THE

# YMCA

CONFERENCE 2019

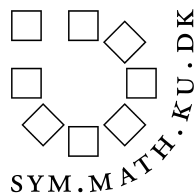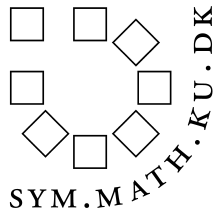# INFORMATION

AND

# ABSTRACTS

Centre for Symmetry and Deformation

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# Contents

# Practical information

## Welcome

We are delighted to welcome you to the Young Mathematicians in $C^*$-Algebras conference 2019. In this booklet we have included descriptions of the conference events, suggestions for what to do around Copenhagen, and many other useful bits of information.

## Locations

The University of Copenhagen has buildings all around Copenhagen city, but the Faculty of Science is mainly concentrated around Universitetsparken (english: the university park). A large part, including the Department of Mathematics, is in the building called the H.C. Ørsted Institute (named after the Danish physicist Hans Christian Ørsted), and this is where all parts of the conference, except lunch and excursions, will take place. If you just got a physical copy of this booklet, then with high probability this is the building you are in now.

Most of the conference will take place in the HCØ building either in auditorium 4 or in the southern end of the main hall, where the registration was. To be more precise, the different events will take place at the following locations:

- ▶ **Mini-courses**, **participant talks**, and the **panel discussion** take place in **auditorium 4**.
- ▶ **Breaks** take place in the **southern end** of the main hall.
- ▶ **Lunch** takes place in the canteen of the **Biocenter building**.
- ▶ The **reception** and **conference dinner** take place in the **HCØ canteen**.
- ▶ The **mentor lunch** takes place in **room A102**.

To find these places you can use the map on page 11.

## Internet

If you have **eduroam** then you can simply log in using your usual settings. If you do not have eduroam or cannot get it to work, then you should log into the **KU Guest** network, where you need to provide an email address and a phone number to get access.

## Who are the organisers?

If you have questions or need help, do not hesitate to contact the organisers. All of them have coloured name tags. There are 11 organisers present at the conference and some of those should be around at all times.

You can also reach the organisers at the e-mail address

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ymcstara2019@gmail.com
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or, if your matter requires immediate attention, call the organiser phone at

+45 91 92 85 49.

## Lunch

We do not provide lunch, and people are free to go wherever they choose to eat lunch. But for your convenience, we have booked room at the canteen in the Biocenter building. Most people will probably go there, so you can just follow the crowd. There will definitely be some local people leading the way.

## Reception

On Monday, there will be a reception featuring pizza, beer and soft drinks. The reception starts after the talks in the HCØ canteen.

## Dinner

On Tuesday, there will be a conference dinner. The dinner will start at 18:00 in the HCØ canteen where Indian food and beverages will be served.

## Posters

No formal poster session is organised. Instead, posters will be displayed from the beginning of the conference until the end, so there should be plenty of time to discuss their contents during coffee breaks.

If you have not been able to print your poster, then the organisers can help you print it, but it will be printed in A3 on an ordinary office printer.

## Excursions

On Thursday, we have planned several excursions. These are all described below and will start from the southern end of the main hall after lunch. Most of the excursions require an entrance fee which you will have to pay on site by cash or card, but we will cover the cost of public transportation where necessary.

- ▶ **Tivoli Gardens:** Tivoli is a world-class amusement park in the center of Copenhagen. More than two dozen rides await you, all of them designed to match Tivoli's architecture and gardens. Some are wonderfully nostalgic, others again will match the expectations of the keenest thrill-seekers, such as the "Vertigo". This ride will turn you upside down at 100 km/h and was voted Europe's Best Ride in 2014. Tivoli's oldest ride, the wooden Roller Coaster from 1914, is one of only seven roller coasters worldwide which have a brakeman on board every train. As there are over 30 eateries in Tivoli, it is a natural place for us to grab dinner afterwards. You can find more information about Tivoli on:

