Inaugural France-Korea Conference

Algebraic Geometry, Number Theory, Partial Differential Equations

November 24-27 2019

Institute of Mathematics
University of Bordeaux

General information

Scientific committee

Denis Benois (Univ. of Bordeaux)
Stéphane Brull (Bordeaux INP)
Vincent Koziarz (Univ. of Bordeaux)
Philippe Thieullen (Univ. of Bordeaux)
Dongho Chae (Chung-Ang Univ.)
YoungJu Choie (Postech)
Seung Yeal Ha (SNU)
Hyung Ju Hwang (Postech)
Jonghae Keum (KIAS)
Sijong Kwak (KAIST)
Yong-Geun Oh (IBS-CGP, Postech)

Local organizers

Stéphane Brull	Seung Yeal Ha	Philippe Thieullen
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Sponsors

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Bordeaux INP
IDEX Initiative Excellence
CNRS
Korea Institute for Advanced Study
IBS Center for Geometry and Physics
Seoul National University

Time Schedule
Algebraic Geometry and Number Theory

	Monday		**Tuesday**	**Wednesday**
08:30–09:00	opening	**08:30–09:00**	Jian Wang salle 1	Jun-Yong Park amphi
09:00–09:20	speech amphi F	**09:00–09:50**	Gérard Besson salle 1	Dohoon Choi amphi
09:20–10:10	Jonghae Keum amphi F	**09:50 –10:30**	Dimitri Zvonkine salle 1	Carlo Gasbarri amphi
10:10–10:40	**break**	**10:30–11:00**	**break**	**break**
10:40–11:30	Christophe Breuil amphi F	**11:00–11:50**	Jihun Park salle 1	Bo-Hae Im amphi
11:30–12:00	Junhwa Choi amphi F	**11:50–12:30**	YoungJu Choie salle 1	Insong Choe amphi
12:00–13:30	**lunch at Bordeaux INP**	**12:30–14:00**	**lunch at IMB**	**lunch at IMB**
14:00–14:50	Laurent Berger amphi	**14:00–14:50**	Claire Voisin amphi	Yann Bugeaud salle 1
14:50–15:30	Tuan Ngo Dac amphi	**14:50–15:30**	Stefano Morra amphi	Dohyeong Kim salle 1
15:30–16:00	Yonghwa Cho amphi	**15:30–16:00**	Myungjun Yu amphi	Seul Bee Lee salle 1
16:00–16:30	**break**	**16:00–16:30**	**break**	**break**
16:30–17:20	Sijong Kwak amphi	**16:30–17:10**	Chol Park amphi	Euisung Park salle 1
17:20–18:00	Gerard Freixas i Montpleit amphi	**17:10–17:40**	Hyeonjun Park amphi	
18:00–18:30	Mathieu Dutour amphi	**17:40–18:10**		

20:00–22:00	**KIAS Banquet**	**20:00–22:00**	**IMB Banquet**

amphi F,G: amphitheater at Bordeaux INP, fist floor
amphi: amphitheater at the Institute of Mathematics IMB, first floor, main entrance
KIAS Banquet: Chez Jean, 1 Place du Parlement, 33000 Bordeaux
IMB Banquet: LA BELLE EPOQUE, 2 Allée d'Orléans, 33 000 BORDEAUX, 0556791458

Time Schedule
Partial Differential Equation and Applications

	Monday		**Tuesday**	**Wednesday**
08:30–09:00	opening	**08:30–09:00**	Jinwook Jung amphi	Aymeric Barradat salle 1
09:00–09:20	speech amphi F	**09:00–09:50**	Isabelle Gallagher amphi	Hyeong-Ohk Bae salle 1
09:20–10:10	Dongho Chae amphi G	**09:50–10:30**	Sung-Jin Oh amphi	Ariane Trescases salle 1
10:10–10:40	**break**	**10:30–11:00**	**break**	**break**
10:40–11:30	Benoît Perthame amphi G	**11:00–11:50**	Seung Yeal Ha amphi	François Golse salle 1
11:30–12:00	Seung-Yeon Cho amphi G	**11:50–12:30**	Marc Briant amphi	Donghyun Lee salle 1
12:00–13:30	**lunch at Bordeaux INP**	**12:30–14:00**	**lunch at IMB**	**lunch at IMB**
14:00–14:50	Hyung Ju Hwang salle 1	**14:00–14:50**	Laurent Desvillettes salle 1	Pierre Degond amphi
14:50–15:30	Delphine Salort salle 1	**14:50–15:30**	Seok-Bae Yun salle 1	Daniel Han-Kwan amphi
15:30–16:00	Andrea Bondesan salle 1	**15:30–16:00**	Joahim Crevat salle 1	In-Jee Jeong amphi
16:00–16:30	**break**	**16:00–16:30**	**break**	**break**
16:30–17:00	Doheon Kim salle 1	**16:30- 17:00**	Jin Woo Jang salle 1	Hyunseok Kim amphi
17:00–17:30	Xavier Lhébrard salle 1	**17:00–17:30**	Théophile Dolmaire salle 1	
17:30–18:10	Kleber Carapatoso salle 1	**17:40–18:10**		

20:00–22:00	**KIAS Banquet**	**20:00–22:00**	**IMB Banquet**

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Abstracts
Algebraic Geometry and Number Theory

Laurent Berger

Affiliation: Ecole Normale Supérieure de Lyon

Title: Trianguline representations

Abstract: Trianguline representations are a special class of p-adic Galois representations. I will explain how they are defined, and why they are important in arithmetic geometry. I will also comment on some of their properties.

Gérard Besson

Affiliation: CNRS-Université Grenoble Alpes

Title: On the Geometrisation of Open 3-Manifolds

Abstract: We will present a survey of recent results on the structure of some open 3-manifolds. We will concentrate on two classes: the (possibly) infinite connected sums of quotients of the 3-sphere and the contractible open 3-manifolds. The existence of a complete metric of positive scalar curvature is the criterion to separate these two classes. This covers joint works of L. Bessières, S. Maillot and myself on the one hand and two recent works of Jian Wang on the other hand.

Christophe Breuil

Affiliation: CNRS et Institut de Mathématique d'Orsay

Title: The multiplicity conjecture: a survey

Abstract: I will give the statement of the multiplicity conjecture (also called the "Breuil-Mézard" conjecture) and survey some results, methods of proofs, and recent variants and generalizations due to various people.

Yann Bugeaud

Affiliation: Université de Strasbourg

Title: On the decimal expansion of $\log(2019/2018)$ and e

Abstract: It is commonly expected that e, $\log 2$, $\sqrt{2}$, π, among other classical numbers, behave, in many respects, like almost all real numbers. For instance, one believes that their decimal expansion contains every finite block of digits from $\{0, \ldots, 9\}$. We are very far away from establishing such a strong assertion. However, there has been some recent progress in that direction and we are now able to show that the decimal expansions of irrational algebraic numbers, of non-zero rational powers of e, of $\log(1 + \frac{1}{a})$ (provided that the integer a is sufficiently large), among other examples, are not 'too simple', in a suitable sense. This is a joint work with Dong Han Kim (Seoul).

Yonghwa Cho

Affiliation: School of Mathematics, KIAS

Title: Ulrich bundles on intersection of two 4-dimensional quadrics

Abstract: Let X be a prime Fano threefold of index 2 and degree 4, namely, a smooth intersection of two quadrics in $\mathbb{P}^5$. We consider the moduli problem concerning Ulrich bundles on X. To study these moduli spaces, we use the method developed by Kuznetsov and Lahoz-Macrì-Stellari. More specifically, we study the derived category of X whose Kuznetsov component is equivalent to the derived category of a curve C of genus 2. Using this information, we may interpret Ulrich bundles on X as vector bundles on C, and describe the moduli space in terms of the moduli space of semistable vector bundles on C. This is a joint work with Yeongrak Kim and Kyoung-Seog Lee.

