Operator Algebras: Subfactors, K-theory and Conformal Field Theory

A conference in honour of David Evans' 70th birthday

Wednesday, 27th July 2022 – Tuesday, 2nd August 2022
at Gregynog Hall, Wales

Organised in partnership with the Clay Mathematics Institute

CMI

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UKRI Engineering and Physical Sciences Research Council

LONDON MATHEMATICAL SOCIETY
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Timetable

Time	Thursday, 28th July	Friday, 29th July	Saturday, 30th July	Sunday, 31st July	Monday, 1st August	Tuesday, 2nd August
until 09:30	Breakfast					
09:30 – 10:30	Dan Voiculescu	Gus Lehrer	Sorin Popa	Stuart White	Emily Peters	Alastair King
10:30 – 11:00	Coffee Break					
11:00 – 12:00	Masaki Izumi	Yasuyuki Kawahigashi	Constantin Teleman	Yuki Arano	Roberto Longo	Ulrich Pennig
12:10 – 12:40	Lucas Hataishi	Stephen Moore	Kan Kitamura	Sergio Giron Pacheco	Roberto H. Palomares	Terry Gannon (from 12:00 - 13:00)
13:00 – 15:00	Lunch Break					
15:00 – 16:00	Mayuko Yamashita	Katrin Wendland		Paul Fendley	Kasia Rejzner	
16:00 – 16:30	Tea					
16:30 – 17:30	Alina Vdovina	Denjoe O'Connor		Pinhas Grossman	Gandalf Lechner	
17:40 – 18:10	Tony Dorlas	Pieter Naaijkens		Claus Koestler	Jan Spakula	
18:10 – 19:00	Time for discussion					
19:00	Dinner					

All meals will be served in the Dining Hall. Tea and coffee during the mid morning and mid afternoon breaks will be served in the Blayney Room. All lectures will be held in the Music Room. The bar in the courtyard will be open before and after dinner. The Senior Common Room is available in the afternoons and evenings for discussion. These rooms are all on the ground floor of the main building. A floor plan is contained in the programme after the abstracts. A plan with some walks around the beautiful landscape surrounding Gregynog Hall is included as well.
There are no talks in the afternoon **on Saturday, 30th July**, but the **conference dinner** will take place on that day at **19:00**.

Abstracts

(speakers are in alphabetical order)

Yuki Arano (Kyoto University)

Tensor category equivariant KK-theory

Abstract
An action of C^*-tensor category on a C^*-algebra, which is a generalization of (quantum) group actions, naturally arises from an inclusion of C^*-algebras of finite index. I will give an overview of the theory of actions of C^*-tensor categories which is an analogue of the subfactor theory for C^*-algebras. Especially, I will focus on the equivariant KK-theory, which may be useful for the classification of inclusions of simple C^*-algebras. This is a joint work with Yosuke Kubota (Shinshu) and Kan Kitamura (Tokyo).

Paul Fendley (University of Oxford)

Categorical symmetries in statistical mechanics

Abstract
Fusion categories lie at the heart of what are now known as as generalised/higher/topological/categorical symmetries. Kramers-Wannier duality is a canonical example of such a symmetry, where the operator implementing it is not even invertible. I will explain how these symmetries are naturally implemented by topological defects, and show how fusion categories yield many such symmetries/defects in 1+1 and 2+0 dimensional lattice statistical-mechanical models models. An advantage of this set-up is that various properties such as critical exponents and boundary g-factors can be computed exactly on the lattice, without utilising or even requiring integrability.

Terry Gannon (University of Alberta)

The classification of exotic quantum subgroups

Abstract
One of the most celebrated results in Conformal Field Theory is the classification by Cappelli-Itzykson-Zuber in 1987 of the conformal field theories with $\mathfrak{sl}(2)$ symmetry. They found that they fall mysteriously into an A-D-E pattern. A few years later the analogous result for $\mathfrak{sl}(3)$ was obtained; these have a mysterious connection with Jacobians of Fermat curves. It wasn't until the involvement of Dai Evans and collaborators that the proper mathematical context was obtained. Even so, progress on this problem was slow until two recent breakthroughs. My talk is aimed at nonexperts. It describes the history of the problem, and where we are now after the breakthroughs.

