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C*-ALGEBREN

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The meeting was organised by Dietmar Bisch (Santa Barbara), Eberhard Kirchberg (Berlin) and Georges Skandalis (Paris).

As in previous years, many top mathematicians from about a dozen different countries (including Canada, Denmark, France, Germany, Great Britain, Italy, Japan, Norway, USA) participated in this year's C*-Algebren meeting. The program consisted of a good mixture of talks by recent Ph.D.'s and talks by more established mathematicians. It was the intention of the organisers to give young researchers an opportunity to present their latest results at this meeting. At the same time plenty of time was made available for mathematical discussions.

The talks at the conference covered all important research directions within operator algebras. The latest results in the theory of subfactors, free probability theory, non-commutative topology and non-commutative geometry (e.g. related to the Baum-Connes conjecture), operator space theory, the theory of non-commutative dynamical systems, the classification theory of C*-algebras and applications of operator algebraic methods to theoretical physics were presented. This year more talks were selected in the area of non-commutative topology/geometry and the classification of C*-algebras, whereas the emphasis at the last C*-Algebren meeting in 1998 was on subfactors and free probability theory.

In recent years the theory of operator algebras has developed into one of the most important areas of modern mathematics. Non-commutative methods have had spectacular applications to several areas of mathematics and theoretical physics and continue to be used towards the solution of long-standing problems. The program of this conference featured talks on all recent developments in the different sub-areas of operator algebras.

The abstracts below appear in the order in which the talks were presented.

Abstracts

Non Hausdorff groupoids, proper actions and K-Theory

Jean-Louis Tu, Paris, France

(Joint work with P. Y. Le Gall) Let G be a locally compact groupoid with Haar system. If G is Hausdorff, it is known that the K-theory of $C_r^*(G)$ can be studied using the Baum-Connes assembly map. Here we study the non-Hausdorff case. We first introduce a notion of proper (non Hausdorff) groupoid which is invariant under Morita-equivalence, and of proper action of a groupoid. We show that a generalized homomorphism from G to G' satisfying certain conditions induces an element of $KK(C_r^*(G'), C_r^*(G))$. Then, in order to work with actions on non Hausdorff manifolds, we introduce the notion of action by Morita-equivalences. The construction of the KK_G groups is currently in process.

A proof of the general Connes-Kasparov conjecture

Siegfried Echterhoff, Münster, Germany

We explain the main points of the proof of the general Connes-Kasparov conjecture for almost connected groups (joint work with Jérome Chabert and Ryszard Nest). This means: We show that for all almost connected groups the Baum-Connes assembly map with trivial coefficients between the topological K-theory of G and $\mathrm{KK}_*(C_r^*(G))$ is an isomorphism. Under some mild conditions on the group G, this implies that the K-theory of $C_r^*(G)$ is isomorphic (up to a dimension shift) to the representation ring of the maximal compact subgroup of G.

Covering dimension for C*-algebras

Wilhelm Winter, Münster, Germany

We introduce the homogeneous rank and the decomposition rank (joint work with E. Kirchberg), both notions of covering dimension for nuclear C^*-algebras and analyze some of their properties. Both theories behave nicely with respect to direct sums, quotients, ideals and inductive limits. For abelian C^*-algebras they coincide with covering dimension of the spectrum and there are similar results for continuous trace C*-algebras.

As it turns out, a C^*-algebra is zero-dimensional precisely if it is AF. We consider various examples, like the irrational rotation algebras, the Bunce-Deddens algebras, Blackadar's simple unital projectionless C^*-algebra and C^*-algebras of minimal diffeomorphisms. Finally, we outline how the decomposition rank is related to the concept of (inner) quasidiagonality.

Some new results on orbit equivalence of $\mathbb{Z}^2$ actions on Cantor sets

Christian Skau, Trondheim, Norway

We introduce the notion of an affable (AF-able) equivalence relation on a Cantor set. Then we prove a crucial lemma that can be used to show that certain etale equivalence relations are affable. This in turn can be used, together with so-called positive cocycle, to show that certain minimal $\mathbb{Z}^2$ actions are orbit equivalent to a Cantor minimal system, i.e. to a minimal $\mathbb{Z}$ action. The grand goal is to extend this result to a minimal action of a countable amenable group. Our work is the topological analogue of a celebrated result by Connes, Feldman and Weiss in the measurable setting. This is joint work with I. Putnam and Thierry Giordano.