Insong Choe

Affiliation: Department of Mathematics, Konkuk University

Title: Minimal rational curves on the moduli of symplectic and orthogonal bundles

Abstract: Xiaotao Sun proved that the Hecke curves are rational curves on the moduli of vector bundles over a curve which have minimal degree among the rational curves passing through a general point. We discuss a similar result for the moduli of symplectic and orthogonal bundles. We also discuss its applications to nonabelian Torelli theorem and automorphism groups of the moduli spaces. This is a joint work with Kiryong Chung(KNU) and Sanghyeon Lee(KIAS).

Dohoon Choi

Affiliation: Department of Mathematics, Korea University

Title: Uniqueness of an automorphic representation of GL_n with certain local representations

Abstract: Let A_K be the adele ring of a number field K. The strong multiplicity one theorem says that a cuspidal representation of $\mathrm{GL}_n(A)$ is uniquely determined by its local representation at v for all but finitely many places v of K. Based on this theorem, it is a natural question to find a subset S of the set of places of K such that a cuspidal representation of $\mathrm{GL}_n(A_K)$ is uniquely determined by its local representation at v for $v \in S$. In this talk, I will discuss about this question.

Junhwa Choi

Affiliation: Korea Institute for Advanced Study

Title: A conjecture of Watkins and its application

Abstract: Let E be an elliptic curve defined over $\mathbb{Q}$ and let $r = \mathrm{rank}_{\mathbb{Z}}(E(\mathbb{Q}))$. Watkins conjectured that the modular degree of E is divisible by 2^r. In this talk, I will discuss recent progress on this conjecture and its application to quadratic twists of an elliptic curve.

YoungJu Choie

Affiliation: Department of Mathematics, POSTECH

Title: Modular form and Cohomology

Abstract: In 1991 Zagier gave a striking closed formula for the sum of all Hecke eigenforms on Γ, multiplied by their odd period polynomials in two variables, as a single product of Jacobi theta series. We show this identities can be more general.

Tuan Ngo Dac

Affiliation: Université Claude Bernard Lyon 1

Title: On special L-values of Anderson modules

Abstract: First we recall the celebrated log-algebraicity theorem of Anderson-Thakur for tensor powers of the Carlitz module. Then we present various log-algebraicity identities for some Anderson modules generalizing Anderson-Thakur's work based on the key notion of Stark units. This is a joint work with B. Anglès and F. Tavares Ribeiro.

Mathieu Dutour

Affiliation: Sorbonne Université

Title: Quillen metrics on modular curves

Abstract: In a 2007 article, Takhtajan and Zograf proved a curvature formula for the determinant of an endormorphism bundle over a modular curve without elliptic points, relatively to a renormalization of the L2-metric using the first order derivative at 1 of the Selberg zeta function, which they called the Quillen metric.

However, such a metric should be more than just smooth in family, as it should fit naturally in a Riemann-Roch type theorem, like the one proved by Deligne in 1987. It does not here in general.

In this talk, we will see the main ideas required to get a Deligne-Riemann-Roch isometry for certain flat unitary vector bundles over modular curves. The resulting Quillen metric, as a renormalization of the L2-metric by an explicit factor involving the first non-zero derivative of the Selberg zeta function, will be compatible with the work of Takhtajan and Zograf.

Gerard Freixas i Montplet

Affiliation: C.N.R.S. – Institut de Mathématiques de Jussieu-Paris Rive Gauche

Title: Genus one mirror symmetry and the arithmetic Riemann–Roch theorem

Abstract: Mirror symmetry, in a crude formulation, is usually presented as a correspondence between the Gromov–Witten theory of a Calabi–Yau variety X, and some invariants extracted from the degeneration of Hodge structures of a mirror family of Calabi–Yau varieties $\mathcal{X}^\vee \to \mathbf{D}$. After physicists Bershadsky–Cecotti–Ooguri–Vafa (henceforth BCOV), this is organised according to the genus of the curves in X we wish to enumer-

ate, and gives rise to an infinite recurrence of differential equations. The first equation in the recurrence amounts to the classical genus zero mirror symmetry considered by Candelas–de la Ossa–Green–Parkes, and is nothing but an expression of the Yukawa coupling of the mirror family in terms of the genus 0 Gromov–Witten invariants of X. The Yukawa coupling is indeed an invariant of the degeneration of Hodge structures (in the middle degree) of $\mathcal{X}^\vee \to \mathbf{D}$. Many instances of the genus 0 conjecture are nowadays known, *e.g.* when X is a general Calabi–Yau hypersurface in projective space. In this talk, I will present a rigorous mathematical formulation of the BCOV conjecture at genus one, in terms of a lifting of the Grothendieck–Riemann–Roch relationship to a canonical isomorphism of line bundles. I will explain a proof of the conjecture for Calabi–Yau hypersurfaces in projective space, based on the Riemann–Roch theorem in Arakelov geometry. Our results generalise from dimension 3 to arbitrary dimensions previous work of Fang–Lu–Yoshikawa. This is joint work with D. Eriksson and C. Mourougane.

Carlo Gasbarri

Affiliation: Université de Strasbourg

Title: Transcendental Liouville inequality and rational points on disks

Abstract: Liouville inequality is an important tool in almost any proof in diophantine geometry. It essentally tells us that if a global section of a line bundle over a projective variety X do not vanish on a rational point, its value on it cannot be too small. Even if we cannot expect a similar phenomenon on transcendental points of X, we will describe inequalities which hold for "almost any" transcendental points. We will also describe how these inequalities may be used to estimate the number of rational points of bounded height on Zariski dense analytic discs.

Bo-Hae Im

Affiliation: Department of Mathematical Sciences, KAIST

Title: The infinite rank of abelian varieties over fields with finitely generated Galois groups

Abstract: In this talk, we define an anti-Mordell-Weil field and present special properties of anti-Mordell-Weil fields. We introduce Larsen's conjecture which says that the rank of an abelian variety over a field of characteristic 0 with finitely generated absolute Gaiois group is infinite and present some related results in the sense of the full Haar measure. The main result is a joint work with Michael Larsen.

Jonghae Keum

Affiliation: School of Mathematics, Korea Institute for Advanced Study

Title: Algebraic surfaces with the same Betti numbers as the complex projective plane

Abstract: These are algebraic surfaces defined over the complex number field with minimal possible Betti numbers.

They are called Q-homology projective planes. Smooth examples are the complex projective plane and fake projective planes.

In dimension one, any smooth algebraic curve (compact Riemann surface) with minimal Betti numbers must be isomorphic to the complex projective line (Riemann sphere). In dimension two, if the surfaces are allowed to have mild singulariies, then the study of such objects is rich.

I will describe examples and recent progress in the study of such surfaces including the famous, fake projective planes.

The study of these surfaces are also related to the study of circle actions of the 5-dimensional sphere in differential topology, which is called the Montgomery-Yang problem. I will also discuss open questions on this problem.

Dohyeong Kim

Affiliation: Department of Mathematical Sciences, SNU

Title: Integral models for the unipotent completion of a finitely generated group

Abstract: Using a fragment of Lazard's theory, we construct integral unipotent completions of a finitely generated group. We will discuss its appliation to arithmetic, especially in view of the Chabauty-Kim method, by considering fundamental groups of curves.

