find in the limit vortex models in the spirit of Marchioro and Pulvirenti's wave-vortex system, in which the vortices are either classical point-vortices (following the flow of the regular part of the velocity) or massive point-vortices (fulfilling a second-order equation with a right-hand side reminiscent of the Kutta-Joukowski force of the irrotational theory). This is a joint work with Franck Sueur (Bordeaux).
10:30am	Coffee break
11:00am	**François Bolley (Univ. Paris 6, France)** **Dynamics of a Coulomb gas in dimension two** We study the dynamics of interacting planar Brownian particles subject to Coulomb pair repulsion. In contrast with the one dimensional log-gases associated with the Dyson Brownian motion, the system is well-posed for any temperature. We also discuss the invariant law and large time

	convergence to it in presence of an additional external force field. This is a joint wok with D. Chafaï and J. Fontbona.
11:40am	**Aymeric Baradat (École Polytechnique, France)** **Dependence with respect to the data in incompressible optimal transport** Incompressible optimal transport (or Brenier model) is a minimization problem introduced by Brenier in 89 in order to describe the behavior of an incompressible and inviscid fluid in a Lagrangian way. The data of the problem is the joint law of the initial and final positions of the particles, and the dynamics is guided by the Lagrange multiplier corresponding to the incompressibility constraint: the pressure field. In this talk, I will present a positive and a negative result concerning the continuous dependence of the pressure field with respect to the data. The negative part is related to the question of ill-posedness of the so-called kinetic Euler equation, a kinetic PDE known in plasma physics as the limit of the Vlasov-Poisson equation in a quasineutral regime**.**
12:20pm	Lunch
2:30pm	**Laurent Laflèche (Univ. Paris-Dauphine, France)** **Semiclassical limit from Hartree to Vlasov-Poisson equation** The Hartree equation is the mean field equation which describes the evolution of a system of particles in interaction in quantum mechanics. It can be proved that it converges in some weak sense to the Vlasov equation when the Planck constant \hbar becomes negligible. In this talk, I will present how this convergence can be quantitatively measured by introducing the Wigner transform, a semiclassical version of the Wasserstein-Monge-Kantorovitch distance introduced by F. Golse and T. Paul, and also a semiclassical analogue of the kinetic Lebesgue norms. One of the key step to reach this result is the propagation in time of semiclassical moments, in the spirit of the proof of existence for the Vlasov-Poisson equation by P.-L. Lions and B. Perthame, and weighted Schatten norms of the solution, which implies the boundedness of the spatial density of particles. This can be proved by using the formal analogies between the density operator formulation of quantum mechanics and kinetic theory.
3:10pm	Short break
3:20pm	**Matthieu Léautaud (École Polytechnique, France)** **Unique continuation for waves and applications** In this talk, we shall first present quantitative unique continuation

	estimates for wave equations. We shall then explain how such inequalities apply to the approximate and exact controllability of waves, and to hypoelliptic equations. This is based on joint works with Camille Laurent.
4:00pm	Coffee break
4:30pm	**Frédérique Charles (Univ. Paris 6, France)** **From particle methods to hybrid semi-Lagrangian schemes for transport equations** Particle methods for transport equations consist in pushing forward particles along the characteristic lines of the flow, and to describe then the transported density as a sum of weighted and smoothed particles. In this talk we present two classes of particle methods which aim at improving the accuracy of the numerical approximations with a minimal amount of smoothing. The idea of the Linearly Transformed Particle method is to transform the shape functions of particles in order to follow the local variation of the flow. This method has been adapted and analyzed for the Vlasov- Poisson system and for a compressible aggregation equation. In both cases the error estimate is improved compared to classical particle methods, with the gain of a strong convergence of the numerical solution. However, for long remapping periods, shapes of particles could become to much stretched out. The second method solve this problem of locality by combining a backward semi-Lagrangian approach and local linearizations of the flow. This is a joint work with Martin Campos-Pinto.