K-theory for crossed products of the Cantor set by free minimal actions of $\mathbb{Z}^d$

N. Christopher Phillips, Eugene, USA

Let $\mathbb{Z}^d$ act freely and minimally on the Cantor set X, and let $A = C^*(\mathbb{Z}^d, X)$ be the crossed product C*-algebra. In a recent paper in Commun. Math. Phys., Ian Putnam considered the special case in which the action arises from a substitution tiling system satisfying the finite pattern condition, and proved that the order on $K_0(A)$ is determined by traces. That is, an element of $K_0(A)$ is positive whenever its images under the maps determined by all the tracial states are strictly positive. We show that this result holds for arbitrary free minimal actions of $\mathbb{Z}^d$ on the Cantor set. We also prove, in the same generality, that the crossed product has stable rank one and real rank zero.

The invariant subspace problem relative to a von Neumann factor of type II_1

Uffe Haagerup, Odense, Denmark

The invariant subspace problem relative to a von Neumann algebra M on a Hilbert space H can be formulated in the following way: Does every operator T in M have a non-trivial closed invariant subspace E affiliated with M (i.e. of the form $E = P(H)$ for a projection P in M)?

Recently we have shown, that under the assumption that M is embeddable in an ultrapower R^ω of the hyperfinite II_1 factor (which might well be true for all II_1 factors) one can to EVERY operator T in M and EVERY Borel set in the complex plane associate a closed T-invariant subspace $E(T, B)$ of H affiliated with M.

In comparison with the classical Apostol-Foias decomposition theory, the key new idea is to replace the spectrum of an operator with L.G. Brown's spectral distribution measure

$\mu(T)$, and the space $E(T,B)$ we construct is the unique closed T-invariant subspace affiliated with M, which "cut" the Brown measure $\mu(T)$ into a part concentrated on B and another part concentrated on the complement $\mathbb{C}\backslash\mathbb{B}$.

This shows in particular, that unless $\mu(T)$ is concentrated in a single point, T has a non-trivial closed invariant subspace affiliated with M.

DT–operators

Ken Dykema, College Station, USA

The DT-operators are introduced as elements in a tracial von Neumann algebra whose $*$-moments are given as the large-n limit of certain upper triangular random matrices. Voiculescu's circular operator is an example of a DT-operator. By considering spectral subspaces, we show that every DT-operator is decomposable in the sense of Foias. Finally, we discuss recent combinatorial results about $*$-moments of the quasi-nilpotent DT-operator.

Representation theory of Popa algebras

Nate Brown, Mount Pleasant, USA

We study approximation properties for traces on unital, separable C*-algebras. We observe that hyperfiniteness of (tracial) GNS representations is completely determined by the approximation properties of the trace. We then use these tracial invariants and some fairly standard inductive limit techniques to construct new examples of simple C*-algebras. For example, we construct a simple, exact, quasidiagonal C*-algebra with real rank zero but which has non-hyperfinite II$_1$ factor representations. Finally we observe that these techniques lead to a new characterization of those McDuff factors which are embeddable into the ultrapower of the hyperfinite II$_1$ factor.

Operator algebraic analysis of solvable lattice models

Antony Wassermann, Marseille, France

In 1980 Baxter introduced the corner transfer matrix technique for studying solvable lattice models such as the 8-vertex model and its generalizations (Andrews-Baxter-Forrester models). Baxter predicted that the corner transfer matrix Hamiltonian, which depends on a real parameter q, should have finite multiplicity spectrum lying in $\{0,1,2,\dots\}$ and independent of q. We formulate Baxter's problem in terms of unbounded derivations of AF algebras of local observables. We prove a uniqueness result for ground states of these dynamical systems which roughly states that there are unique analytic continuations from ground states at $q = 0$. These have a very simple "crystal" structure allowing one to explicitly construct all the finitely many ground states. On the other hand, by realising the AF algebra of local observables using products of vertex operators of quantum affine algebras (introduced by the Kyoto school of Jimba, Miwa, Kashiwara et al), one can show that the dynamical systems are all periodic and can explicitly write down an analytic family of ground states, thus proving Baxter's conjecture.