Sergio Giron Pacheco (University of Oxford)

Anomalous symmetries of classifiable C^*-algebras

Abstract
In this talk I will discuss anomalous actions on simple C^*-algebras. I will start by introducing the notion of an anomalous action and talk about the existence question, in this part I will discuss K-theoretic obstructions that occur, one that follows from considering the algebraic K_1-group and one that appears from considering the K_0-group. Time permitting I will also shortly discuss the Rokhlin property on anomalous actions and the classification question of these actions.

Pinhas Grossman (UNSW Sydney)

Quadratic fusion categories and modular data

Abstract
A quadratic category is a fusion category which contains a unique non-trivial orbit under the tensor product action of its group of invertible objects. Evans and Gannon found striking patterns in the modular data associated to Drinfeld centers of certain types of quadratic categories, and made some remarkable conjectures about the existence and structure of infinite families of quadratic categories. In this talk we will discuss some generalizations of the Evans-Gannon conjectures, and work-in-progress on constructing associated fusion categories. This is joint work with Masaki Izumi.

Lucas Hataishi (University of Oslo)

Injective envelopes of C*-module categories and boundary theory

Abstract
We study injectivity for C^*-algebra objects in C^*-tensor categories. Generalizing work of Hamana, we prove that every cyclic C^*-module category over a rigid C^*-tensor category has an injective envelope. Building on a categorical construction of Hataishi, Habbestad and Neshveyev, we show that the Furstenberg-Hamana boundary theory of Drinfeld doubles of compact quantum groups can be carried on entirely at the level of the representation category of the quantum groups. Based on joint work with M. Yamashita.

Roberto Palomares Hernandez (Ohio State University)

K-theoretic classification of inductive limit actions of fusion categories on AF-algebras

Abstract
I will introduce a K-theoretic complete invariant of inductive limits of finite dimensional actions of fusion categories on unital AF-algebras. This framework encompasses all such actions by finite groups on AF-algebras. Our classification result essentially follows from applying Elliott's Intertwining Argument adapted to this equivariant context, combined with tensor categorical techniques. Time allowing, we will discuss some applications.

Masaki Izumi (Kyoto University)

G-kernels of C^*-algebras

Abstract
For a group G, a G-kernel is a group homomorphism from G into the outer automorphism group of an operator algebra A. When A has trivial center, one can associate the third cohomology obstruction in $H^3(G, \mathbb{T})$ to a G-kernel. In the case of the hyperfinite II_1-factor, this is known to be a complete invariant for discrete amenable G due to Connes, Jones, and Ocneanu. In their recent work, Evington and Pacheco started first systematic analysis of G-kernels in the case of C^*-algebras. Using algebraic K-thoery, they showed that the third cohomology obstruction of G-kernels of stably finite C^*-algebras cannot be arbitrary, and in fact they are trivial in the case of Jiang-Su algebras.
In this talk, I introduce a new invariant for G-kernels only using ordinary K-theory, and apply it to the case of purely infinite C^*-algebras. It turns out that when G is finite, we still have a strong constraint to on the third cohomology obstructions, while the situation is completely different for infinite G. For example, in the case of the Cuntz algebra $\mathcal{O}_\infty$, injective $\mathbb{Z}^3$-kernels are completely classified by $H^3(\mathbb{Z}^3, \mathbb{R})$.

Yasuyuki Kawahigashi (University of Tokyo)

A characterization of a finite-dimensional commuting square producing a subfactor of finite depth

Abstract
We give a characterization of a finite-dimensional commuting square with a normalized trace that produces a hyperfinite type II_1 subfactor of finite index and finite depth in terms of Morita equivalence of fusion categories. This type of commuting squares were studied by N. Sato in 1990's, and we show that a slight generalization of his construction covers the fully general case of such commuting squares. We also give a characterization of such a commuting square that produces a given hyperfinite type II_1 subfactor of finite index and finite depth. These results also give a characterization of certain 4-tensors appearing in recent studies of matrix product operators in 2-dimensional topological order in condensed matter physics.