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  https://www.tivoligardens.com
  ```

  - ▶ Entrance fee is **130 DKK**. Additionally, rides cost **30–90 DKK**, or you can get unlimited rides for **240 DKK**.

- ▶ **Bouldering:** Bouldering is a form of climbing, on not-too-high walls, typically 3–4 meters. This also means that no safety harness is required, instead thick mattresses are laid out to break your fall. There are routes (called "problems") ranging all the way from beginner to expert. Much of the joy of bouldering comes from trying to figure out the best way to "solve" the problems, so this is a natural activity for mathematicians!

The climbing will take place at Beta Boulders. This is a new bouldering gym that has quickly become the favourite of the UCPH-boulderers. We have booked an instructor who will help to get beginners started, as well as provide tips for those who have tried before. You can find more information about the gym on:

`https://www.betaboulders.com`

- ▶ Entrance fee is **150 DKK**, which includes rental of climbing shoes.
- ▶ **NB:** The location has changed since the original announcement, Beta Boulders is the *new* location.

▶ **Amager Beach Park:** Amager Strandpark is the best place in Copenhagen to escape the scorching summer heat. It comes with sand for sunbathing and seawater for swimming, so remember to bring your bathing suit. Amager Strandpark also has some other nice features. For instance, there are places to play beach volleyball, football, and frisbee. We will make sure to bring some balls and frisbees. There is also mini-golf nearby. We'll stop by a supermarket to buy some drinks and snacks. In summary: {sand, sea, sun, balls, disks} = beach!

- ▶ No entrance fee!

▶ **Copenhagen Zoo:** Copenhagen Zoo is a zoological garden, as you'd find it in most major cities around the world. The unique features of Copenhagen Zoo include a relatively new elephant house designed by Norman Foster. The house is considered one of the best elephant facilities in the world. Here, the animals can be seen at close quarters, for example when they bathe in a water tomb, which is deep enough for the elephants to dive underwater so their entire bodies are covered. Another unique feature is the Arctic Ring, which gives you an opportunity to get close to polar bears, North Atlantic birds, and seals both above and below the water surface. The most recent addition are the two panda bears Mao Sun and Xing Er. You can find more information about the zoo on:

`https://www.zoo.dk/en`

- ▶ Entrance fee is **195 DKK**.

► **SMK (National Gallery of Denmark):** Statens Museum for Kunst is Denmark's largest art museum, featuring outstanding collections of Danish and international art from the past seven centuries. No other museum in Denmark shows such a rich and varied selection of art—from the European classics of the Renaissance to the overwhelming diversity of modern and contemporary art. Here you will find gems by artists such as Mantegna, Nolde, Anna Ancher, Derain, Rubens, Matisse, Hammershøi, Munch, Abramovic, Danh Vo, and Elmgreen & Dragset. The SMK is especially famous for its beautiful collection of Danish Golden Age art, the country's most comprehensive collection of Danish contemporary art, and one of the world's best Matisse collections. You can find more information about SMK on:

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https://www.smk.dk/en
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> ► Entrance fee is **120 DKK**.
> ► **NB:** The guided tour was cancelled due to too few pre-registered participants for the event.

► **Guided walking tour of Copenhagen:** The city of Copenhagen dates back more than 1000 years, and for almost 600 years it's been the main seat of the royal family of Denmark. Not many buildings date back more than 300 years though, because the city has been ravaged by two great fires and one major bombardment. For this reason, the old city center of Copenhagen is a relatively new town built on top of the ruins of the old. Our tour will take us through the city center and we will take a look at what was, what became, and what disappeared forever.

> ► The fee is **80–200 DKK** for the tour, depending on the number of participants.

An email regarding pre-registration for the excursions has been sent out to all participants. **If you have not yet registered for an excursion, you may do so by registering on**

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https://www.math.ku.dk/english/research/conferences/2019/
                  ymcstara2019/excursion
```

**within the morning of Tuesday, August 6th.**

Before the first lecture on Wednesday, we will provide some practical details about the excursions, and we will point out who is in charge of the different excursions, so that you know whom to follow.

Please note that some excursions might be cancelled if there aren't enough participants, in which case you may choose to attend a different one. Should the weather be particularly bad we may also swap some of the outdoor excursions for something indoors.

## Places to eat in CPH

Here is a list with some suggestions on where to eat in Copenhagen.

- **Spiseloppen:** Located in Christiania, this is a nice place to eat if you are in the neighbourhood. The restaurant is located at:

    *Bådsmandsstræde 43, 1407 København K*

- **Grød:** Grød, which means porridge, is a restaurant that specializes in porridge. Indeed, this is the only thing they serve, but this is not a bad thing. A bowl of porridge is about 70 DKK. Grød has three different restaurants located at:

    *Jægersborggade 50, kld. tv, 2200 København N*

    *Hal 2, Stade 8A, Linnésgade 17, 1362 København K*

    *Falkoner alle 34, 2000 Frederiksberg C*

- **Aroii:** The take-away part of the Michelin restaurant Kiin Kiin, which serves Thai food. Aroii has three different restaurants located at:

    *Guldbergsgade 21, 2200 København N*

    *Hausergade 38, 1128 København K*

    *Thorvaldsensvej 2, 1871 Frederiksberg C*

- **Kate's Joint:** The menu changes regularly, but consists mainly of various Asian and African dishes. The restaurant is located at:

    *Blågårdsgade 12, 2200 København N*

- **The Bronx Burger Bar:** As the name suggest this is a burger bar, but the high end kind. A burger with fries is about 100 DKK. Bronx has two different restaurants located at:

*Godthåbsvej 30, 2000 Frederiksberg C*

*Vandkunsten 1, 1467 København K*

► **Halifax:** This is a burger joint in the same category as Bronx, but maybe slightly more expensive. A burger with fries is about 130 DKK. Halifax has seven different restaurants located at:

*Trianglen 1, 2100 København Ø*

*Frederiksborggade 35, 1360 København K*

*Larsbjørnsstræde 9, 1454 København K*

*Falkoner Plads 1, 2000 Frederiksberg*

*Vesterbrogade 72, 1620 København V*

*Skolegade 9, 2500 Valby*

*Amagerbro Torv 13, 2300 København S*

► **LêLê Street Kitchen:** If you feel like having some Vietnamese food, then LêLê Street Kitchen is a good option. A large dish will cost you about 100 DKK, but they also serve smaller ones for about 50 DKK. There are four different street kitchens, located at:

*Vesterbrogade 56, 1620 København V*

*Østerbrogade 56, 2100 København Ø*

*H.C. Andersens Boulevard 8, 1553 København V*

*Torvehallerne, hal 2, Frederiksborggade 21, 1360 København K*

# Map of the campus



(1) Auditorium 4.
(2) Southern end of the main hall.
(3) HCØ canteen.
(4) Biocenter.
(5) Entrances to the HCØ building.