Longitudinal noncommutative residue for foliations
Stéphane Vassout, Paris-Rome, France-Italy

We explain the construction of a Wodzicki residue for longitudinal operators along the leaves of a compact measured foliation. The construction of this residue includes the development of complex powers for elliptic operators in the framework of Hilbert C*-module theory, strengthening the noncommutative approach of Connes to these operators. We also propose a construction of a Sobolev scale of Hilbert C*-modules which fits well the previous interpretation. Finally we study the properties of the longitudinal noncommutative residue, and we propose to complete the definition given by Benameur and Fack of a von Neumann spectral triple, possibly to reach a local formula for the indices in the von Neumann framework.

Some results on the ideal property
Cornel Pasnicu, San Juan, Puerto Rico

Jointly with M. Rørdam, we prove that the minimal tensor product of two C*-algebras with the ideal property (i.e. each ideal is generated by projections) does not necessarily have the ideal property (J. Funct. Anl.). The proof relies heavily on two theorems of E. Kirchberg and also on a construction of M. Dadarlat and uses in a "surprising" way homotopy theory (shape theory). Jointly with G. Gong and L. Li we prove, in particular, that each AH algebra A with the ideal property and with uniformly bounded dimensions of the local spectra can be written as an AH algebra with special local spectra of dimensions not larger than 3. This generalizes a theorem of G. Gong when A is simple and also a theorem of M. Dadarlat and G. Gong when A has real rank zero. I generalize also some of my results on the ideal property and ideal structure for AH algebras to more general C*-algebras, called LB algebras (which have "good" local approximation properties). I generalize also a result of L. Brown and M. Dadarlat involving quasidiagonal extensions.

Grothendieck's theorem for operator spaces

Gilles Pisier, Paris, France

We prove several versions of Grothendieck's Theorem for completely bounded (c.b.) linear maps $T\colon\ E \to F^*$, when E and F are operator spaces. We prove that if E, F are C^*-algebras, of which at least one is exact, then every completely bounded $T\colon\ E \to F^*$ can be factorized through the direct sum of the row and column Hilbert operator spaces. Equivalently T can be decomposed as $T = T_r + T_c$ where T_r (resp. T_c) factors completely boundedly through a row (resp. column) Hilbert operator space. This settles positively (at least partially) some earlier conjectures of Effros-Ruan and Blecher on the factorization of completely bounded bilinear forms on C^*-algebras. Moreover, our result holds more generally for any pair E, F of "exact" operator spaces. As a corollary we prove that, up to a complete isomorphism, the row and column Hilbert operator spaces and their direct sums are the only operator spaces E such that both E and its dual E^* are exact.

Finally we illustrate these results with Schur multipliers as follows: Let S_1 be the space of trace class matrices $x = (x_{ij})$ with norm $\|x\|_1 = tr(|x|)$ and equipped with the operator space structure dual to that of $K(l_2)$. Let $M_\varphi : B(l_2) \to S_1$ be a Schur multiplier of the form $(x_{ij}) \to (\varphi(i,j)x_{ij})$. Then: i) $M_\varphi : B(l_2) \to S_1$ is c.b. iff there are x, y in l_2 such that $|\varphi(i,j)| \le |x_i y_j|$ for all i, j. ii) M_φ is bounded iff φ admits a decomposition as $\varphi(i,j) = a(i,j) + b(i,j)$ with $\sum_i \sup_j |a(i,j)| + \sum_j \sup_i |b(i,j)| < \infty$. Note that (ii) does not imply (i). (Joint paper with D. Shlyakhtenko. The paper can be obtained at the Los Alamos preprint server http/xxx.lanl.gov/math.OA/0108205.)