Wednesday 3 July – Centre for Mathematical Sciences

9:00am	**Daniel Han-Kwan (École Polytechnique, France)** **On large time behaviour for the Vlasov-Navier-Stokes system** We will review some recent results describing the large time behavior of solutions to the Vlasov-Navier-Stokes system, which is a fluid-kinetic coupled system modelling the dynamics of sprays. Joint works with O. Glass, A. Moussa and I. Moyano.
9:40am	Short break
9:50am	**Didier Bresch (Univ. Chambéry, France)** **A two velocity hydrodynamic story** In a series of papers over 9 years (2004-2012), Howard Brenner (1929--2013) [who was emeritus professor at MIT in chemical engineering]

	proposed a new theory in compressible fluid mechanics with high gradient of density based on the concept of two different velocities: the mass and the volume velocities. At the same time, D.B. with B. Desjardins discovered (with E. Zatorska later on) that a structure with two velocity hydrodynamics already exists in standard models (i.e. with one velocity field) if the shear and the bulk viscosities satisfy the BD algebraic relation. In this talk, I will try to give an historical overview of this mathematical story and explain at the end a recent mathematical result with A. Vasseur and C. Yu. Several comments and remarks will be related to kinetic equations and particle systems.
10:30am	Coffee break
11:00am	**Megan Griffin-Pickering (Univ. Cambridge, UK)** **A Particle Approximation for a Kinetic Euler Equation** The kinetic incompressible Euler equation is a model for plasma. It is the formal limit of the classical Vlasov-Poisson system in the `quasi-neutral' limit where the Debye length tends to zero. The Vlasov-Poisson system can itself be derived formally from a system of interacting particles, in the limit as the number of particles tends to infinity. The rigorous justification of this `mean field' limit remains a major open problem. However, in recent years, researchers have derived the Vlasov-Poisson equation rigorously from various regularised microscopic systems. In this talk, I will present a joint work with Mikaela Iacobelli, in which we give a rigorous derivation of the kinetic incompressible Euler equation from a regularised particle system, using a combined mean field and quasi-neutral limit.
11:40am	**François Golse (École Polytechnique, France)** **Partial Regularity in Time for the Landau Equation (with Coulomb Interaction)** We prove that the set of singular times for weak solutions of the space homogeneous Landau equation with Coulomb potential constructed as in [C. Villani, Arch. Rational Mech. Anal. 143 (1998), 273-307] has Hausdorff dimension at most 1/2. Joint work with M.P. Gualdani, Cyril Imbert and Alexis Vasseur.
12:20pm	Lunch

Thursday 4 July – Trinity Hall WYNG Gardens

9:50am	**Francis Filbet (Univ. Toulouse, France)** **Rigorous derivation of the nonlocal reaction-diffusion FitzHugh-Nagumo system** We introduce a spatially extended transport kinetic FitzHugh-Nagumo model with forced local interactions and prove that its hydrodynamic limit converges towards the classical nonlocal reaction-diffusion FitzHugh-Nagumo system. Our approach is based on a relative entropy method, where the macroscopic quantities of the kinetic model are compared with the solution to the nonlocal reaction-diffusion system. This approach allows to make the rigorous link between kinetic and reaction-diffusion models.
10:30am	Coffee break
11:00am	**Pierre-Emmanuel Jabin (Univ. Maryland, US)** **Quantitative estimates of propagation of chaos for large systems of interacting particles** We present a new method to derive quantitative estimates proving the propagation of chaos for large stochastic or deterministic systems of interacting particles. Our approach requires to prove large deviations estimates for non-continuous potentials modified by the limiting law. But it leads to explicit bounds on the relative entropy between the joint law of the particles and the tensorized law at the limit. The method can be applied to very singular kernels that are only in negative Sobolev spaces and include the Biot-Savart law for 2d Navier-Stokes or repulsive gradient flows with less than Poisson singularity. This is a joint work with Z. Wang
11:40am	**Luis Silvestre (Univ. Chicago, USA)** **Regularity estimates for the Boltzmann equation without cutoff** We study the regularization effect of the inhomogeneous Boltzmann equation without cutoff. We obtain a priori estimates for all derivatives of the solution depending only on bounds of the hydrodynamic quantities: mass density, energy density and entropy density. As a consequence, a classical solution to the equation may fail to exists after certain time T only if at least one of these hydrodynamic quantities blows up. Our analysis applies to the case of moderately soft and hard potentials. We use methods that originated in the study of nonlocal elliptic equations: a weak Harnack inequality in the style of De Giorgi, and a Schauder-type estimate. We apply them to gain regularity iteratively and we combine them with a pointwise decay estimate for large velocities. This talk is