Alastair King (University of Bath)

NIMreps and Modular Invariants

Abstract
I will review the famous fact that the diagonal part of a modular invariant is the spectrum of the associated NIMrep, through the lens of representations of the tube category.

Claus Koestler (University College Cork)

The Jones-Temperley-Lieb algebra from the viewpoint of distributional invariance properties

Abstract
Semi-cosimplicial objects in a category of noncommutative probability spaces have recently been found to be in close contact with a distributional invariance principle called 'spreadablity'. I will discuss in my talk that the Jones-Temperley-Lieb algebra is a semi-cosimplicial C^*-algebra for small Jones index. Furthermore, again for small Jones index, the sequence of Jones-Temperley-Lieb projections is shown to be 'partially spreadability'. Here 'partial spreadability' is implemented through an action of the Thompson monoid F^+ which generalizes 'spreadability'. If time permits, I will formulate some conjectures for the case of large Jones index. My talk is based on joint work with G. Evans, R. Gohm, A. Krishnan, and S. Wills.

Gus Lehrer (University of Sydney)

The second fundamental theorem for the orthosymplectic supergroup

Abstract
I outline joint work with R. Zhang and P. Deligne, in which we use super-algebraic geometry to relate invariants of OSp and super-GL. This leads to both first and second fundamental theorems of invariant theory for OSp. The latter may be interpreted in terms of diagrammatics, and so reduces to combinatorial questions.

Roberto Longo (Tor Vergata)

Entropy and the modular Hamiltonian

Abstract
I will talk about recent results on the modular Hamiltonian in QFT. In particular, the notion of entropy of a vector in a complex Hilbert space H with respect to a real linear subspace of H plays a key role.

Stephen Moore (IMPAN, Torun)

Limits of Traces for Temperley-Lieb algebras

Abstract
We review the classification of extremal traces on the infinite Temperley-Lieb algebra in the generic case and extend the classification to the root of unity case. As a result, we obtain Hilbert space structures on the full infinite Temperley-Lieb algebra at roots of unity.

Pieter Naaijkens (Cardiff University)

Topological phases of matter in an operator-algebraic approach

Abstract
The study of conformal field theory and superselection sectors in an operator-algebraic approach has lead to many interesting connections with tensor categories and subfactor theory, and vice versa. In more recent years, many of these techniques have found applications in the study of topological phases of matter, even if from a technical point of view they appear very different at first sight. For example, in typical examples such as Kitaev's toric code, the local algebras are finite dimensional matrix algebras, whereas in field theory they are generically Type III. Nevertheless, many ideas carry over. In this talk I will give a brief overview of the problem of topological phases of matter and their classifications, and point out some interesting connections to techniques coming from subfactor theory or conformal field theory.

Denjoe O'Connor (Dublin Institute for Advanced Studies)

Matrix Trace Relations and Hagedorn Phase Transitions

Abstract
I will review what is known of the algebra of invariants for a system of d, $N \times N$-matrices and describe a universal result in the counting of such invariants. The result arises in the context of Hagedorn Phase transitions in quantum matrix models.

Emily Peters (Loyola University Chicago)

Conway's Rational Tangles and the Thompson group

Abstract
In the process of studying Thompson's group F (of piecewise linear homeomorphisms from the closed unit interval $[0, 1]$ to itself, which are differentiable except at finitely many dyadic rational numbers), Vaughan Jones observed a map from F to knots. He proved that every knot is in the image of this map – that is, that every knot can be seen as the "knot closure" of a Thompson group element. Jones' algorithm to achieve this is rather piecemeal, and he asked if there was a better one.
In a project with undergraduate student Ariana Grymski, we approach this question through the lens of Conway's rational tangles. We are able to give methods to construct any product or concatenation of simple tangles, and we hope these are seeds for a more skein-theoretic approach to the construction question.