# Public transport

You can get around Copenhagen by bus, train, metro, bike, and of course by foot. We recommend using the website **www.rejseplanen.dk**, the corresponding app **Rejseplanen**, **CityMapper** or **Google Maps** to find the best routes. Note that Rejseplanen will always include some kind of public transportation, so it is not very well suited for short trips which may simply be taken by foot.

There are several ticket options for the public transport, and which one is best suited for you depends on how much you plan to it. The options are:

► **You can buy a single ticket each trip.** This option is only relevant if you do not plan to use public transport much, since a ticket for getting around the inner city will cost 24 DKK, which is a bit expensive in the long run. Please note that you need to pay with cash on the buses (no large bills), but you can use cash as well as credit cards for the machines at the train stations or at 7-Eleven kiosks.

► **You can buy tickets on your smartphone,** by downloading "DOT Mobilbilletter" from App Store or Google Play. This option is essentially the modern version of the previous one, eliminating the need to find a ticket machine or a 7-Eleven kiosk. In the app you can select the fare you need by choosing an appropriate number of zones and pay by entering your credit card details.

► **You can buy a "CityPass" small** for up to five days. This option will enable you to use public transportation in Zones 1 to 4, including the airport. A pass for five days will cost 300 DKK.

► **You can buy a "Rejsekort".** A Rejsekort (english: travelcard) is a plastic card that can be used for almost all kinds of travel in Denmark. One simply has to check in at the starting point and for every change of transportation during the journey, and check out at the end. This is done by holding the card near to a "check in" or "check out" stand, respectively, which are both easily recognised by the blue light.

You can purchase an anonymous Rejsekort for 80 DKK at various train stations, but you also have to put some money on the card to travel. A single journey inside Zones 1 and 2 will cost either 12 DKK or 15 DKK, depending on the time of day, and going from the airport to the city will be 20 DKK. However, you cannot check in unless you have at least 70 DKK on your card. This means that a Rejsekort is really only suited for those who plan to visit Denmark frequently and/or for an extended period of time.

# YWC*A events

## Mentor lunch (women only)

The Women in Operator Algebras lunch will be during the Wednesday lunch break in room A102. We will gather in the main lecture room at 12:00.

The aim of this lunch is to provide the female participants a chance to candidly discuss issues that are distinct to female mathematicians and, more specifically, women in operator algebras.

## Panel: Early Career Advice and Issues of Equity (open to all)

Instead of a second Women in Operator Algebras lunch, a panel discussion will be held on Friday.

Because of overwhelming interest, we will separate the lunch from the related activities. Participants are asked to acquire lunch independently and reconvene in Auditorium 4 at 13:00. We will begin by sharing some of the conversations that came about during the mentor lunch. Afterwards, we will have a panel of established researchers who will answer questions about their life and career as a mathematician. Participants are encouraged to submit questions for the panel in the box that will be provided at all the coffee breaks Monday–Wednesday.

# Mini-courses & keynote address

The conference features three mini-courses, each of which consists of four lectures, given by Cornelia Drutu (University of Oxford), Ilijas Farah (York University) and Ian F. Putnam (University of Victoria). In addition, Nadia S. Larsen will deliver the inaugural keynote address. The address will be delivered in two parts: one a traditional keynote address and the other a perspective on life as an operator algebraist.

*Cornelia Drutu*

## $C^*$-algebras and Geometric Group Theory

This mini-course will overview various topics at the interface between $C^*$-algebras and Geometric Group Theory, from the Rapid Decay property to Kazhdan projections and various versions of amenability.

*Ilijas Farah*

## Massive $C^*$-algebras and their Applications

Given a separable $C^*$-algebra $A$ one can define the asymptotic sequence algebra $\ell_\infty(A)/c_0(A)$. By taking further quotients, one obtains various other extensions of $A$, the most important of which are the ultrapowers. When $A$ is separable, the relation between $A$ and these 'massive' $C^*$-algebras is used to provide information about $A$ itself. Quite surprisingly, this approach is frequently more efficient than the direct study of $A$ itself. In these lectures, I will provide a friendly introduction to asymptotic $C^*$-algebras and ultrapowers, and show that in a certain precise sense the latter construction is, for all practical purposes, more general (i.e., more useful).

