ICMP Contributed Talks 1
Communications libres ICMP 1

IMANE BOUSSETOUAN, Ecole Supérieure de Technologies Industrielles, Annaba, Algeria
Existence and approximation for non-isothermal fluid flows with Tresca's friction and Cattaneo's heat law

Motivated by lubrication and extrusion phenomena, we consider a two dimensional non-isothermal incompressible fluid flow involving heat transfer and friction. We model heat conduction with Cattaneo's law instead of the commonly used Fourier's law, in order to overcome the physical paradox of infinite propagation speed. We assume a strong coupling due to temperature dependent viscosity and velocity dependent heat capacity. The problem is thus described by a Navier-Stokes system with Tresca's friction law on a part of the boundary, coupled with the hyperbolic heat equation. By using a time-splitting technique, we construct a sequence of decoupled approximate problems and we prove the convergence of the corresponding approximate solutions, leading to an existence theorem for the coupled fluid flow/heat transfer problem. Finally, we present some numerical tests to illustrate our theorical results.

CLAUDIO DAPPIAGGI, University of Pavia
On the canoncial commutation relations for the wave operator on static Lorentzian manifolds with timelike boundary

We consider the wave operator on static, Lorentzian manifolds with timelike boundary. The quantization of the underlying field theory is based on the identification of the commutation relations in terms of advanced and retarded fundamental solutions. Since the manifold has a non empty boundary their existence is not guaranteed a priori and it must be discussed in terms of boundary conditions. By means of spectral calculus we prove that answering this question is equivalent to studying the self-adjoint extensions of an associated elliptic operator on a Riemannian manifold with boundary (M, g), assumed to be of bounded geometry. This problem can be tackled within the framework of boundary triples. These consist of the assignment of two surjective, trace operators from the domain of the adjoint of the elliptic operator into an auxiliary Hilbert space h, which is the third datum of the triple. Self-adjoint extensions of the underlying elliptic operator are in one-to-one correspondence with self-adjoint operators Θ on h. On the one hand, we show that, for a natural choice of boundary triple, each Θ can be interpreted as the assignment of a boundary condition for the original wave operator. On the other hand, we prove that, for each such Θ, there exists a unique advanced and retarded fundamental solution. In addition, we prove that these share the same structural property of the counterparts associated to the wave operator on a globally hyperbolic spacetime. This is joint work with Nicolò Drago and Hugo Ferreira, based on 1804.03434 [math-ph]

MARKUS B FRÖB, University of York, UK
Anomalous Ward identities in the BV-BRST formulation of quantum gauge theories

We show that every (graded) derivation on the algebra of free quantum fields and their Wick powers in curved spacetimes gives rise to a set of anomalous Ward identities for time-ordered products, with an explicit formula for their classical limit. We study these identities for the Koszul–Tate and the full BRST differential in the BV–BRST formulation of perturbatively interacting quantum gauge theories, and show that the quantum BRST differential, the quantum antibracket and the higher-order anomalies form an L_∞ algebra. The defining relations of this algebra ensure that the gauge structure is well-defined on cohomology classes of the quantum BRST operator, i.e., on the interacting observables. Furthermore, we show that one can determine contact terms such that also the interacting time-ordered products of multiple interacting fields are well defined on cohomology classes. The talk is based on arXiv:1803.10235.

FELIX HÄNLE, Ludwig-Maximilians University Munich, Mathematical Institute
Relation between the Resonance and the Scattering Matrix in the massless Spin-Boson Model

We establish the precise relation between the integral kernel of the scattering matrix and the resonance in the massless Spin-Boson model which describes the interaction of a two-level quantum system with a second-quantized scalar field. For this purpose, we derive an explicit formula for the two-body scattering matrix. We impose an ultraviolet cut-off and assume a slightly less singular behavior of the boson form factor of the relativistic scalar field but no infrared cut-off. The purpose of this work is to bring together scattering and resonance theory and it is inspired by a similar result as provided by B. Simon (published in the Annals of Mathematics, 1973), where it was shown that the singularities of the meromorphic continuation of the integral kernel of the scattering matrix are located precisely at the resonance energies. The corresponding problem has been open in quantum field theory ever since. To the best of our knowledge, the presented formula provides the first rigorous connection between resonance and scattering theory in the sense of Simon's result in a model of quantum field theory.

ROBERTA ANNA ISEPPI, Centre for Quantum Geometry of Moduli spaces, Aarhus University
The Batalin-Vilkovisky construction: a noncommutative geometric approach

The *BRST cohomology complex*, discovered by Becchi, Rouet, Stora and Tyutin in 1975, plays a very important role in facing the problem of quantizing non-abelian gauge theories via the path integral approach. Indeed, this quantization procedure fails when applied to gauge theories, where the presence of local symmetries causes the degeneracy of the propagator. This problem is overcame by introducing extra (non-physical) fields, called *ghost-fields*, and defining the so-called BRST cohomology complex. It is precisely this cohomology complex that allows the recovery of important information on the theory, such as its set of observables or its renormalizability. Despite of its relevance in the context of quantum fields theory, this cohomology still deserves to be fully understood from a mathematical/geometrical point of view.