	based on a series of papers. Part of them are joint work with Cyril Imbert, and part are joint with Clément Mouhot as well**.**
12:20pm	Lunch
2:30pm	**Camille Tardif (Univ. Paris 6, France)** **Anomalous diffusion for kinetic Fokker-Planck equation** We consider a one dimensional particle having Langevin dynamics where the velocity $(v_t)_{t\geq 0}$ is a reversible diffusion process with invariant probability measure being of Cauchy type : i.e is asymptoticly equivalent to $l v l^{-\beta}$, $\beta >0$. We prove that, under a suitable rescaling, the position process resembles a Brownian motion if $\beta>5$, a stable process if $\beta \in [1,5)$. This recovers a work by G. Lebeau and M. Puel with an alternative probabilist approach.
3:10pm	Short break
3:20pm	**Mario Pulvirenti (Univ. Roma "La Sapienza", Italy)** **Backward clusters and Wild sum in a low-density regime for Hard-sphere systems** When studying the dynamics of a tagged particle in a N-particle system it is natural and useful the introduction of the backward cluster of that particle. We want to estimate the size of a backward cluster in a low-density regime. In doing this we establish a rigorous connection with the Wild's sum for the Boltzmann equation and this justifies heuristic assumptions in previous papers. This is a research in collaboration with S. Simonella.
4:00pm	Coffee break
4:30pm	**Zeinab Karaki (Univ. Nantes, France)** **Study of Fokker-Planck operator with an external magnetic field** In this talk, I will present results about the exponential decay of the semi-group associated to Fokker-Planck operator with an external magnetic field, in Banach spaces with a polynomial weight. I will first introduce the hypocoercivity method with exponential weight, and then explain how enlargement theories help us achieve our goal.

Friday 5 July – Trinity Hall WYNG Gardens

9:00am	**Sergio Polidoro (Univ. Modena, Italy)** **The regularity theory for degenerate Kolmogorov equations** The aim of my talk is to present a survey of results concerning a family of degenerate linear second order Partial Differential Equations that includes some non-homogeneous kinetic equations. In the first part of my talk, I describe the main points of the regularity theory for classical solutions. In particular, the existence of a fundamental solution, the interior Schauder estimates, the boundary value problem and the Harnack inequality will be discussed. I will conclude with some recent achievements on the theory of weak solutions.
9:40am	Short break
9:50am	**Martin Taylor (Univ. Princeton, USA)** **Global nonlinear stability of Minkowski space for the massive and massless Einstein–Vlasov systems** The Einstein—Vlasov system describes an ensemble of collisionless particles interacting via gravity, as modelled by general relativity. Under the assumption that all particles have equal mass the system is qualitatively different depending on whether this mass is zero or nonzero. I will present two theorems concerning the global nonlinear stability of the trivial solution, Minkowski space, in the two respective cases. The massive case is joint work with Hans Lindblad.
10:30am	Coffee break
11:00am	**Laurent Desvillettes (Univ. Paris 7, France)** **Interplay between diffusion and coagulation processes** Coagulation processes can be modeled thanks to the Smoluchowsky equations (in the spatially homogeneous case, they constitute an infinite system of ODEs). Blowup in those equations is related to the physical phenomenon of gelation. The interaction of coagulation with diffusion (once one considers the spatially inhomogeneous case) is complex because the diffusion coefficients of clusters depend on their size. We explain how refined duality lemmas enable to overcome this difficulty in some cases. This presentation is based on a work in collaboration with Maxime Breden.
12:00pm	Lunch

MAFRAN Conference

Centre for Mathematical Sciences, University of Cambridge
1-5 July 2019

Organisers

Professor Clément Mouhot, Univ. Cambridge
Dr Émeric Bouin, Univ. Paris-Dauphine
Dr Jessica Guerand, Univ. Cambridge
Dr Ivan Moyano, Univ. Cambridge

On Monday to Wednesday we will be at the Centre for Mathematical Sciences

All lectures will take place in MR3.

Lunches and coffee breaks will take place in the Central Core

Centre for Mathematical Sciences
University of Cambridge
Wilberforce Road
Cambridge CB3 0WA

Google maps (Train Station to CMS): https://goo.gl/maps/zD8xxh4MUdk7K62G7

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Conference Dinner

A conference dinner will take place at Wolfson College on Wednesday 3 July. A drinks reception at 7:00pm will be followed by dinner at 7:30pm.

Google maps (CMS to Wolfson College): https://goo.gl/maps/aX5J2RskzsavjCRS7

Accommodation

Accommodation has been booked at Churchill College (ref 45360) as requested. Breakfast is in the dining hall from 7:30-9:30am. Check in is from 2:00pm and check out is by 10:00am, both at the Porters' Lodge.

Google maps (CMS to Churchill College): https://goo.gl/maps/c1Dkv9ztt2YErxpG9

Conference website

https://mafran2019.sciencesconf.org/

This conference is funded by the European Research Council (ERC) MAFRAN grant under the European Union's Horizon 2020 research and innovation programme (grant agreement No 726386).