Square integrable representations, lattices and von Neumann dimension

Bachir Bekka, Metz, France

Let Γ be a discrete subgroup of the locally compact group G. If π is a square integrable irreducible unitary representation of G, then H_π is a module over $VN(\Gamma)$, the von Neumann algebra generated by the left regular representation of Γ. As such, H_π has a von Neumann dimension, given by the Atiyah-Schmid formula, $\dim_{VN(\Gamma)} H = d_\pi vol(G/\Gamma)$, where d_π is the formal dimension of π and $vol(G/\Gamma)$ is the volume of a fundamental domain of G.

In case Γ is not an ICC group, $VN(\Gamma)$ is not a factor and the von Neumann dimension is not a complete invariant for the modules over $VN(\Gamma)$. One has instead to consider the centre valued (or extended) von Neumann dimension $c\dim_{VN(\Gamma)} H$ which is defined in terms of the canonical centre valued trace on $VN(\Gamma)$. We give an explicit formula for $c\dim_{VN(\Gamma)} H_\pi$ where π is as above. The result is valid for square integrable representations which are square integrable modulo the centre of G. In this case, H_π is a module over $VN(\Gamma, \chi)$, the von Neumann algebra of Γ twisted by a character χ of the centre of Γ. Explicit computation are given in case G is the Heisenberg group.

Bivariant homology theories on the category of separable C*-algebras
Andreas Thom, Münster, Germany

We consider stable homotopy theory as the universal bivariant homotopy theory. Several constructions are introduced, producing new bivariant theories out of old ones. A generalization of connective K-theory and homology with coefficients in $\mathbb{Z}$ is given.

An application of expanders to $\mathbb{B}(\ell_2) \otimes \mathbb{B}(\ell_2)$
Narutaka Ozawa, Tokyo, Japan

With the help of Kirchberg's and Selberg's theorems, we prove that the minimal tensor product of $\mathbb{B}(\ell_2)$ with itself does not have the WEP (weak expectation property) of Lance.

Free Araki-Woods factors
Dimitri Shlyakhtenko, Los Angeles, USA

Free Araki-Woods factors are free probability analogs of hyperfinite factors of type III. We discuss recent progress in their classification, including a new invariant for type III factors, which distinguishes more algebras than the previously known invariants.

Classification of local conformal nets: case $c < 1$ (joint work with Roberto Longo)
Yasuyuki Kawahigashi, Tokyo, Japan

We completely classify diffeomorphism invariant local nets of factors on the circle with central charge less than 1. They are in a bijective correspondence to the pairs of A-D-E Dynkin diagrams with difference of their Coxeter numbers being 1.

For this purpose, we first identify the Virasoro nets constructed by Loke, following Wassermann's work, with the coset nets construced by Xu from $SU(2)_k$. In this way, we get complete rationality of the Virasoro nets by a recent work of Longo.

We next classify irreducible local extensions of the Virasoro nets on the circle with central charge less than 1. Then using theory of α-induction and classification of modular invariants of the minimal models by Cappelli-Itzykson-Zuber, we get the desired classification. Here Goodman-de la Harpe-Jones subfactors play an important role and a relation to the Cappelli-Itzykson-Zuber classification of modular invariants for $SU(2)_k$ is clarified.

Xu noticed three coset models, including a so-called "maverick" one, give the same topological invariants of 3-manifolds of Reshetikhin-Turaev type. Our classification shows that these three cosets are indeed isomorphic as nets of factors.

Böckenhauer-Evans considered two certain coset nets as extensions of the Virasoro nets, but were unable to prove that these have the expected properties about α-induction. Our classification result, together with a recent result of Rehren on canonical tensor product subfactors, show that these coset nets indeed have these properties.

Centralizer algebras of Lie type E_N

Hans Wenzl, San Diego, USA

We determine a minimum set of generators for the centralizer algebras of minuscule representations of Lie type E_6 and E_7, and for the corresponding fusion categories. This is new even in the classical case. It allows for a description by graphs of the centralizer algebras (e.g. for E_6, we have oriented graphs with only trivalent and 10-valent vertices).