A very promising approach to reach this goal is to try to insert the BRST cohomology (constructed following the Batalin-Vilkovisky (BV) approach) in the framework given by *Noncommutative Geometry*. In this talk I will consider U(n)-gauge theories naturally induced by finite spectral triples and show how, by introducing the notion of *BV-spectral triple*, all the properties of the BV-extended theory, such as its bosonic/fermionic content, can have a (noncommutative) geometric interpretation.

YULIA MESHKOVA, Chebyshev Laboratory, St. Petersburg State University
Operator error estimates for homogenization of periodic hyperbolic systems

In $L_2(\mathbb{R}^d;\mathbb{C}^n)$, we consider a matrix elliptic second order differential operator $A_\varepsilon = A_\varepsilon^* \geqslant 0$ given in a factorized form. The coefficients of the operator A_ε are periodic and depend on $\mathbf{x}/\varepsilon$, $0 < \varepsilon \leqslant 1$. So, they oscillate rapidly as $\varepsilon \to 0$.

First result is the estimate

$$\|A_\varepsilon^{-1/2}\sin(tA_\varepsilon^{1/2}) - (A^0)^{-1/2}\sin(t(A^0)^{1/2})\|_{H^1(\mathbb{R}^d)\to L_2(\mathbb{R}^d)} \leqslant C_1\varepsilon(1+|t|).$$

Here A^0 is the effective operator with constant coefficients. The main result is approximation with the corrector $K(\varepsilon;t)$:

$$\|A_\varepsilon^{-1/2}\sin(tA_\varepsilon^{1/2}) - (A^0)^{-1/2}\sin(t(A^0)^{1/2}) - \varepsilon K(\varepsilon;t)\|_{H^2(\mathbb{R}^d)\to H^1(\mathbb{R}^d)} \leqslant C_2\varepsilon(1+|t|).$$

The constants C_1 and C_2 are controlled explicitly. The results of this type are called operator error estimates.

Results are applied to homogenization of periodic hyperbolic systems

$$\begin{cases} \partial_t^2 \mathbf{u}_\varepsilon(\mathbf{x},t) = -A_\varepsilon \mathbf{u}_\varepsilon(\mathbf{x},t), \quad \mathbf{x}\in\mathbb{R}^d,\ t\in\mathbb{R}; \\ \mathbf{u}_\varepsilon(\mathbf{x},0) = 0, \quad (\partial_t \mathbf{u}_\varepsilon)(\mathbf{x},0) = \boldsymbol{\psi}(\mathbf{x}), \quad \mathbf{x}\in\mathbb{R}^d, \end{cases}$$

where $\boldsymbol{\psi} \in H^1(\mathbb{R}^d;\mathbb{C}^n)$ or $\boldsymbol{\psi} \in H^2(\mathbb{R}^d;\mathbb{C}^n)$. Then $\mathbf{u}_\varepsilon(\cdot,t) = A_\varepsilon^{-1/2}\sin(tA_\varepsilon^{1/2})\boldsymbol{\psi}$ and

$$\|\mathbf{u}_\varepsilon(\cdot,t) - \mathbf{u}_0(\cdot,t)\|_{L_2(\mathbb{R}^d)} \leqslant C_1\varepsilon(1+|t|)\|\boldsymbol{\psi}\|_{H^1(\mathbb{R}^d)},$$
$$\|\mathbf{u}_\varepsilon(\cdot,t) - \mathbf{v}_\varepsilon(\cdot,t)\|_{H^1(\mathbb{R}^d)} \leqslant C_2\varepsilon(1+|t|)\|\boldsymbol{\psi}\|_{H^2(\mathbb{R}^d)}.$$

Here $\mathbf{u}_0$ is the solution of the effective problem and $\mathbf{v}_\varepsilon = \mathbf{u}_0 + \varepsilon K(\varepsilon;t)\boldsymbol{\psi}$ is the first order approximation.

We use the spectral approach to homogenization problems developed by M. Sh. Birman and T. A. Suslina. The method is based on the scaling transformation, the Floquet-Bloch theory and analytic perturbation theory. It turns out that homogenization is a spectral threshold effect at the bottom of the spectrum.

More details: arXiv:1705.02531.

The research was supported by project of RSF no. 17-11-01069.

TIMOTHÉ POULAIN, Université Paris-Sud 11
One-loop order quantum properties for κ-Poincaré invariant scalar field thories with KMS weight.

It is widely believed that the classical notion of space-time is no longer adequate at the Planck scale to reconcile gravity with quantum mechanics. One possible attempt to reach this goal comprises to trade the continuous smooth manifold describing the space-time by a non-commutative space. In this spirit, κ-Minkowski appears to be one of the most studied (Lie algebra type) non-commutative space and is sometimes regarded as a promising candidate to be involved in the description of quantum gravity models.