List of Participants

Pedro Aceves-Sanchez (NC State, USA)
Adam Almakroudi (Imperial College London, UK)
Francesca Anceschi (Univ. Modena e Reggio Emilia, Italy)
Aymeric Baradat (École Polytechnique, France)
Claude Bardos (Univ. Paris 7, France)
Simon Becker (Univ Cambridge, UK)
Gabriele Benomio (Imperial College London, UK)
François Bolley (Univ. Paris 6, France)
Emeric Bouin (Univ. Paris-Dauphine, France)
Didier Bresch (Univ. Chambéry, France)
Nicolas Brigouleix (École Polytechnique, France)
Tristan Buckmaster (Univ. Princeton, USA)
Laurent Chaminade (WSPC)
Frédérique Charles (Univ. Paris 6, France)
Joachim Crevat (IMT, France)
Laurent Desvillettes (Univ. Paris 7, France)
Antoine Diez (Imperial College London, UK)
Josephine Evans (Univ. Paris-Dauphine, France)
Francis Filbet (Univ. Toulouse, France)
Olivier Glass (Univ. Paris-Dauphine, France)
François Golse (École Polytechnique, France)
Megan Griffin-Pickering (Univ. Cambridge, UK)
Jessica Guerand (Univ. Cambridge, UK)
Daniel Han-Kwan (Ecole Polytechnique, France)
Jan Haskovec (KAUST, Saudi Arabia)
Andrei Ichim (Univ. Cambridge, UK)
Pierre-Emmanuel Jabin (Univ. Maryland, US)
Zeinab Karaki (Univ. Nantes, France)
Christoph Kehle (Univ. Cambridge, UK)
Lisa Maria Kreusser (Univ. Cambridge, UK)
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Matthieu Léautaud (École Polytechnique, France)
Fabricio Macia (UPM, Spain)
Sibylle Marcotte (Univ. Cambridge, UK)
Antoine Mellet (Univ. Maryland, US)
Angeliki Menegaki (Univ. Cambridge, UK)

Stéphane Mischler (Univ. Paris-Dauphine, France)
Clément Mouhot (Univ. Cambridge, UK)
Ivan Moyano (Univ. Cambridge, UK)
Yingping Peng (Imperial College London, UK)
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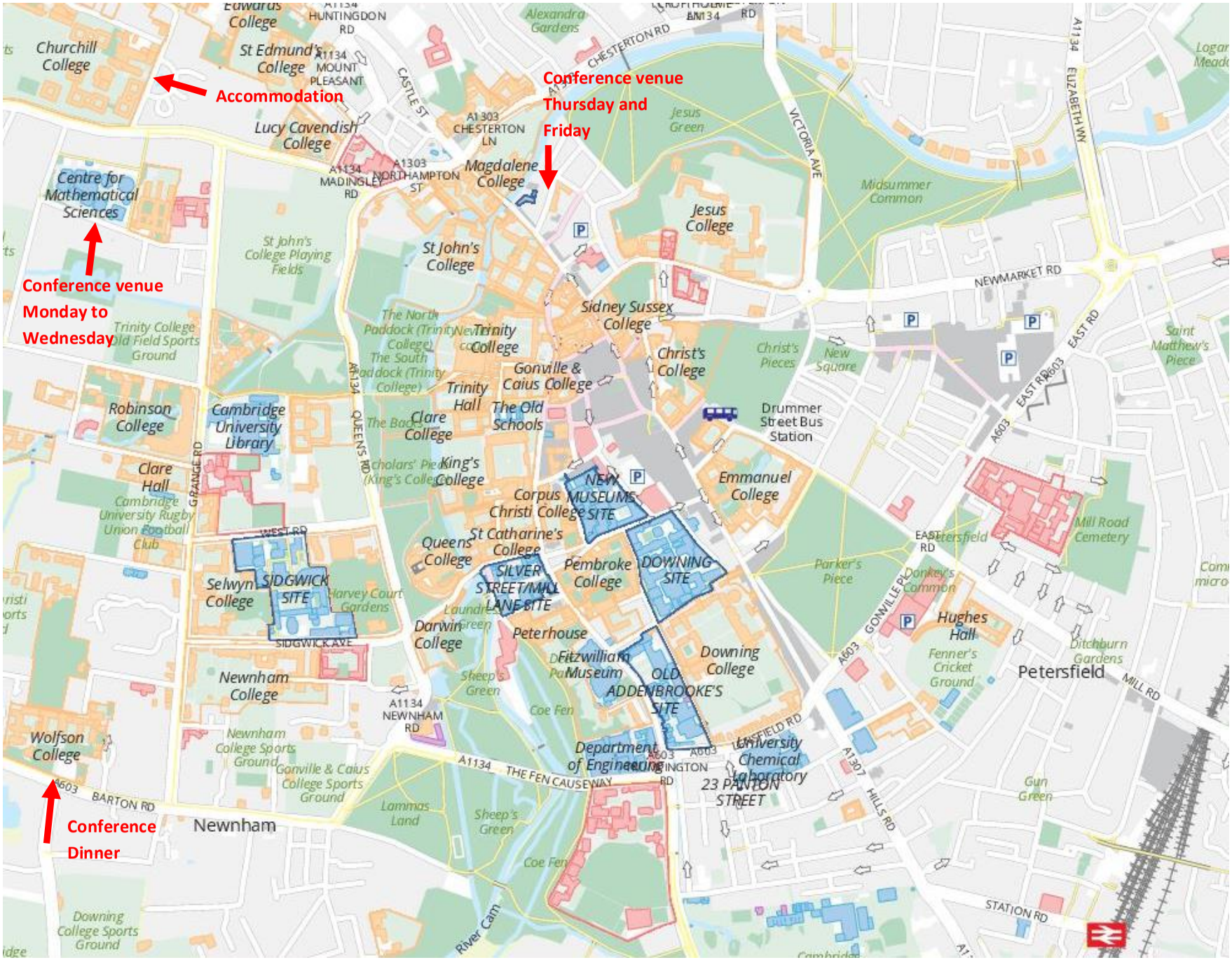
Mario Pulvirenti (Univ. Roma "La Sapienza", Italy)
Frédéric Rousset (Univ. Paris-Sud, France)
Renato Ruiz Velozo (Univ. Cambridge, UK)
Samir Salem (Univ. Paris-Dauphine, France)
Luis Silvestre (Univ. Chicago, US)
Martin Taylor (Univ. Princeton, USA)
Camille Tardif (Univ. Paris 6, France)
Rita Teixeira da Costa (Univ. Cambridge, UK)
Arti Sheth Thorne (Univ. Cambridge, UK)
Quinten Tupker (Univ. Cambridge, UK)
Alexis Vasseur (Univ. Texas, US)
Zhenfu Wang (Univ. Pennsylvania, UK)
Kung-Chien Wu (National Cheng Kung Univ., Taiwan)