K-homology for the Weyl algebra

Joachim Cuntz, Münster, Germany

The Weyl algebra W is the algebra over $\mathbb{C}$ generated by two elements p, q satisfying the Heisenberg relation $pq - qp = 1$. Equipped with the locally convex topology given by the family of all seminorms on W, it may be considered as a locally convex algebra.

We define a K-homology theory on the category of locally convex algebras, denoted by k^*, which gives the correct result for the standard examples (in particular $k^*(C^\infty M) = K_*M$ for a compact C^∞-manifold M) and which is defined and can be computed also for non-standard algebras like W. It turns out that $k^0(W) = \mathbb{Z}$, $k^1(W) = 0$, the generating class in k^0 being two-dimensional.

This fits with the Chern-Connes character $k^*(W) \to HP^*(W)$ into cyclic cohomology, where $HP^0W = \mathbb{C}$, $HP^1W = 0$, the generating class in HP^0 being two-dimensional.

Generalized fixed point algebras

Ralf Meyer, Münster, Germany

The construction of generalized fixed point algebras goes back to Rieffel. A prerequisite for his construction is the existence of a dense subalgebra with certain properties. He defines a Hilbert module over the reduced crossed product and defines the generalized fixed point algebra as the algebra of compact operators on this Hilbert module. It is thus, by definition, equivalent to an ideal in the reduced crossed product. We examine this construction more closely in the setting of G-equivariant Hilbert modules over some fixed G-C*-algebra B, where G is some locally compact group. We show that each Hilbert module over $C^*_r(G, B)$ arises by this construction, and that the outcome may depend on the choice of a dense subspace. We examine two special cases that behave quite differently. If $B = \mathbb{C}$ and G is abelian, one is basically dealing with continuous and measurable fields of Hilbert spaces over G. This example shows that the generalized fixed point algebra may depend on the choice of the dense subspace. If the action of G on B is proper in Kasparov's strong sense, then the choice of the dense subspace does not matter, one obtains a bijection between Hilbert modules over $C_r^*(G, B)$ and G-equivariant Hilbert modules over B.

K-theory and Langlands' multiplicity formulas

Francois Pierrot, Paris, France

A celebrated theorem of Langlands calculates the multiplicity of an integrable representation of a semisimple Lie group G in $L^2(G/\Gamma)$ for Γ a discrete cocompact torsion-free subgroup of G. We prove a generalization of this formula valid in particular in the p-adic case, using K-theory.

Simple C*-algebras and extensions of stable C*-algebras

Mikael Rørdam, Copenhagen, Denmark

An example is given of a simple C*-algebra that contains a non-zero finite and an infinite projection, and hence of a stably infinite C*-algebra that is not purely infinite. The example is based on the multiplier algebra of the stabilization of an abelian C*-algebra. An analysis of when projections in this multiplier algebra fails to be properly infinite leads is an essential ingredient in the contruction. The same methods also leads to an example of a non-stable extension of two stable type I C*-algebras, which shows that an extension of two stable C*-algebras need not be stable.

Singly generated planar algebras and subfactors

Dietmar Bisch, Santa Barbara, USA

A *planar algebra* is a graded vector space $\mathcal{P} = (P_k)_{k \geq 0}$ with an action of the "operad" of planar tangles (Jones). Jones showed that the standard invariant of an extremal subfactor is a planar algebra, a result which has led to the study of subfactors in terms of generators and relations (for the associated planar algebras). From this point of view the simplest planar algebras are Jones' Temperley-Lieb algebras. The next simplest class of interesting examples are planar algebras generated by a single 2-box, that is a non-trivial element in P_2. It seems reasonable to expect that a complete enumeration of such planar algebras is possible, if one imposes the conditions $\dim P_2 = 3$ and $\dim P_3 \leq 15$. I explain why 15 is relevant here and I discuss the classification results that Jones and I have obtained so far in joint work. We show that if $\dim P_3 \leq 12$ the only subfactor planar algebras are the Fuss-Catalan systems (of Jones and myself) and an exceptional one coming from the subfactor $M^{\mathbb{Z}_3} \subset M$. If $\dim P_3 = 13$ we prove that there is only one such planar algebra, namely the one associated to the index 5 subfactor $R \rtimes \mathbb{Z}_2 \subset R \rtimes D_5$ (where we fix any outer action of the dihedral group D_5 on the hyperfinite II_1 factor R). This is a surprising rigidity result since one would expect the number of examples to grow as $\dim P_3$ increases. If $\dim P_3 = 14$ or 15, all Birman-Murakami-Wenzl subfactors will be part of this program. It is at this point not clear if there are others, although we have recently made some progress in these two remaining cases.