Sijong Kwak

Affiliation: Department of Mathematical Sciences, KAIST

Title: Recent progress on regularity problem due to Castelnuovo-Mumford-Eisenbud-Goto

Abstract: Regularity of projective varieties or coherent sheaves has been very useful in understanding some topics on classical algebraic geometry. In this talk, I introduce the notion of regularity of ideal shaves of projective subschemes and interesting counterexample on Eisenbud-Goto conjecture due to McCullough-Peeva and positive result due to Jinhyung Park and I.

Seul Bee Lee

Affiliation: Dongguk University, Seoul National University, Université Paris-Est Créteil Val de Marne

Title: Odd-odd continued fraction

Abstract: (With Dong Han Kim and Lingmin Liao) It is known that regular continued fraction gives the best approximation of an irrational number with rationals. We investigate a continued fraction, say odd-odd continued fraction, which gives the best approximation of an irrational with rationals whose numerator and denominator are odd. To show our results, we see that our continued fraction is related to Farey graph and Ford circles. This is joint work with Dong Han Kim and Lingmin Liao.

Stefano Morra

Affiliation: Laboratoire d'Analyse, Géométrie et Algèbre, Université Paris 13

Title: Local-Global Compatibility in the mod p Langlands Program

Abstract: The mod p-local Langlands program generated from the proof of the Shimura–Taiyama–Weil conjecture performed by Breuil–Conrad–Diamond–Taylor, by the observation that certain invariants on local Galois deformation rings can be predicted by the modular representation theory of finite groups of Lie type.

The latter observation was the starting point of the Breuil–Mézard conjecture, which, predicts in its geometric formulation, a labeling of the components of deformation rings in terms of Serre weights. This labeling is important since it gives predictions about the $\mathrm{GL}_n(\mathrm{F}_p)$-action on Hecke isotypical spaces in the mod p-cohomology of arithmetic manifolds with full congruence level at p.

In this talk we report on a joint work with Daniel Le, Bao Viet Le Hung, Chol Park and Zicheng Qian on a procedure which goes the other way round: we determine the local Galois parameter attached to a modular residual Galois representation, in terms of the Hecke action on the eigenspaces of the mod p-cohomology spaces mentioned above. In terms of the Breuil–Mézard conjecture, we consider Galois parameters which lie in very generic loci in the irreducible components of the moduli stack of mod p Galois representations, giving evidence for the existence of cuspidal components in Hecke isotypical space of the mod p cohomology with infinite level at p.

Chol Park

Affiliation: Department of Mathematical Sciences, UNIST

Title: Potentially crystalline deformation rings for certain shapes of colength one

Abstract: For a given mod-p representation $\overline{\rho}$ of the absolute Galois group of a p-adic field K, one can define a mod-p automorphic representation $\overline{\Pi}$ of $GL_n(K)$ by a certain space of mod-p algebraic automorphic forms on a unitary group. We wish that $\overline{\Pi}$ corresponds to $\overline{\rho}$ for a mod-p Langlands correspondence, but the structure of $\overline{\Pi}$ is quite mysterious as a representation. It is natural to ask if $\overline{\Pi}$ determines $\overline{\rho}$, and our approach towards this question, in the case that $\overline{\rho}$ is Fontaine-Laffaille, requires constructing certain potentially crystalline deformation rings. In this talk, we will discuss how we construct these deformation rings.

This is a joint work with Daniel Le, Bao Le Hung, Stefano Morra, and Zicheng Qian.

Euisung Park

Affiliation: Department of Mathematics, Korea University

Title: On the rank of quadratic equations of projective varieties

Abstract: We say that a projective variety $X \subset \mathbb{P}^r$ satisfies property $QR(k)$ if its homogeneous ideal can be generated by quadratic forms of rank $\leq k$. Many classical varieties such as rational normal scrolls and Segre-Veronese varieties are known to satisfy property

$QR(4)$. In 2012, G. Smith and J. Sidman show that for a given variety X, any sufficiently ample line bundle on X is determinantally presented and hence satisfies property $QR(4)$. From this point of view, in this talk, I will speak about some projective varieties which satisfy property $QR(3)$. This is a joint work with Kangjin Han (DGIST), Wanseok Lee (PNU) and Hyunsuk Moon (NIMS).

Hyeonjun Park

Affiliation: Department of Mathematical Sciences, SNU

Title: Virtual intersection theories

Abstract: In this talk, I will discuss how to construct virtual fundamental classes in all intersection theories including Chow groups, algebraic K-theory and algebraic cobordism. Then I will discuss key techniques on them such as virtual pullback, torus localization and cosection localization. This is based on the joint work with Young-Hoon Kiem.

Jihun Park

Affiliation: IBS-CGP, POSTECH

Title: Cayley octads, plane quartic curves, Del Pezzo surfaces of degree 2, and double Veronese cones

Abstract: A net of quadrics in the 3-dimensional projective space whose singular members are paramet-rized by a smooth plane quartic curve has exactly eight distinct base points, called a regular Cayley octad. It is a classical result that there is a one-to-one correspondence between isomorphism classes of regular Cayley octads and isomorphism classes of smooth plane quartic curves equipped with even theta-characteristics. We can also easily observed a one-to-one correspondence between isomorphism classes of smooth plane quartic curves and isomorphism classes of smooth Del Pezzo surfaces of degree 2. In my talk, I will set up a one-to-one correspondence between isomorphism classes of smooth plane quartic curves and isomorphism classes of double Veronese cones with 28-singular points. Also, I will explain how the 36 even theta characteristics of a given smooth quartic curve appears in the corresponding double Veronese cone.

Jun–Yong Park

Affiliation: Center for Geometry and Physics, IBS

Title: Arithmetic & Étale topology of the moduli of elliptic surfaces

Abstract: We consider the arithmetic & the étale topological invariants of the moduli stack $\mathcal{L}_{1,12n} := \mathrm{Hom}_n(\mathbb{P}^1, \overline{\mathcal{M}}_{1,1})$ of stable elliptic fibrations over $\mathbb{P}^1$, also known as stable elliptic surfaces, with $12n$ nodal singular fibers and a distinguished section. Afterwards, by a sequence of natural transformations, we show the Tate motivic nature $\mathfrak{M}(\mathcal{L}_{1,12n}) \in \mathrm{Obj}(\mathbf{DTM}(K, \mathbb{Q}))$ with K is any field of characteristic $\neq 2, 3$ manifests into the Grothendieck virtual motive class $[\mathcal{L}_{1,12n}] = \mathbb{L}^{10n+1} - \mathbb{L}^{10n-1} \in K_0(\mathrm{Stck}_K)$ being a polynomial in $\mathbb{L}$ and the weighted point count $\#_q(\mathcal{L}_{1,12n}) = q^{10n+1} - q^{10n-1}$ being a polynomial in q as well as the compactly supported étale cohomology is of mixed Tate

type with the ℓ-adic rational cohomology type of a 3-sphere. This is a joint work with Dr. Changho Han (UGA) and Dr. Hunter Spink (Harvard).

Claire Voisin

Affiliation: Collège de France

Title: Hyper-Kähler manifolds

Abstract: Projective complex algebraic geometry is a major source of construction of compact complex manifolds. Some of them can be deformed to nonprojective complex manifolds, the simplest examples being complex tori, whose topology is well understood. I will describe another kind of complex manifolds with a similar property, namely hyper-Kähler manifolds, and their relation to Yau's theorem on the existence of Kähler-Einstein metrics. Finally I will explain the main known facts concerning their deformation theory, and some methods of construction via algebraic geometry.

Jian Wang

Affiliation: Universität Augsburg

Title: Geometry of 3-manifolds with uniformly positive scalar curvature

Abstract: It is unknown how to classify 3-manifolds with positive scalar curvature up to diffeomorphism. Using minimal surfaces theory, we show that any orientable complete 3-manifold with uniformly positive scalar curvature is an infinite connected sum of spherical 3-manifolds. In this talk, we will present the proof. Further, we will talk about minimal surfaces in a 3-manifold and its relationship with Geometrisation Conjecture.