Accommodation
Conference venue
Thursday and
Friday
Conference venue
Monday to
Wednesday
Conference
Dinner
Churchill College
St Edmund's College
Lucy Cavendish College
Centre for Mathematical Sciences
Magdalene College
Jesus College
St John's College
Sidney Sussex College
Trinity College
Christ's College
Gonville & Caius College
Trinity Hall
The Old Schools
Clare College
King's College
Robinson College
Cambridge University Library
Clare Hall
Emmanuel College
NEW MUSEUMS SITE
Corpus Christi College
Queens' College
St Catharine's College
Pembroke College
DOWNING SITE
SILVER STREET/MILL LANE SITE
SIDGWICK SITE
Selwyn College
Darwin College
Peterhouse
Fitzwilliam Museum
OLD ADDENBROOKE'S SITE
Downing College
Newnham College
Wolfson College
Department of Engineering
University Chemical Laboratory
23 PAYNTER STREET
Hughes Hall
Petersfield
Drummer Street Bus Station
Mill Road Cemetery
Parker's Piece
Jesus Green
Midsummer Common
Christ's Pieces
New Square
Saint Matthew's Piece
Ditchburn Gardens
Fenner's Cricket Ground
Gun Green
Lammas Land
Sheep's Green
Coe Fen
Harvey Court Gardens
Newnham College Sports Ground
Gonville & Caius College Sports Ground
Downing College Sports Ground
Trinity College Old Field Sports Ground
St John's College Playing Fields
Cambridge University Rugby Union Football Club
Alexandra Gardens
Logan Meadow
Donkey's Common
Newnham
River Cam
CHESTERTON RD
HUNTINGDON RD
MOUNT PLEASANT
CASTLE ST
CHESTERTON LN
MADINGLEY RD
NORTHAMPTON ST
VICTORIA AVE
ELIZABETH WY
NEWMARKET RD
EAST RD
QUEENS RD
GRANGE RD
WEST RD
SIDGWICK AVE
NEWNHAM RD
BARTON RD
THE FEN CAUSEWAY
HILLS RD
STATION RD
MILL RD
GONVILLE PL
A1134
A1303
A603
A1307