Masas in crossed products

Sergey Neshveyev, Oslo, Norway

(Joint work with Erling Størmer). We consider a free measure preserving action of a countable abelian group G on a Lebesgue space (X, μ). The crossed product algebra $R_T = L^\infty(X) \rtimes G$ has two distinguished maximal abelian subalgebras, the Cartan masa $C_T = L^\infty(X)$ and the singular masa S_T generated by the image of G. We discuss the problem of extracting information about the system from the positions of C_T and S_T inside R_T. Our main result is that the pair consisting of S_T and the inner conjugacy class of C_T is an invariant of the system. We give also an example of non-conjugate singular masas with the same Pukanszky invariant.

Approximate decompositions of representations into irreducible representations

Marius Dadarlat, West Lafayette, USA

Let A be a separable unital commutative C*-algebra. For any finite subset F of A and $\epsilon > 0$ there are finitely many irreducible representations $\pi_1, ..., \pi_n$ of A such that any other representation of A can be approximated on F within ϵ by a representation unitary equivalent to a direct sum of multiples of $\pi_1, ..., \pi_n$.

We study generalizations of this approximation property for separable exact C*-algebras. As applications we show that if a separable exact residually finite dimensional C*-algebra A is KK-equivalent to a commutative C*-algebra, then A embeds in a UHF algebra. Let G be a countable discrete amenable subgroup of the unitary group of a separable simple unital AF algebra. Then $C^*(G)$ embedds in a separable simple unital AF algebra.

Shapiro's lemma for topological K-theory of groups

Hervé Oyono, Clermont-Ferrand, France

(Joint work with J. Chabert and S. Echterhoff). Let $X \rtimes G$ be the crossed product groupoid of a locally compact group G acting on a locally compact space X. For any $X \rtimes G$-algebra A we show that a natural forgetful map from the topological K-theory $\mathrm{K}_*^{\mathrm{top}}(X \rtimes G; A)$ of the groupoid $X \rtimes G$ with coefficients in A to the topological K-theory $\mathrm{K}_*^{\mathrm{top}}(G; A)$ of G with coefficients in A is an isomorphism. This result has the two following consequences:

- *The Symetric Imprimitivity Theorem:* Let X be a locally compact space equipped with some commuting free and proper actions of two groups H and K and let A be a $X \rtimes (H \times K)-$algebra. We denote by A^K and A^H the generalised point-fixed algebras correponding to H and K constructed by Kasparov. Then the two following assertions are equivalent:

  1. The group H satisfies the Baum-Connes conjecture with coefficient in A^K;
  2. The group K satisfies the Baum-Connes conjecture with coefficient in A^H.

  In partcular, this give another proof for the heredity of the Baum-Connes conjecture with coefficient with respect to passing to closed subgroups.

- Let X be a locally compact space equipped with an amenable action of a locally compact group G. Then the group G satisfies the Baum-Connes conjecture with coefficient in any $X \rtimes G-$algebra. In particular, this give another proof of the Baum-Connes conjecture with coefficient in a proper algebra.

On pure stellar infiniteness or Towards a C*-analogue of type III von Neumann algebras

Etienne Blanchard, Paris, France

We compare several definitions of pure infiniteness for C*-algebras A, and obtain that they are equivalent, if the primitive ideal space of A is Hausdorff and of finite dimension. We get that A is isomorphic to $A \otimes O_\infty$ if A is (1-)purely infinite, separable, stable, nuclear and $\mathrm{Prim}(A)$ is a Hausdorff space (not necessarily of finite dimension) (joint work with Eberhard Kirchberg).

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