Myungjun Yu

Affiliation: Korea Institute for Advanced Study

Title: Elliptic curves with complex multiplication and root numbers

Abstract: One of the most important invariant in the study of elliptic curves is the rank. Unfortunately there is no known general method to compute the rank explicitly. However there is a fairly computable invariant called the root number, which conjecturally gives the parity of the rank. In this talk, we discuss the root number of an elliptic curve with complex multiplication. This is joint work with Wan Lee.

Dimitri Zvonkine

Affiliation: CNRS and Versailles University

Title: On the intersection theory of moduli spaces of curves

Abstract: In this talk I will present several results on the cohomology ring of the moduli space $\overline{\mathcal{M}}_{g,n}$ of stable curves. I will show concrete formulas for relations between natural generators of this ring. Other formulas express the cohomology classes of interesting cycles. All these formulas have a similar flavour. The reason is that they have a common origin: Teleman's classification of semi-simple cohomological field theories based on Givental's group action.

Abstracts
Partial Differential Equation And Applications

Hyeong-Ohk Bae

Affiliation: Department of Financial Engineering, Ajou University

Title: Boundary regularity for the steady shear thickening flow

Abstract: (With Jörg Wolf) We work on the boundary regularity for weak solutions to the stationary Navier–Stokes type equations with shear dependent viscosity, which shows the Hölder continuity.

For the proof, we first approximate the equations by adding the Laplacian to the viscosity term, then estimate the tangential derivatives. Later, using weighted embedding techniques we estimate the normal derivative.

Aymeric Baradat

Affiliation: Ecole Polytechnique

Title: Multiphase formulation of plasma physics

Abstract: The main question to be asked in this talk will be the question of nonlinear instability in Vlasov type equations around stationary solutions that are homogeneous with respect to the space variable and only measures with respect to the velocity variable. I will show that a multiphase reformulation of this type of equations makes it possible to recover the so-called Penrose condition in this non-smooth setting. As an application, I will present an ill-posedness result concerning the so-called kinetic Euler equation, also known as the quasineutral limit of the Vlasov-Poisson equation. I will also mention an ongoing work concerning the Lyapounov instability of the Vlasov-Poisson equation.

Andrea Bondesan

Affiliation: Université Paris 5

Title: Stability of the spectral gap for the Boltzmann multi-species operator linearized around non-equilibrium Maxwellian states

Abstract: We consider the Boltzmann operator for mixtures with cutoff Maxwellian, hard potential, or hard-sphere collision kernels. In a perturbative regime around the global Maxwellian equilibrium, the linearized Boltzmann multi-species operator $\mathbf{L}$ is known to possess an explicit spectral gap $\lambda_{\mathbf{L}}$, in the global equilibrium weighted L^2 space. We study a new operator $\mathbf{L}^\varepsilon$ obtained by linearizing the Boltzmann operator for mixtures around local Maxwell distributions, where all the species evolve with different small macroscopic velocities of order ε, $\varepsilon > 0$. This is a non-equilibrium state for the mixture. We establish a quasi-stability property for the Dirichlet form of $\mathbf{L}^\varepsilon$ in the global equilibrium weighted L^2 space. More precisely, we consider the explicit upper bound that has been proved for

the entropy production functional associated to $\mathbf{L}$ and we show that the same estimate holds for the entropy production functional associated to $\mathbf{L}^\varepsilon$, up to a correction of order ε.

This is a joint work with L. Boudin, M. Briant and B. Grec.

Marc Briant

Affiliation: Université Paris 5

Title: Hypocoercive Techniques in Collisional Kinetic Theory

Abstract: The issue of long-time behaviour of solutions of a PDE, more precisely the convergence towards an equilibrium, can be viewed at a linear(ized) level by adopting a perturbative approach. In such a framework one expects the dynamics of the linear operator to take over higher order terms for small initial data. When the linear operator is symmetric negative then obvious Gronwall-type arguments apply to obtain explicit rate of decay for the solutions. Unfortunately for a lot of collisional kinetic equations, the linear operator indeed offers a negative feedback but only outside of its kernel. In this talk we present different techniques used in order to recover a full coercivity thanks to the interplay between collision and transport operator : opertor commutators, weak ellipticity, $L^2 - L^\infty$, extension methods... We shall present some models where such hypocoercivity proved itself useful to construct explicit Cauchy theories and rates of convergence.

Kleber Carrapatoso

Affiliation: École Polytechnique

Title: Long-time dynamics of isothermal fluids

Abstract: In this talk I shall consider compressible fluid equations, namely classical and quantum Euler and Navier-Stokes equations. I will show that in the isothermal case, that is when the pressure is a linear function of the density, the long-time behavior is rigid, in contrast to what happens with polytropic fluids. This is a joint work with Rémi Carles and Matthieu Hillairet.

Dongho Chae

Affiliation: Department of Mathematics, Chung-Ang University, Republic of Korea

Title: On Type I blow-up for the incompressible Euler equations

Abstract: In this talk we discuss the Type I blow-up and the related problems of the Euler equations. Small Type I conditions are easily excluded. In the case of the Euler equations Type I condition without smallness implies exlclusion of atomic concentration of energy. As an important corollary we remove discretely self-similar blow-up in the energy conserving scale. We also discuss the Type I condition for the 2D Boussinesq system. The localized version of this result leads to removing some of Type II blow-up in the axisymmetric Euler equations off the axis. These results are joint works with J. Wolf.

Seung-Yeon Cho

Affiliation: Department of Mathematics, University of Catania

Title: A conservative reconstruction and its applications

Abstract: In this talk, I will introduce a conservative reconstruction and apply this to semi-Lagrangian finite difference methods for hyperbolic relaxation systems. To deal with the relaxation parameter of each system, implicit schemes are considered, which can be solved explicitly. The performance of conservative reconstructions and devised semi-Lagrangian methods will be confirmed by several numerical tests. This is a joint work with Prof. Boscarino (UNICT), Prof. Russo (UNICT) and Prof. Yun (SKKU).

Joachim Crevat

Affiliation: Université de Toulouse

Title: Rigorous derivation of a macroscopic model for the spatially-extended FitzHugh-Nagumo system

Abstract: We consider the spatially-extended kinetic FitzHugh-Nagumo equation to model a network of an infinite number of neurons interacting with eachother. It describes the time evolution of the probability measure of finding neurons in the network, depending on their spatial position, on their membrane potential and on their adaptation variable. Our main purpose is to rigorously derive a macroscopic system from this kinetic equation. Such a macroscopic model accounts for the time evolution of the average membrane potential and adaptation variable in the network. Its interest stems from the analysis of the collective behaviour of large assemblies of neurons.

Our approach consists in considering the regime of strong local interactions in the kinetic model, and we prove that its diffusive limit converges towards a reaction-diffusion FitzHugh-Nagumo system. To do so, we use a relative entropy argument. The main difficulty is to adapt such an argument in the presence of nonlinear reaction terms.

Pierre Degond

Affiliation: Department of Mathematics, Imperial College London

Title: Mathematical models of collective dynamics and self-organization

Abstract: In this talk, we start by reviewing a certain number of mathematical challenges posed by the modelling of collective dynamics and self-organization. Then, we focus on two specific problems, first, the derivation of fluid equations from particle dynamics of collective motion and second, the study of phase transitions and the stability of the associated equilibria.