*Nadia S. Larsen*

## Equilibrium states on Nica-Toeplitz $C^*$-algebras

Equilibrium states have their origin in statistical mechanics. Their operator algebraic manifestation has provided a successful vein of investigation of many

$C^*$-algebras, fostering rich interaction with fields such as number theory and ergodic theory. Equilibrium states for one-parameter groups on Toeplitz and Cuntz-Pimsner $C^*$-algebras associated to a $C^*$-correspondence were studied in work of Pinzari, Watatani and Yonetani, and of Laca and Neshveyev, almost two decades ago. These results have found numerous counterparts in modern examples of Toeplitz and Cuntz-Pimsner type $C^*$-algebras associated to semigroups of $C^*$-correspondences based on Nica's quasi-lattice ordered groups. In this talk I will present an overview of this development and discuss recent findings from joint work with Z. Afsar and S. Neshveyev.

*Ian F. Putnam*

## $C^*$-algebras and Dynamics

The main goal of the lectures is to provide an introduction to the connections between topological dynamical systems and $C^*$-algebras. This interaction has been fruitful for both fields, going back to the seminal work of Murray and von Neumann. On the one hand, $C^*$-algebras constructed from dynamical systems provide important examples. On the other, $C^*$-algebraic techniques and tools, particularly $K$-theory, provide interesting new insights into the dynamical systems.

The lectures will begin with the construction of $C^*$-algebras from groupoids, since this is at the heart of the interaction. We will briefly discuss $K$-theory, particularly for groupoid $C^*$-algebras and crossed products. We will also give a substantial list of topological dynamical systems, simply to provide a first insight into the types of behaviors that are possible, discussing the $C^*$-algebras briefly in each case. These include minimal systems, $AF$-equivalence relations, Smale spaces, and examples from the field of aperiodic tilings.

Finally, we discuss applications of relative $K$-theory to the dynamics. The first example of such results was in the so-called orbit-splitting subalgebras of crossed products, which have played a key part in Elliott's classification program, at least as it applies to crossed products. We will give some more recent results along these lines, with applications to such systems as the dynamics of flat surfaces and some problems in the Elliott classification scheme.

# Abstracts

Here you find the abstracts for the participant talks given at the conference.

*Maria Stella Adamo*

## Structure Properties of Generalized Crossed Products

This is the second of two talks about properties of $C^*$-algebras arising from generalized crossed products, a joint work (in progress) with D. Archey, M. Georgescu, M. Forough, J.A. Jeong, K. Strung, M.G. Viola. The first talk will be given by M. Georgescu.

Crossed products by minimal Cantor systems provide inspiring examples of unital, separable, simple and nuclear $C^*$-algebras. Orbit-breaking subalgebras, introduced by I. Putnam in 1989, played a central role in investigating those crossed products as they are "large" enough to be very similar to the crossed product itself, while at the same time being more tractable. The concept of a given $C^*$-algebra containing a subalgebra which shares many of its properties was put into an abstract framework by N.C. Phillips and shown by D. Archey and N.C. Phillips to pass properties such as simplicity, Z-stability, and stable rank to its containing $C^*$-algebra. In this talk, I will discuss some of the properties of $C(X) \rtimes_{\mathscr{F}} \mathbb{Z}$ where $\mathscr{F}$ is a $C(X)$-bimodule. In particular, when $X$ is the Cantor set and $\mathscr{F}$ is a full finitely generated minimal Hilbert $C(X)$-bimodule, we show that the large subalgebras introduced in the talk of M. Georgescu are in fact AF. This then implies that the crossed product has real rank zero, stable rank one and is Z-stable. In particular, such $C^*$-algebras can be classified by their Elliott invariants.

*Are Austad*

## K-theory and Gabor analysis

A recently proven theorem on Heisenberg modules, namely that module frames for Heisenberg modules give Gabor frames for an associated Hilbert space and vice versa, strengthens the connection between Gabor analysis and ope-

rator algebras. In some cases it allows us to reduce problems in operator algebras to finding frames for $L^2(G)$, for $G$ a second countable locally compact abelian group. This is sometimes quite a simplification. In this talk we explain the basics of Gabor frame theory, and show that in many cases the K-theory of twisted group $C^*$-algebras of locally compact abelian groups can largely be reduced to a classification of Gabor frames. Indeed, in case the abelian group is discrete, we get a full description of the K-theory of the twisted group $C^*$-algebra through Gabor frame theory. We also give examples of some explicit projections in the noncommutative 2-torus coming from Gabor analysis. Parts of this talk is joint work with Ulrik Enstad.

*Ian Charlesworth*

## Free Stein Irregularity

I will give an overview and introduction to free entropy and regularity problems in free probability. From there, I will speak on recent joint work with Brent Nelson, where we introduce a free probabilistic regularity quantity we call the free Stein irregularity. The free Stein irregularity measures in a certain sense how close a system of variables is to admitting conjugate variables in the sense of Voiculescu. I will discuss some properties of the free Stein irregularity and how it relates to other common regularity conditions.