Although the classical properties of κ-Minkowski have been extensively studied in the literature, almost nothing have been done in the study of its quantum properties.

I will talk about my latest results in that direction presenting the computation of the one-loop 2-point and 4-point functions for various classes of κ-Poincaré invariant scalar field theories with quartic interactions whose commutative limit coincides with the usual ϕ^4 theory. The computations are performed using a star product obtained from mere adaptation of the Weyl quantisation scheme. I will show that the κ-Poincaré invariance forces the integral involved in the action to be a twisted trace, thus defining a KMS weight for the non-commutative C^*-algebra modeling κ-Minkowski. In all the field theories, the twist generates different planar one-loop contributions to the 2-point function which are at most UV linearly diverging and the one-loop quantum corrections to the 4-point function appears to be finite. In other models, UV/IR mixing shows up in non-planar contributions at exceptional zero external momenta while staying finite otherwise.

PETAR SIMIDZIJA, University of Waterloo
Information carrying capacity of a cosmological constant

A question of fundamental importance in Relativistic Quantum Information asks what is the information carrying capacity of a quantum field. Previous studies have discussed that in curved spacetimes and in particular in cosmology, information flows decouple from energy flows. Remarkably, these studies show that information can travel in massless fields between timelike separated observers. In other words, the propagation of light signals leaves a timelike echo in the entire future lightcone of the emitter. In this setting we can imagine ourselves to be Bob, a late observer in an expanding de Sitter Universe attempting to retrieve information that was imprinted in a massless quantum field by an early time emitter Alice in our timelike past. We will show that, contrary to intuition, the faster the exponential expansion of the Universe the more information Alice can send Bob through a timelike communication channel via the quantum field. Even more remarkably, we will see that the channel capacity does not decay with Alice and Bob's spatial or temporal separations, in contrast with i) the capacity of conventional lightlike channels (suggesting that it is possible to gather information about the early Universe from timelike signals with much greater efficiency than by pointing our telescopes to distant light signals) and ii) with the timelike channel capacity in slower, polynomially-expanding cosmologies. I will try to convince you that if we wait a billion years before reading Alice's message, we could (in principle) recover the same amount of information as if we read the message today.

ALEXANDER STOTTMEISTER, Università degli Studi di Roma "Tor Vergata"
Gauge theory, lattices, and operator algebras

We present an operator-algebraic approach to gauge theory via projective systems of lattices. As an instructive example, we discuss Yang-Mills theory in two dimensions (YM_2) on a spacetime cylinder $\mathbb{R} \times S^1$. We explicitly construct the spatially-localized algebras of time-zero fields in the time gauge. Moreover, we obtain an associated 1-parameter family of gauge-invariant states arising via the Kogut-Susskind prescription for the Hamiltonian. By implementing gauge invariance in the field algebra, we recover the expected results for YM_2. Our work complements existing results in the literature (notably by Witten, Sengupta et al., Dimock, Hall and King, Ashtekar et al., Balaban et al.). Furthermore, we relate our approach to a recent construction of unitary representations of Thompson's groups by Jones.

This talk is based on work done with Arnaud Brothier.

MICHAŁ WROCHNA, Université Grenoble Alpes

The holographic Reeh-Schlieder property

Non-interacting quantum fields have good properties at the conformal boundary of Anti-de Sitter spacetimes if their n-point functions satisfy a holographic version of the celebrated Hadamard condition. I will briefly report on the following consequence: it is possible to reconstruct the whole Hilbert space by acting on the vacuum vector with observables supported on the boundary, thus giving rise to what one could call a holographic Reeh-Schlieder theorem (partially based on joint work with Maximilian Duell and Wojciech Dybalski).

SVETOSLAV ZAHARIEV, City University of New York

Infinite volume limits in Euclidean quantum field theory via stereographic projection

I shall present a general scaling limit construction of probability measures obeying the Glimm-Jaffe axioms of Euclidean quantum field theory in arbitrary space-time dimension in which the ultraviolet and the infrared (infinite volume) limits are obtained simultaneously. Given a sequence of mollifiers on the standard sphere and a sequence of functionals defined on smooth functions that satisfy simple integral bounds, one defines a sequence of measures on smooth functions on the sphere. These measures are then transferred to smooth functions on Euclidean space via a scaling limit procedure utilizing the stereographic projection and one shows that the transferred sequence contains a subsequence weakly convergent on distributions.

A particular example of the above construction is obtained by taking a uniformly bounded sequence of densities arising from an arbitrary real continuous function (representing a self-interaction of a scalar field) and an appropriate sequence of coupling constants. One expects that in many special cases the limit measures so obtained coincide with the free scalar field measure, however I shall also discuss the possibility of constructing non-uniformly bounded densities that have a better chance for producing non-Gaussian models.

This talk is largely based on my preprint "On scaling limits in Euclidean quantum field theory" available at arxiv.org/abs/1701.05569.