Laurent Desvillettes

Affiliation: Université Paris Diderot, Sorbonne Paris Cité, Institut de Mathématiques de Jussieu-Paris Rive Gauche

Title: Validity of the Euler-Vlasov and Navier-Stokes-Vlasov systems: a mesoscopic point

of view

Abstract: The Euler-Vlasov and Navier-Stokes-Vlasov models and their variants are used in the simulation of technical devices as well as natural phenomena. A model system (written in a system of units where the physical constants do not appear) is the following:

$$\partial_t u + (u \cdot \nabla_x) u + \nabla_x p = \Delta_x u + \int f\,(v-u)\,dv,$$

$$\nabla_x \cdot u = 0,$$

$$\partial_t f + v \cdot \nabla_x f + \nabla_v \cdot ((u-v)\,f) = 0,$$

where $u := u(t,x)$ is the velocity of an incompressible gas, and $f := f(t,x,v)$ is the density in the phase space of a disperse phase (droplets or solid specks of dust) surrounded by this gas.

This kind of system can be obtained in some very specific situations starting from the equations of a gas surrounding N particles by letting N tend to ∞. In a series of papers written with Etienne Bernard, François Golse and Valeria Ricci, we show that it is also posible to get them as the formal limit of systems of two coupled Boltzmann equations in the hydrodynamic limit, provided that suitable mass ratios are assumed in this limit. We discuss the advantages and the limitations of this mesoscopic (that is, based on kinetic theory) approach.

Théophile Dolmaire

Affiliation: Université Paris Diderot

Title: From Newton to Boltzmann : Lanford's theorem in a domain with boundary condition

Abstract: One shall first introduce formally the Boltzmann equation, used to describe a diluted gas, presenting its elementary properties and its singular role in mathematical physics. Then, one will present a rigorous derivation of the Boltzmann equation from a microscopic description of the matter. In particular, after a brief presentation of the hypotheses chosen to describe the particles constituting the gas, one will focus on the main steps and the crucial results obtained by Lanford to complete this rigorous derivation, and finally present the difficulties arising in Lanford's proof when taking the boundary into account.

Isabelle Gallagher

Affiliation: Ecole Normale Supérieure de Paris

Title: Sur la dérivation de l'équation de Boltzmann : irréversibilité, et fluctuations

Abstract:

Il est connu depuis les travaux de Lanford de 1974 que dans la limite où le nombre de particules tend vers l'infini, dans un gaz raréfié, la distribution d'une particule vérifie

l'équation de Boltzmann, au moins pour un temps court. Dans cet exposé nous tenterons de justifier l'apparition de l'irréversibilité dans ce passage à la limite, et nous analyserons les fluctuations autour de cette limite. Il s'agit d'un travail en collaboration avec Thierry Bodineau, Laure Saint-Raymond et Sergio Simonella.

François Golse

Affiliation: Ecole Polytechnique

Title: Partial regularity in time for the Landau equation with Coulomb interaction

Abstract: The purpose of this talk is to 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. This result has been obtained in collaboration with Cyril Imbert, Maria Pia Gualdani and Alexis Vasseur and is discussed in detail in the preprint [arXiv:1906.02841 [math.AP]].

Seung-Yeal Ha

Affiliation: Department of Mathematical Sciences, SNU

Title: From bacteria aggregation to tensor aggregation

Abstract: In this talk, we briefly discuss four topics such as the universality of the collective dynamics, second-order Cucker-Smale flocking on Riemannian manifolds, a generalized aggregation model for the ensemble of rank-m tensors with the same size and it application to the consensus-based optimization algorithms. In our first story, we discuss universal triality relation between bacteria aggregation, Cucker-Smale flocking and Kuramoto synchronization. These three seemingly different phenomena can be integrated into a common nonlinear consesnsus framework. In our second story, we present a second-order Cucker-Smale modeling on Riemannian manifolds such as the unit circle, the unit sphere in R^2 and Poincare upper half plane model for hyperbolic geometry. In our third story, we introduce a new unified model for the ensemble of aggregation of tensors with the same rank and size. Finally, we also discuss an application of the first-order consensus model to the consensus-based optimization algorithm.

Daniel Han-Kwan

Affiliation: Ecole Polytechnique

Title: Asymptotic stability of homogeneous equilibria for screened Vlasov-Poisson systems

Abstract: We shall describe a recent alternative proof of the Landau Damping result on the whole space obtained by Bedrossian, Masmoudi and Mouhot. Our approach is based on the method of characteristics and on the derivation of pointwise in time dispersive estimates for the linearized equation. Joint work with T. Nguyen (Penn State) and F. Rousset (Orsay).

Hyung Ju Hwang

Affiliation: Department of Mathematics, POSTECH

Title: Deep Neural Network Approach to PDEs and Kinetic Fokker-Planck Equations

Abstract: In this talk, I will discuss approximated solutions of Differential Equations (DEs) using the Deep Neural Network (DNN). Furthermore, I will present an architecture that includes the process of finding model parameters through experimental data, the inverse problem. That is, a unified framework of DNN architecture that approximates an analytic solution and its model parameters simultaneously. Finally, I will show numerical experiments to validate the robustness of our simplistic DNN architecture for some partial differential equations including the kinetic Fokker-Planck equations.

Jin Woo Jang

Affiliation: IBS - Center for Geometry and Physics

Title: On an initial-boundary value problem for Landau's kinetic equation

Abstract: In this talk, I will introduce a recent development in the global well-posedness of the Landau equation (1936) in a general smooth bounded domain, which has been a long-outstanding open problem. This work proves the global stability of the Landau equation in an $L^\infty_{x,v}$ framework with the Coulombic potential in a general smooth bounded domain with the specular reflection boundary condition for initial perturbations of the Maxwellian equilibrium states. Our methods consist of the generalization of the well-posedness theory for the Fokker-Planck equation (HJV-2014, HJJ-2018) and the extension of the boundary value problem to a whole space problem, as well as the use of a recent extension of De Giorgi-Nash-Moser theory for the kinetic Fokker-Planck equations (GIMV-2016) and the Morrey estimates (BCM-1996) to further control the velocity derivatives, which ensures the uniqueness. This is a joint work with Y. Guo, H. J. Hwang, and Z. Ouyang.

In-Jee Jeong

Affiliation: Korea Institute for Advanced Study

Title: Ill-posedness of the Hall MHD system without resistivity

Abstract: We show that the incompressible Hall-MHD system without magnetic resistivity is ill-posed in the strongest sense of Hadamard; that is, there exist smooth initial data which do not have a smooth solution. To obtain this nonlinear result, we first consider the linearization around a special class of stationary magnetic fields and show that this linear equation is ill-posed. The proof is based on construction of "degenerating" approximate solutions and application of a generalized version of the energy identity. This is joint work with Sung-Jin Oh (UC Berkeley).

Jinwook Jung

Affiliation: Department of Mathematical Sciences, Seoul National University

Title: Asymptotic analysis for Vlasov-Fokker-Planck/compressible Navier-Stokes equations with a density-dependent viscosity

Abstract: In this talk, we study a hydrodynamic limit of a system of coupled kinetic and fluid equations under a strong local alignment force and a strong Brownian motion. More precisely, we consider the Vlasov-Fokker-Planck type equation and compressible Navier-Stokes equations with a density-dependent viscosity on the whole domain. Based on a relative entropy argument, by assuming the existence of weak solutions to that kinetic-fluid system, we rigorously derive a two-phase fluid model consisting of isothermal Euler equations and compressible Navier-Stokes equations with a density-dependent viscosity. This is a joint work with Prof. Young-Pil Choi(Yonsei University).