*Sayan Das*

## On the generalized Neshveyev-Stormer conjecture

The study of group actions on probability measure spaces occupies a central role in modern mathematics. If a group $G$ acts on a probability measure space $(X, \mu)$, one can associate a von Neumann algebra, namely the crossed product von Neumann algebra, denoted by $L^\infty(X) \rtimes G$. This von Neumann algebra naturally contains a copy of the group von Neumann algebra, denoted by $L(G)$. A far reaching conjecture of Neshveyev and Stormer predicts that the inclusion $L(G) \subseteq L^\infty(X) \rtimes G$ "remembers" the group and the action. In my talk, I shall show that the conjecture is true for a large class of actions of i.c.c. groups. This talk is based on a joint work with Prof. Ionut Chifan.

*Kari Eifler*

**Non-local Games and the Graph Isomorphism Game**

Non-local games give us a way of observing quantum behaviour through the observation of only classical data, and there are several different mathematical models to consider. The graph isomorphism game is important in quantum information theory and is an example of a non-local game. We show that the *-algebraic, $C^*$-algebraic, and quantum commuting (qc) notions of a quantum isomorphism between classical graphs $X$ and $Y$ are all equivalent.

*Ulrik Enstad*

**Wavelets and Hilbert $C^*$-modules**

A multiresolution analysis (MRA) for $L^2(\mathbb{R}^n)$ is, intuitively speaking, an approximation of $L^2(\mathbb{R}^n)$ by a nested sequence of closed subspaces

$$V_0 \subseteq V_1 \subseteq V_2 \subseteq \cdots \subseteq V_k \subseteq \cdots \subseteq L^2(\mathbb{R}^n)$$

where $V_k$ approximates $L^2(\mathbb{R}^n)$ better and better as $k$ increases. The main application of MRAs is the construction of wavelets, which are of great practical importance in signal processing.

In the wavelet literature, $C^*$-valued inner products are often implicitly used. In fact, the space $V_0$ from an MRA has the structure of a free, finitely generated Hilbert $C^*(\mathbb{Z}^n)$-module. It is then an interesting question if one can obtain MRAs from projective modules over $C(\mathbb{T}^n)$ that are not free. This leads to the notion of a projective multiresolution analysis (PMRA) due to J. Packer and M. Rieffel. This talk will be an introduction to PMRAs and their properties. I will also present a new result on the isomorphism class of the associated wavelet module $W_0$ that satisfies $V_0 \oplus W_0 = V_1$.

*Menevse Eryuzlu*

**Exact Sequences in the Enchilada Category**

Imprimitivity theorems provide a fundamental tool for studying the representation theory. It was shown that all imprimitivity theorems can be viewed as natural isomorphisms between various crossed-product functors among certain equivariant catagories. In the proof, we see that there exists a category (the *enchilada category*) in which objects are $C^*$-algebras, and the morphisms

from $A$ to $B$ are the isomorphism classes of $A$–$B$ correspondences. We study whether exact sequences exist in this category and try to see if the crossed-product functors preserve exact sequences. Our goal is to determine whether we can have a better understanding of the Baum–Connes conjecture by using enchilada categories.

*Eske Ewert*

### Generalized fixed point algebras and pseudodifferential operators

Generalized fixed point algebras were introduced by Rieffel to extend the notion of proper group actions on spaces to $C^*$-algebras. In this talk, I will explain their construction and describe how the pseudodifferential operator extension for a manifold $M$,

$$0 \longrightarrow \mathbb{K}(L^2(M)) \longrightarrow C^*(\Psi DO_0(M)) \longrightarrow C_0(S^*M) \to 0,$$

can be obtained using generalized fixed point algebras. Here, we use a certain zoom action of $\mathbb{R}_{>0}$ on an ideal in the $C^*$-algebra of Connes' tangent groupoid.

Moreover, I would like to give an outlook, how this technique can be used to find a similar extension as above, if $M$ is replaced by a homogeneous Lie group. Instead of $C_0(S^*M)$, we recover a non-commutative algebra of symbols, which has been studied in this context before. Our approach allows now to calculate its K-theory and, therefore, to do index computations.

*Ruaridh Gardner*

### The Nuclear Dimension of Generalised Toeplitz Algebras

Generalised Toeplitz Algebras are those which, similar to the Toeplitz alegbra, exist as extensions of continuous functions for a given space by the compacts. The goal is to make use of the nuclear dimension of the underlying space to find a bound for the nuclear dimension for the generalised Toeplitz algebra. The methodology is to use an argument similar to that employed by Brake and Winter in their 2018 paper showing that the nuclear dimension of the Toeplitz algebra is 1.

*Magdalena Georgescu*

## Large Subalgebras in Generalized Crossed Products

This is the first of two talks about properties of $C^*$-algebras arising from generalized crossed products, a joint work (in progress) with M.S. Adamo, D. Archey, M. Forough, J.A. Jeong, K. Strung, M.G. Viola. The other talk will be given by M.S. Adamo. In 1989, I. Putnam introduced the concept of orbit breaking subalgebras in the process of studying the properties of crossed products by minimal Cantor systems. These subalgebras are "large" enough to share many properties with the crossed product, but are more tractable. This approach was generalized by N.C. Phillips, who introduced the concept of a large subalgebra for a given $C^*$-algebra, defined in such a way that the large subalgebra shares many of the properties of the containing algebra. In this talk, I will introduce large subalgebras for $C^*$-algebras with a $\mathbb{Z}$-grading. In particular, I will discuss specific large subalgebras of $C(X) \rtimes_{\mathscr{F}} \mathbb{Z}$, where $\mathscr{F}$ is a $C(X)$-bimodule.