Sorin Popa (UCLA)

W^*-representation theory for subfactors

Abstract
A *W^*-representation* of a II_1 subfactor $N \subset M$ with finite Jones index, $[M : N] < \infty$, is a non-degenerate commuting square embedding of $N \subset M$ into an inclusion of atomic von Neumann algebras $\oplus_{i\in I}\mathcal{B}(\mathcal{K}_i) = \mathcal{N} \subset^{\mathcal{E}} \mathcal{M} = \oplus_{j\in J}\mathcal{B}(\mathcal{H}_j)$. I will give examples, present some basic results and explain why this notion is interesting, especially for identifying the set $\mathcal{C}(M)$ of indices of irreducible subfactors of a given II_1 factor M, notably in the case $M = R$.

Kasia Rejzner (University of York)

The C^*-algebraic approach to interacting QFT (renormalization and symmetries)

Abstract
In this talk I will present recent results related to the Buchholz-Fredenhagen construction of nets of C^*-algebras of interacting QFT models. I will focus on the notion of renormalization group and the treatment of symmetries. This is based on a recent paper with Brunetti, Duetsch and Fredenhagen "The unitary Master Ward Identity: Time slice axiom, Noether's Theorem and Anomalies."

Jan Spakula (University of Southampton)

Some uniformly bounded representations of hyperbolic groups

Abstract
For any (Gromov) hyperbolic group G, we construct a family of uniformly bounded representations of G indexed by complex numbers z for $Re(z)$ around $1/2$, namely $[(D-2)/(2D), (D+2)/(2D)]$. We utilise the action of G on its boundary, and D is the Hausdorff dimension of a boundary.

For a bit of context, constructing such a family for the larger range Re(z) in $[0,1]$ is the "representations" counterpart to weak amenability of G.

This is joint work (in progress) with K. Boucher.

Constantin Teleman (University of California, Berkeley)

Coulomb branches for gauge theory and higher twistings of K-theory

Abstract
Formulas for the index of vector bundles over the moduli of principal G-bundles on a Riemann surface were written out in joint work with Woodward. They are controlled by 2-dimensional TQFTs, whose description requires (higher) twistings of equivariant K-theory, and even their deloopings. The latter are described in terms of Theta-functions and dilogarithms of representations of G. The same dilogarithm formulas appear in the construction of 'Coulomb branches' for 3-dimensional gauge theory with linear matter. I will outline the relation between these stories.

Alina Vdovina (Newcastle University)

Buildings, C^*-algebras and new higher-dimensional analogues of the Thompson groups.

Abstract
We present explicit constructions of infinite families of CW-complexes of arbitrary dimension with buildings as the universal covers. These complexes give rise to new families of C^*-algebras, classifiable by their K-theory. The underlying building structure allows explicit computation of the K-theory. We will also present new higher-dimensional generalizations of the Thompson groups, which are usually difficult to distinguish, but the K-theory of C^*-algebras gives new invariants to recognize non-isomorphic groups.
We will also discuss new directions of generalizations to higher dimensions of the work of Vaughan Jones and his collaborators on connections of the Thomson's group and Theoretical Physics.

Dan-Virgil Voiculescu (University of California, Berkeley)

A noncommutative nonlinear condensor capacity

Abstract
The quasicentral modulus is key in many questions about commutants mod normed ideals and in normed ideal perturbations of n-tuples of operators. I have extended the definition to that of a condenser quasicentral modulus and I will point out an analogy with condenser capacity in nonlinear potential theory.

Katrin Wendland (Trinity College Dublin)

Elliptic genera for ADE

Abstract
In joint work with Yuhang Hou, we construct elliptic genera that allow a geometric interpretation on ADE type surface singularities.

Stuart White (University of Oxford)

Classification of simple nuclear C^*-algebras

Abstract
I'll give a survey of recent progress in the classification of simple nuclear C^*-algebras, drawing parallels with the von Neumann theory. My aim is to try and indicate why this is the right time for increased connections between the subfactor and C^*-classification communities.

Mayuko Yamashita (RIMS, Kyoto University)

Category of QFTs and differential cohomology

Abstract
Recently, higher categorical understandings of quantum field theories have been rapidly developing. On the other hand, differential cohomology theories, whose relationships with physics are classical, are most modernly understood in terms of sheaves on manifolds with values in $(\infty, 1)$-categories. In this talk, I explain an ongoing work to combine them, and to give a higher relations between QFTs and differential cohomology. Invertible QFTs are expected to form a sheaf of higher groupoids, and we apply the framework of differential cohomology to this sheaf. This is a joint work with K. Ohmori (U. Tokyo).