Doheon Kim

Affiliation: School of Mathematics, Korea Institute for Advanced Study

Title: BGK-type models for chemically reacting gas mixtures

Abstract: In this talk, I will introduce some BGK-type models describing chemically reacting gas mixtures, and address the boundary value problems for those models. Under fixed inflow boundary conditions, the existence and uniqueness of the mild solution is established. This is a joint work with Mr. Myeong Su Lee (Sungkyunkwan University) and Prof. Seok-Bae Yun (Sungkyunkwan University).

Hyunseok Kim

Affiliation: Department of Mathematics, Sogang University

Title: On local existence results for generalized MHD equations

Abstract: We consider generalized MHD equations with fractional diffusions $(-\Delta)^\alpha$, where $\alpha \geq 0$. Existence of local solutions (u, b) has been well-known for initial data (u_0, b_0) in Sobolev spaces H^s, if s is sufficiently large. The goal of the talk is to present local existence results for solutions (u, b) with initial data (u_0, b_0) in $H^{s_1} \times H^{s_2}$ of lower orders s_1 and/or s_2, which extend recent existence results by Fefferman, McCormick, Robinson, and Rodrigo(2014, 2017). This is a joint work with Yong Zhou at the Sun Yat-Sen University (Zhuhai), China.

Donghyun Lee

Affiliation: Department of Mathematics, POSTECH

Title: Regularity and asymptotic behavior of the Boltzmann equation with boundary condition

Abstract: The Boltzmann equation is a mathematical model for rarefied gas. In spite of long history for the study of the Boltzmann equation, many boundary problems are still open. This is mainly due to lack of regularity and low regularity approaches have been to introduced to study asymptotic behavior (convergence to equilibrium) for boundary problems. In this talk, we discuss recent results about local regularity and asymptotic behavior.

Xavier Lhebrard

Affiliation: Ecole Normale Supérieure de Rennes

Title: Positive and entropic scheme for nonconservative bitemperature Euler system with transverse magnetic field

Abstract: In this work we are interested in inertial confinement fusion. For this application, thermal equilibrium is not reached between electrons and ions. Moreover there exists self-induced magnetic fields which have an important role in the plasma dynamic. Thus we will start from a two species kinetic model coupled with Maxwell equations and obtain by hydrodynamic limit a new model of bifluid magnetohydrodynamic type. The model is nonlinear, hyperbolic and involves five variables (unknows): density, velocity, electronic temperature, ionic temperature and transverse magnetic field. Then we will explain how to develop a finite volume scheme by solving a relaxation system. The interest of this method, is that it is possible to show that there exists sufficient CFL condition to preserve positivity of densities and temperatures, and satisfy a discrete entropy inequality. Finally we will propose new challenging test cases and investigate robustness and accuracy of our scheme.

Sung-Jin Oh

Affiliation: Department of Mathematics, UC Berkeley, USA

Title: Wellposedness of the Hall-MHD equations without resistivity

Abstract: The Hall-MHD equations without resistivity exhibit strong illposedness near the trivial solution (see In-Jee Jeong's talk). Such a phenomenon motivates the topic of this talk, which is to give various geometric conditions that ensure wellposedness of the incompressible Hall-MHD equations without magnetic resistivity. In particular, the Hall-MHD equations are locally well-posed for sufficiently regular and decaying, but possibly large, perturbations of nonzero uniform magnetic fields, in striking contrast to the illposedness result above. This is joint work with In-Jee Jeong (KIAS).

Benoît Perthame

Affiliation: Laboratoire J.-L. Lions, Sorbonne-Université, CNRS, Université de Paris, Inria

Title: Bacterial movement by run and tumble: models, patterns, pathways, scales

Abstract: At the individual scale, bacteria as *E. coli* move by performing so-called run-and-tumble movements. This means that they alternate a jump (run phase) followed by fast re-organization phase (tumble) in which they decide of a new direction for run. For this reason, the population is described by a kinetic-Botlzmann equation of scattering type. Nonlinearity occurs when one takes into account chemotaxis, the release by the individual cells of a chemical in the environment and response by the population.

These models can explain experimental observations, fit precise measurements and sustain various scales. They also allow to derive, in the diffusion limit, macroscopic

models (at the population scale), as the Flux-Limited-Keller-Segel system, in opposition to the traditional Keller-Segel system, this model can sustain robust traveling bands as observed in Adler's famous experiment.

Furthermore, the modulation of the tumbles, can be understood using intracellular molecular pathways. Then, the kinetic-Boltzmann equation can be derived with a fast reaction scale. Long runs at the individual scale and abnormal diffusion at the population scale, can also be derived mathematically.

Delphine Salort

Affiliation: Sorbonne Université

Title: Qualitative properties on a Fokker-Planck equation in neurosciences

Abstract: We are going to present a PDE model that describe the evolution of a network of neurons that interact via their common statistical distribution. We will focus above all on qualitative and asymptotic properties of solutions describing convergence to a stationary state, blow up or synchronization phenomena. We will discuss the assumptions that are needed, on the coupling between the neurons and the intrinsic dynamic of neurons, to obtain complex patterns. This talk is based on collaborations with M. Caceres, J. A. Carrillo, K. Ikeda, B. Perthame, P. Roux, R. Schneider, D. Smets.

Ariane Trescases

Affiliation: CNRS & Université de Toulouse

Title: Cross-diffusion, repulsion and attraction

Abstract: In Population dynamics, reaction-cross diffusion systems model the evolution of populations of multiple species where the interactions betweens species affect the spreading of the individuals of each species. This effect can typically model repulsion, leading to segregation between species, but it can also model attraction. Mathematically, the cross-diffusion terms result in a strong coupling between the equations of the system. In this talk, I will address questions related to the existence of solutions, modeling, and an application to chemotaxis. This is a joint work with L. Desvillettes, Y. J. Kim and C. Yoon.

Seok-Bae Yun

Affiliation: Department of Mathematics, Sungkyunkwan University

Title: Stationary flows in a slab for the ellipsoidal BGK model with correct Prandtl number

Abstract: Ellipsoidal BGK model is a general version of the BGK model where the local Maxwellian is generalized to a ellipsoidal Gaussian with a Prandtl parameter ν so that the model can produce the correct transport coefficient in the Navier-Stokes limit. In this talk, we consider the existence and uniqueness of stationary solutions for ES-BGK model in a slab imposed with the mixed boundary conditions.

In the non-critical case $-1/2 < \nu < 1$, we estimate the temperature tensor using the equivalence relation with the temperature.

In the critical case, $\nu = -1/2$, where such equivalence relation breaks down, we utilize the fact that the size of bulk velocity in x direction can be controlled by the discrepancy of boundary flux, and estimates the difference between the total energy and the directional energy to estimate the temperature tensor, to bound the temperature tensor from below. This is a joint work with Stephane Brull.

Poster
Algebraic Geometry and Number Theory

SungSoon Kim

Affiliation: Université d'Amiens & Women's University (South Korea)

Title: Monomial bases for the primitive complex Shepard groups of rank three

Abstract: (With Dong-Il Lee) For the group algebra of each primitive non-Coxeter Shephard group of rank three, we construct a monomial basis and its explicit multiplication table. First, we construct a Grobner-Shirshov basis for the Shephard group of type L2. Then, since each of the groups of types L3 and M3 has a parabolic subgroup isomorphic to the group of type L2, by using the sets of minimal right coset representatives of L2 in L3 and M3, respectively, we apply the Grobner-Shirshov basis theory to find the monomial bases for the Shephard groups of rank three L3 and M3. From this, we obtain the operation tables between the elements in each of the groups respectively. Also we explicitly show that the group of type M3 has a subgroup of index 2 isomorphic to the group of type L3.