*Dimitrios Gerontogiannis*

## K-homological finiteness for Ruelle algebras

In this talk we will discuss about a class of hyperbolic dynamical systems known as Smale spaces. Smale spaces have very chaotic behaviour and in most cases, even though the dynamics are smooth, the dynamically interesting part of the space, called non-wandering set, is some sort of fractal; a highly non-smooth structure. Hyperbolicity is a notion that is strongly related to this fact. Following the philosophy of non-commutative topology, one can encode certain dynamical aspects of Smale spaces into topological groupoids and then construct their $C^*$-algebras. A particularly nice class of such $C^*$-algebras are the Ruelle algebras introduced by Ian Putnam. They can be thought as higher-dimensional analogues of Cuntz-Krieger algebras. They are separable, simple, nuclear, purely infinite, stable and in the UCT class. Hence, they can be classified by their K-theory. A first step towards their index theory was achieved by Jerome Kaminker, Ian Putnam and Mike Whittaker where they proved a Poincaré duality result that relates the K-theory with the K-homology of these algebras. We will broadly mention some of the tools needed to realise this Poincaré duality class as a Fredholm module which in addition, has remarkable geometric properties that lead to K-homological finiteness.

*Saeed Ghasemi*

## Universal AF-algebras

We show that there is a separable AF-algebra $\mathscr{A}$ with the property that any separable AF-algebra is isomorphic to a quotient of $\mathscr{A}$. Equivalently, there is a surjectively universal countable scaled (or with order-unit) dimension group. In some contexts, $\mathscr{A}$ can be considered as the appropriate noncommutative analog of the Cantor set. An intriguing feature of the Cantor set is that it is the "Fraïssé limit" of the category of all nonempty finite spaces and surjective maps. As a consequence, the Cantor set is a unique and "generic" object in the category of all compact zero-dimensional metrizable spaces. This feature naturally passes on to $\mathscr{A}$. Therefore the extensions of many properties of the Cantor set that can be proved using the Fraïssé theory, such as the homogeneity and universality, also can be proved for $\mathscr{A}$. In fact, $\mathscr{A}$ is the Fraïssé limit of the category of all finite-dimensional $C^*$-algebras and left-invertible embeddings. Fraïssé theory can also be employed to describe the Bratteli diagram of $\mathscr{A}$ and provide conditions characterizing it up to isomorphisms. This is joint work with Wiesław Kubiś.

*Mitch Haslehurst*

## Relative K-Theory for $C^*$-algebras

In the past several decades, K-Theory has become a powerful tool in understanding the structure of $C^*$-algebras. K-Theory from the viewpoint of $C^*$-algebras draws on many ideas from the earlier topological viewpoint. There is a notion in topological K-Theory known as "relative K-Theory" where one considers a closed subset $Y$ of a (usually compact) space $X$ and forms an abelian group denoted $K(X, Y)$. I will speak about a slight variant of this idea in the context of $C^*$-algebras as well as some potential applications.

*Paul Herstedt*

## An introduction to Rokhlin dimension

In the quest to classify automorphisms of $C^*$-algebras and obtain permanence results for crossed products, Rokhlin-type properties have been an extremely important tool. In this talk, we gently introduce the subject of Rokhlin dimension, starting with what it means for an action on $C(X)$ to have finite Rokhlin

dimension. From there, we can understand this as a "low-dimesional freeness" condition, and explain why this condition gives us crossed products with desirable properties. We finally summarize recent results and open problems, and explain why the situation is far worse in the non-compact group setting.

*Se-Jin Kim*

## Hyperrgidity for $C^*$-correspondences

A problem of Hao and Ng asks: if $G$ is a locally compact group acting on a non-degenerate $C^*$-correspondence $(C, X)$, when is it the case that we have the identity

$$\mathscr{O}_C(X) \rtimes G = \mathscr{O}_{C \rtimes G}(X \rtimes G)\,?$$

Hao and Ng verify this identity for any amenable locally compact group $G$. In recent work, Katsoulis and Ramsey are able to show that whenever $(C, X)$ attains a property called hyperrigidity, the crossed product $\mathscr{O}_C(X) \rtimes G$ is always a Cuntz-Pimsner algebra associated to a $C^*$-correspondence arising from a certain completion of $(C_c(G, C), C_c(G, X))$. In this talk we describe an exact characterization of hyperrigidity for $C^*$-correspondences. This generalizes the work of Dor-On and Salomon which gives a characterization for $C^*$-correspondences associated to discrete graphs and the work of Katoulis and Ramsey, which give a sufficient condition in the case when $X$ is countably generated over $C$. Beyond this, we explore the behaviour of hyperrigidity under ultraproducts. In particular, we will show that hyperrigidity is not preserved under ultraproducts but that hyperrigidity is preserved under ultrapowers.