Poster
Partial Differential Equation And Applications

Benali Abdelkader

Affiliation: Université de Hassiba Benbouali chlef, Algérie

Title: Homotopy perturbation transform method for solving the partial and the time-fractional differential equations with variable coefficients

Abstract: In this paper, we present the exact solutions of the Parabolic-like equations and Hyperbolic-like equations with Variable Coefficients, by using Homotopy perturbation transform method (HPTM) Finally, we extend the results to the time-fractional differential equations.

Stéphane Ballac

Affiliation: Université de Rennes, CNRS, IRMAR

Title: Resonance computations in optical micro-resonators

Abstract: (With Monique Dauge, Zois Moitier) We are interested in the computation of resonance frequencies of two dimensional dielectric cavities—a component of optical micro-resonators—and more specifically in resonances corresponding to whispering gallery modes (WGM). WGM are optical waves with high polar mode index, circling around the cavity and almost perfectly guided by total internal reflection.

For a two dimensional dielectric micro-disk cavity where the optical index varies with the radial position (referred as graded index micro-resonators in the literature in optics), using a quantum mechanical analogy, we highlight three different behaviors for the WGM depending on the sign of a key parameter expressed as the ratio of the optical index value to its derivative at the cavity boundary. This results in three asymptotic expansions of the resonances for large polar mode index providing approximations of WGM in a simple and quick way.

These asymptotic expansions, very helpful as such in the study of WGM resonances, are also very useful in the numerical simulation of WGM in optical micro-resonators by the Finite Element Method since they provide an information on the localization of the resonances looked for in the spectrum of the matrix resulting from the Finite Element discretization.

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Nacéra Bouizem

Affiliation: Ecole Supérieur en Sciences Appliquées Tlemcen Algérie

Title: Mathematical Model of Leukemia with Imatinib Treatment

Abstract: In this presentation, we propose a mathematical model on leukemia disease more general than that F. Michor, more precisely we consider a system differential equations describing the evolution of normal, cancerous and resistant stem cells as well as normal, cancerous and resistant differentiated cells with imatinib treatment. We find sufficient conditions for existence, local stability and global stability of steady states

Fatima Dib

Affiliation: Superior School of Applied Sciences, Tlemcen, Algeria

Title: An Inverse Problem for a Time-Fractional Diffusion equation

Abstract: In this paper we study the linear heat equation

$$ {}^{c}D^{\alpha}_{0^+}u(x,t) + {}^{c}D^{\beta}_{0^+}u(x,t) - \varrho u_{xx}(x,t) = F(x,t), \quad (x,t) \in \Omega_T, $$

with initial and nonlocal boundary conditions,

$$\begin{aligned} u(x,0) &= \varphi(x), \quad x \in (0,1)\,, \\ u(0,t) &= u(1,t), \quad u_x(1,t) = 0, \quad t \in (0,T], \end{aligned}$$

where $\Omega_T = (0,1) \times (0,T]$, ϱ is a positive constant, ${}^cD^{\alpha}_{0+}$ and ${}^cD^{\beta}_{0+}$ stand for the Caputo fractional derivatives of order α and β, respectively, with $0 < \beta < \alpha < 1$ and $\varphi(x)$ is the initial temperature.

The inverse problem consists of determining a source term independent of the space variable, and the temperature distribution with an over-determining function of integral type.

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Xiaoming Fu

Affiliation: Université de Bordeaux

Title: Solutions integrated along the characteristics for multi-populations with nonlocal advection

Abstract: We consider the pattern formation for a co-culture system through a reaction-diffusion equation with nonlocal advection. We first prove the existence and uniqueness of solutions and the associated semi-flow properties. By employing the notion of solution integrated along the characteristics, we rigorously prove the segregation property of solutions. Furthermore, we construct an energy functional to investigate the asymptotic behavior of the solution. To resolve the lack of compactness of the positive orbit, we use the narrow convergence in the space of Young measures through which we obtain a description of the asymptotic behavior of solutions.

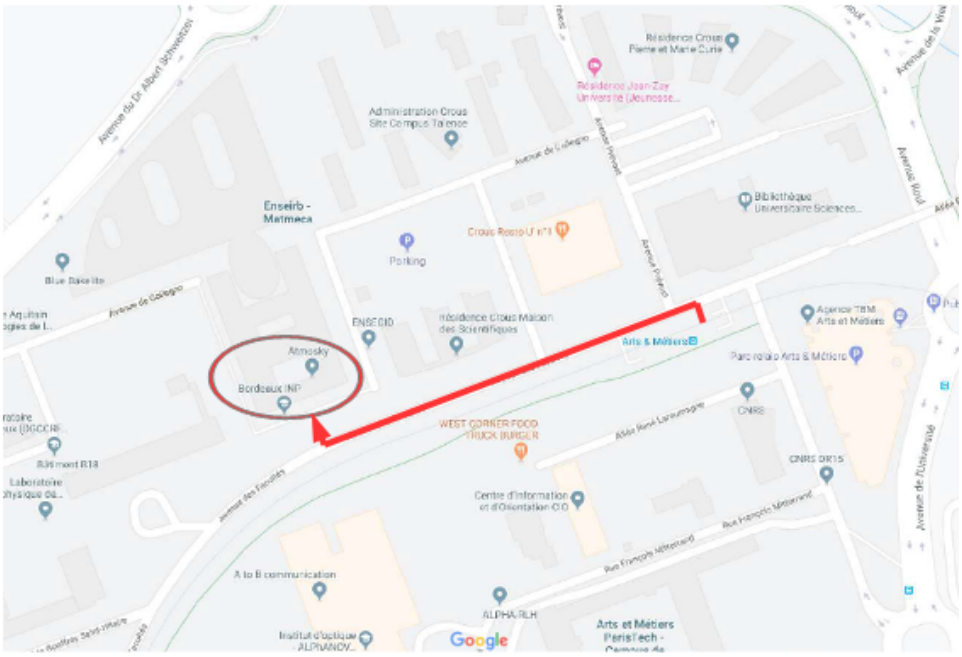
List of participants

Nacer Aarach	Université de Bordeaux	nacer.aarach@math.u-bordeaux.fr
Abhinandan	Université de Bordeaux	abhinandan.abhinandan@math.u-bordeaux.f
Denise Aregba-Driollet	Université de Bordeaux	aregba@math.u-bordeaux.fr
Marc Arnaudon	Université de Bordeaux	marc.arnaudon@math.u-bordeaux.fr
Valentin Ayot	Université de Bordeaux	val.ayot@gmail.com
Hyeong-Ohk Bae	Ajou University	hobae@ajou.ac.kr
Stéphane Balac	Université de Rennes	stephane.balac@univ-rennes1.fr
Aymeric Baradat	Max Planck Institute	aymeric.baradat@mis.mpg.de
Abdelkader Benali	Univ. de Hassiba Benbouali Chlef	benali4848@gmail.com
Nadia Benmabrouk	University of Sfax	nadiabenmabrouk09@gmail.com
Denis Benois	Université de Bordeaux	Denis.Benois@math.u-bordeaux.fr
Laurent Berger	Ecole Normale Supérieure de Lyon	laurent.berger@ens-lyon.fr
Gérard Besson	Université Grenoble ALpes	g.besson@ujf-grenoble.fr
Andrea Bondesan	Université Paris Descartes	andrea.bondesan@parisdescartes.fr
Jean-François Bony	Université de Bordeaux	Jean-Francois.Bony@math.u-bordeaux.fr
Nacera Bouizem	S. S. of App. Sci., Tlemcen, Algeria	nbouizem@yahoo.com
Christophe Breuil	Université Paris Sud	christophe.breuil@math.u-psud.fr
Marc Briant	Université Paris Descartes	briant.maths@gmail.com
Téphane Brull	Université de Bordeaux	Stephane.Brull@math.u-bordeaux.fr
Vincent Bruneau	Université de Bordeaux	Vincent.Bruneau@math.u-bordeaux.fr
Yann Bugeaud	Université de Strasbourg	yann.bugeaud@math.unistra.fr
Kleber Carrapatoso	Université de Montpellier	kleber.carrapatoso@polytechnique.edu
Dongho Chae	Chung-Ang University	dchae@cau.ac.kr
Fangyuan Chen	University of Bordeaux	fychen@mail.bnu.edu.cn
Seung-Yeon Cho	Sungkyunkwan University	chosy89@skku.edu
Yonghwa Cho	Korea Institute for Advanced Study	yhcho88@kias.re.kr
Insong Choe	Konkuk University	ischoe@konkuk.ac.kr
Dohoon Choi	Korea University	dohoon.choi@gmail.com
Junhwa Choi	Korea Institute for Advanced Study	jhchoi.math@gmail.com
YoungJu Choie	Postech	yjc@postech.ac.kr
Joachim Crevat	Université de Toulouse	Joachim.Crevat@math.univ-toulouse.fr
Jean-Marc Couveignes	Université de Bordeaux	jean-marc.couveignes@math.u-bordeaux.fr
Pierre Degond	Imperial College	p.degond@imperial.ac.uk
Laurent Desvillettes	Université Paris Diderot	desvillettes@math.univ-paris-diderot.fr
Fatima Dib	S. S. of App. Sci., Tlemcen, Algeria	fatimadib1967@yahoo.fr
Theophile Dolmaire	Université Paris Diderot	Theophile.DOLMAIRE@imj-prg.fr
Mathieu Dutour	Sorbonne Université	Mathieu.DUTOUR@imj-prg.fr
Gerard Freixas i Montplet	Sorbonne Université	gerard.freixas@imj-prg.fr
Jean Fresnel	Université de Bordeaux	jean.fresnel@math.u-bordeaux.fr
Xiaoming Fu	Université de Bordeaux	xiaoming.fu@math.u-bordeaux.fr
Jean-Philippe Furter	Université de Bordeaux	jpfurter@univ-lr.fr
Isabelle Gallagher	Ecole Normale Supérieure de Paris	gallagher@math.ens.fr
Najwa Ghannoum	Université Cote d'Azur	Najwa.Ghannoum@unice.fr
Carlo Gasbarri	Université de Strasbourg	gasbarri@math.unistra.fr
François Golse	Ecole polytechnique	francois.golse@polytechnique.edu
Seung Yeal Ha	Seoul National University	syha@snu.ac.kr
Mohammed Halimi	CRTI Cheraga Algiers	halimi_md@yahoo.fr
Daniel Han-Kwan	Ecole polytechnique	daniel.han-kwan@polytechnique.edu
Alain Hénaut	Université de Bordeaux	Alain.Henaut@math.u-bordeaux.fr
Hyung Ju Hwang	Postech	hjhwang@postech.ac.kr

Bo-Hae Im	KAIST	bhim@kaist.ac.kr
Jin Woo Jang	IBS-CGP	jangjinw@ibs.re.kr
Pedro Jaramillo Aguayo	Université de Bordeaux	pedro.jaramillo@math.u-bordeaux.fr
In-Jee Jeong	Korea Institute for Advanced Study	ijeong@kias.re.kr
Jinwook Jung	Seoul National University	warp100@snu.ac.kr
Florent Jouve	Université de Bordeaux	florent.jouve@math.u-bordeaux.fr
Karim Kellay	Université de Bordeaux	Karim.Kellay@math.u-bordeaux.fr
Jonghae Keum	Korea Institute for Advanced Study	jhkeum@kias.re.kr
Jean Kieffer	Université de Bordeaux	jean.kieffer@math.u-bordeaux.fr
Doheon Kim	Korea Institute for Advanced Study	doheonkim@kias.re.kr
Dohyeong Kim	Seoul National University	polygon0307@gmail.com
Hyunseok Kim	Sogang University	kimh@sogang.ac.kr
Sung Soon Kim	Université de Picardie	sungsoon.kim@u-picardie.fr
Vincent Koziarz	Université de Bordeaux	Vincent.Koziarz@math.u-bordeaux.fr
Stanislas Kupin	Université de Bordeaux	Stanislas.Kupin@math.u-bordeaux.fr
Sijong Kwak	KAIST	sjkwak@kaist.ac.kr
David Lannes	Université de Bordeaux	David.Lannes@math.u-bordeaux.fr
Kévin Le Balc'h	Université de Bordeaux	kevin.le-balch@math.u-bordeaux.fr
Donghhyun Lee	Postech	donglee@postech.ac.kr
Seul Bee Lee	Seoul National University	sulbiii89@gmail.com
Xavier Lhebrard	Université Paris-Est-Marne-la-Vallée	xavier.lhebrard@gmail.com
Julien Mathiaud	Bordeaux IPB	julien.mathiaud@u-bordeaux.fr
Michel Matignon	Université de Bordeaux	Michel.Matignon@math.u-bordeaux.fr
Laurent Michel	Université de Bordeaux	laurent.michel@math.u-bordeaux.fr
Luc Mieussens	Université de Bordeaux	Luc.Mieussens@math.u-bordeaux.fr
Antoine Mondoloni	Académie de Bordeaux	mondolonia@hotmail.fr
Stefano Morra	Université de Paris Saint-Denis	morra@math.univ-paris13.fr
Tuan Ngo Dac	Université de Lyon	ngodac@math.univ-lyon1.fr
Duc-Manh Nguyen	Université de Bordeaux	Duc-manh.Nguyen@math.u-bordeaux.fr
Sung-Jin Oh	UC-Berkeley	sjoh@kias.re.kr
Marius Paicu	Université de Bordeaux	Marius.Paicu@math.u-bordeaux.fr
Chol Park	Ulsan Nat. Inst. of Sci. and Tech.	cpark@kias.re.kr
Euisung Park	Korea University	euisungpark@korea.ac.kr
Hyeonjun Park	Seoul National University	hyeonjun93@snu.ac.kr
Jihun Park	IBS-CGP Postech	wlog@postech.ac.kr
Jun Yong Park	IBS-CGP Postech	junepark@ibs.re.kr
Benoit Perthame	Sorbonne Université	Benoit.Perthame@sorbonne-universite.fr
Teddy Pichard	Ecole Polytechnique	teddy.pichard@polytechnique.edu
Clair Poignard	Université de Bordeaux	clair.poignard@inria.fr
Nicolas Popoff	Université de Bordeaux	nicolas.popoff@math.u-bordeaux.fr
Delphine Salort	Sorbonne Université	dsalort@gmail.com
Frank Sueur	Université de Bordeaux	franck.sueur@math.u-bordeaux.fr
Philippe Thieullen	Université de Bordeaux	Philippe.Thieullen@math.u-bordeaux.fr
Ariane Trescases	Université de Toulouse	ariane.trescases@math.univ-toulouse.fr
Emanuele Tron	Université de Bordeaux	emanuele.tron@math.u-bordeaux.fr
Claire Voisin	Collège de France	claire.voisin@college-de-france.fr
Jian Wang	Université Grenoble Alpes	jian.wang1@univ-grenoble-alpes.fr
Myungiun Yu	Korea Institut for Advanced Study	mjyu@kias.re.kr
Seok-Bae Yun	Sungkyunkwan	sbyun01@skku.edu
Ning Zhu	Beijing Normal University	ningzhu@mail.bnu.edu.cn
Dimitri Zvonkine	Université de Versailles	dimitri.zvonkine@uvsq.fr

Practical information

How to get to Bordeaux INP from the tram B (stop: Arts et Métiers):



How to get to the Institute of Mathematics from the tram B (stop: Forum)