*Feodor Kogan*

## Lack of functoriality of the groupoid $C^*$-algebra construction

In the commutative setting there is a clear algebra-geometric correspondence given by Gelfand-Naimark duality between the category of compact Hausdorff spaces and unital $C^*$-algebras. Embracing groupoids as "noncommutative spaces" one might want to extend the classic duality to this setting. Apart from the bigger problem of how to construct a groupoid spectrum of a $C^*$-algebra, there is the initial problem that the groupoid $C^*$-algebra construction is not functorial. In this talk I would like to discuss some proposed solutions to this question and some potential applications, some of which are related to the classification program.

*Jacek Krajczok*

## Coamenability of type I locally compact quantum groups

We say that a locally compact quantum group $\mathbb{G}$ is type I if $C_0^u(\hat{\mathbb{G}})$, the universal version of the $C^*$-algebra of continuous functions vanishing at infinity on the dual group, is type I. When $\mathbb{G}$ is classical we have $C_0^u(\hat{\mathbb{G}}) = C^*(\mathbb{G})$ therefore we get the usual notion of type I locally compact group. This class of quantum groups can be though of as an intermediate step between compact and general locally compact quantum groups; in particular type I locally compact quantum groups have tractable representation theory. Neshveyev and Tuset introduced certain operators on $\ell^2(\mathrm{Irr}(\mathbb{G}))$, properties of which allow us to detect whether compact quantum group $\mathbb{G}$ is coamenable. During the talk I will outline some results concerning generalization of such criterion to the case of type I locally compact quantum groups. This is work in progress.

*Arundhathi Krishnan*

## Markovianity and Representations of the Thompson monoid $F^+$

In the process of identifying a suitable distributional symmetry to describe Markovianity, it has been conjectured by C. Köstler that there is a certain correspondence between unilateral Markov shifts and representations of the Thompson monoid $F^+$.

After having illustrated this correspondence in the context of tensor products of $W^*$-algebraic probability spaces, I will present the following two general results. A representation of the Thompson monoid $F^+$ in the endomorphisms of a $W^*$-algebraic probability space yields a noncommutative Markov process (in the sense of Kümmerer). Conversely, such a representation is obtained from a noncommutative Markov process which is given as a coupling to a so-called spreadable noncommutative Bernoulli shift.

*Nicholas Manor*

## Exactness vs $C^*$-exactness for certain non-discrete groups

It is known that exactness for a discrete group $G$ is equivalent to $C^*$-exactness, i.e., the exactness of the reduced $C^*$-algebra $C_r^*(G)$. It is a major open problem to determine whether this equivalence holds for all locally compact groups,

but the problem has recently been reduced by Cave and Zacharias to the case of totally disconnected (td) unimodular groups. We will discuss ways to extend the equivalence of exactness and $C^*$-exactness to classes of non-discrete groups. These include the td groups admitting an invariant neighbourhood of the identity, and a family of td unimodular groups introduced by Yuhei Suzuki in the context of $C^*$-simplicity.

*Diego Martínez*

## Traces in inverse semigroup Roe algebras

Amenability was first introduced by von Neumann as a necessary and sufficient condition opposing the so-called *Banach-Tarski paradox* in the context of discrete groups. It was later observed that the set of traces of the classical Roe algebra $\mathscr{R}_G := \ell^\infty(G) \rtimes_r G$ is naturally isomorphic to the set of invariant means of $G$, as originally introduced by von Neumann. In this talk we will generalize this correspondence to the context of inverse semigroups. In order to do so we will introduce an analogue of the Roe algebra, namely $\mathscr{R}_S := \ell^\infty(S) \rtimes_r S$, where $S$ stands for a discrete and countable inverse semigroup. We will then study its trace simplex, and prove that it is isomorphic to the simplex of certain measures on the semigroup $S$. Time permitting, we will also relate this to the (non)-quasidiagonality of the reduced $C^*$-algebra of the inverse semigroup.

This is joint work with Pere Ara (UAB) and Fernando Lledó (UC3M-ICMAT).

*Sophie Mikkelsen*

## On the quantum twistor bundle

The concept of a quantum principal bundle is well established by now. However, general (locally trivial) fiber bundles are much less understood in the noncommutative setting. Brzeziński and Szymański have recently carried out a case study of a noncommutative sphere bundle from the quantum flag manifold $\mathbb{C}P_q^1 \to SU(3)/\mathbb{T}^2 \to \mathbb{C}P_q^2$. Building on this work, we wish to analyze a noncommutative sphere bundle from what we call quantum twistor bundle. This is defined by starting with the quantum instanton bundle $SU_q(2) \to S_q^7 \to S_q^4$ of Bonechi, Ciccoli, Dabrowski and Tarlini, and then passing to the fixed point algebra for a suitable circle action on the Vaksmann–Soibelman quantum sphere $S_q^7$.

*Shintaro Nishikawa*

## The gamma element and the (gamma) element

For a second countable, locally compact, Hausdorff group $G$, the Baum–Connes assembly map for $G$ is a mysterious homomorphism from the K-homology of co-compact, proper $G$-spaces to the K-theory of the reduced group $C^*$-algebras of $G$. The Baum–Connes conjecture states that the assembly map is an isomorphism of abelian groups for any $G$. The gamma element method (or the dual-Dirac method) is a versatile method to attack the conjecture. The method is initially developed by Gennadi Kasparov in 1988 and is successfully used by him and others to (partially) verify the conjecture for a large class of groups $G$. The main point of this method is to find the so-called gamma element for $G$. I will first explain and describe the gamma element and the gamma element method. Then, I will describe a newly-defined notion, the (gamma) element for $G$ which can be used as a replacement for the gamma element.

*Sujan Pant*

## Recent Results in Group von Neumann Algebra

I will survey recent classification results, and open problems in the area of group von Neumann algebra classification. Also, I will briefly present product rigidity results for $\text{II}_1$ factors of a large class of von Neumann algebras, where all tensor product decompositions of these $\text{II}_1$ factors are in one-to-one correspondence with a direct product decomposition of the generating group.

*André Schemaitat*

## The Jiang-Su algebra is strongly self-absorbing, revisited

Building on ideas of Rørdam and Winter, we introduce so-called unitarily suspended *-endomorphisms of generalized dimension drop algebras and show that any stationary inductive limit of a generalized prime dimension drop algebra together with a fixed unitarily suspended trace-collapsing *-endomorphism is strongly self-absorbing and embeds unitally into any strongly self-absorbing $C^*$-algebra. In particular, we obtain a self-contained proof of the fact that the Jiang-Su algebra is strongly self-absorbing.

*Pieter Spaas*

## Exotic central sequence algebras

We will define and discuss the central sequence algebra of a von Neumann algebra. Furthermore, we will provide examples of von Neumann algebras whose central sequence algebra is not the "tail" algebra associated to any decreasing sequence of von Neumann subalgebras, which settles a question of McDuff from the 60s. We end with a perhaps surprising application to the notion of tracial stability for groups. This is based on joint work with Adrian Ioana.

*Douglas Wagner*

## Exploring the $C^*$-algebra of a URS

A group acts on the set of its subgroups via conjugation; a Uniformly Recurrent Subgroup (URS) is a minimal set of subgroups that is closed in the Chabauty topology. A URS of a finitely generated group can be used to construct a graph, akin to a Cayley graph, which shares much of the URS's dynamics. In a paper in the Journal of Functional Analysis, Gábor Elek used these graphs to construct a new type of $C^*$-algebra. This talk will discuss the research being done on the strange structure of these $C^*$-algebras, including their relation to crossed products.

| Time | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|---|---|---|---|---|---|
| 08:00 - 08:25 | Registration | | | | | |
| 08:30 - 08:55 | Registration | | | | | |
| 09:00 - 09:25 | Putnam | Coffee | Coffee | Coffee | Coffee | Coffee |
| 09:30 - 09:55 | Putnam | Drutu | | Drutu | Putnam | Putnam |
| 10:00 - 10:25 | Break | Break | Break | Drutu | Putnam | Putnam |
| 10:30 - 10:55 | Kogan | Pant | Farah | Break | Martinez | Georgescu |
| 11:00 - 11:25 | Enstad | Das | Eryuzlu | Larsen | Mikkelsen | Adamo |
| 11:30 - 11:55 | Schemaitat | Spaas | Eifler | Charlesworth | Ewert | Break |
| 12:00 - 12:25 | Lunch | Lunch | Mentor Lunch (Women only) | Krishnan | Quick Lunch | Farah |
| 12:30 - 12:55 | Lunch | Lunch | Mentor Lunch (Women only) | Excursion and Lunch | Quick Lunch | Farah |
| 13:00 - 13:25 | | Putnam | Mentor Lunch (Women only) | Excursion and Lunch | Panel Discussion: Early Career Advice and Issues of Equity | Farah |
| 13:30 - 13:55 | Farah | Putnam | Drutu | Excursion and Lunch | Panel Discussion: Early Career Advice and Issues of Equity | Farah |
| 14:00 - 14:25 | Farah | Break | Drutu | Excursion and Lunch | Panel Discussion: Early Career Advice and Issues of Equity | Farah |
| 14:30 - 14:55 | Break | Wagner | Conference Photo | Excursion and Lunch | Farah | Farah |
| 15:00 - 15:25 | Austad | Manor | Gerontogiannis | Excursion and Lunch | Farah | |
| 15:30 - 15:55 | Haslehurst | Manor | Herstedt | Excursion and Lunch | Break | |
| 16:00 - 16:25 | Break | Break | Break | | Kim | |
| 16:30 - 16:55 | Gardner | | Drutu | | Nishikawa | |
| 17:00 - 17:25 | Ghasemi | Drutu | Larsen Keynote Address | | Krajczok | |
| 18:00 - | Reception (with pizza and beer) | Dinner | | | | |