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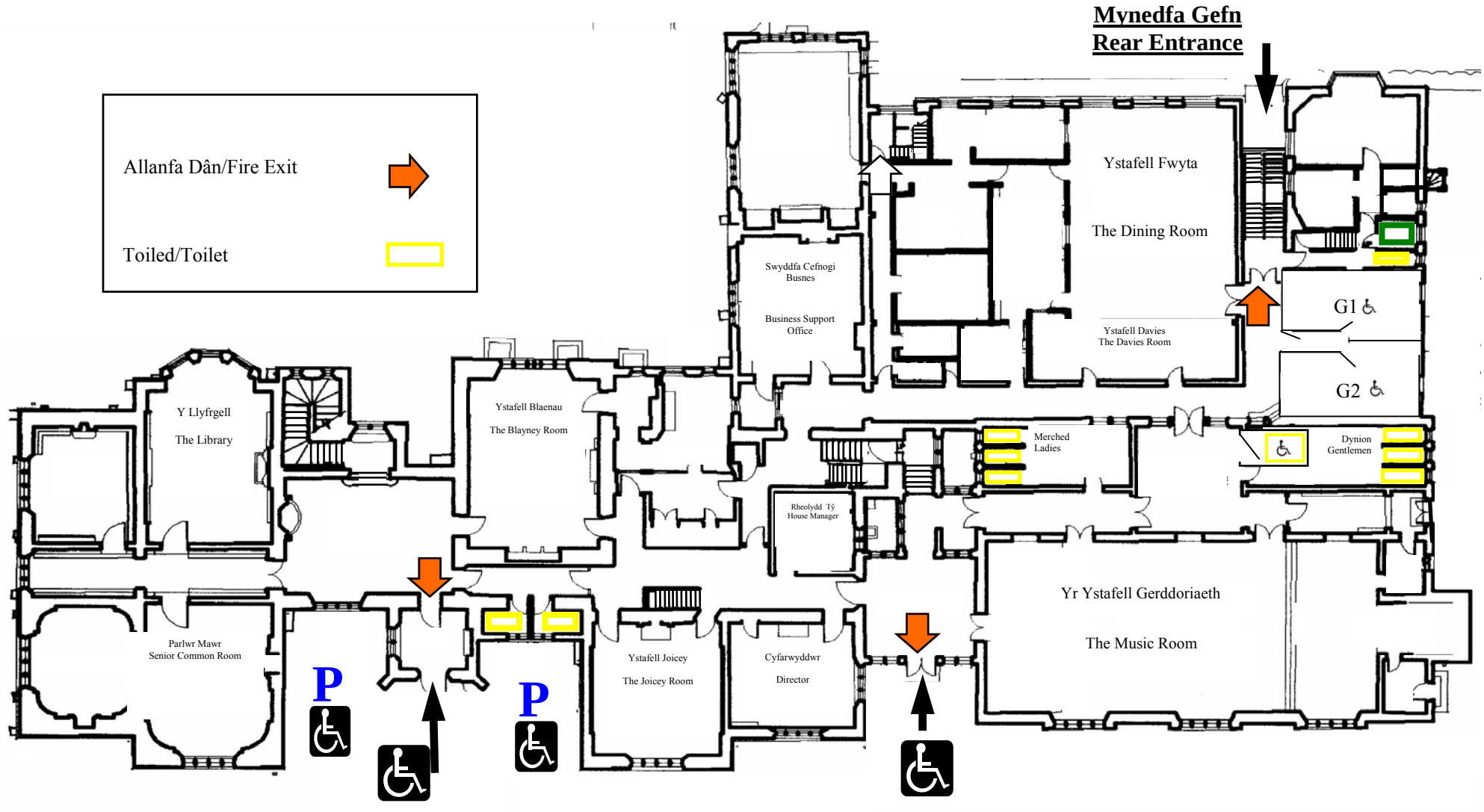
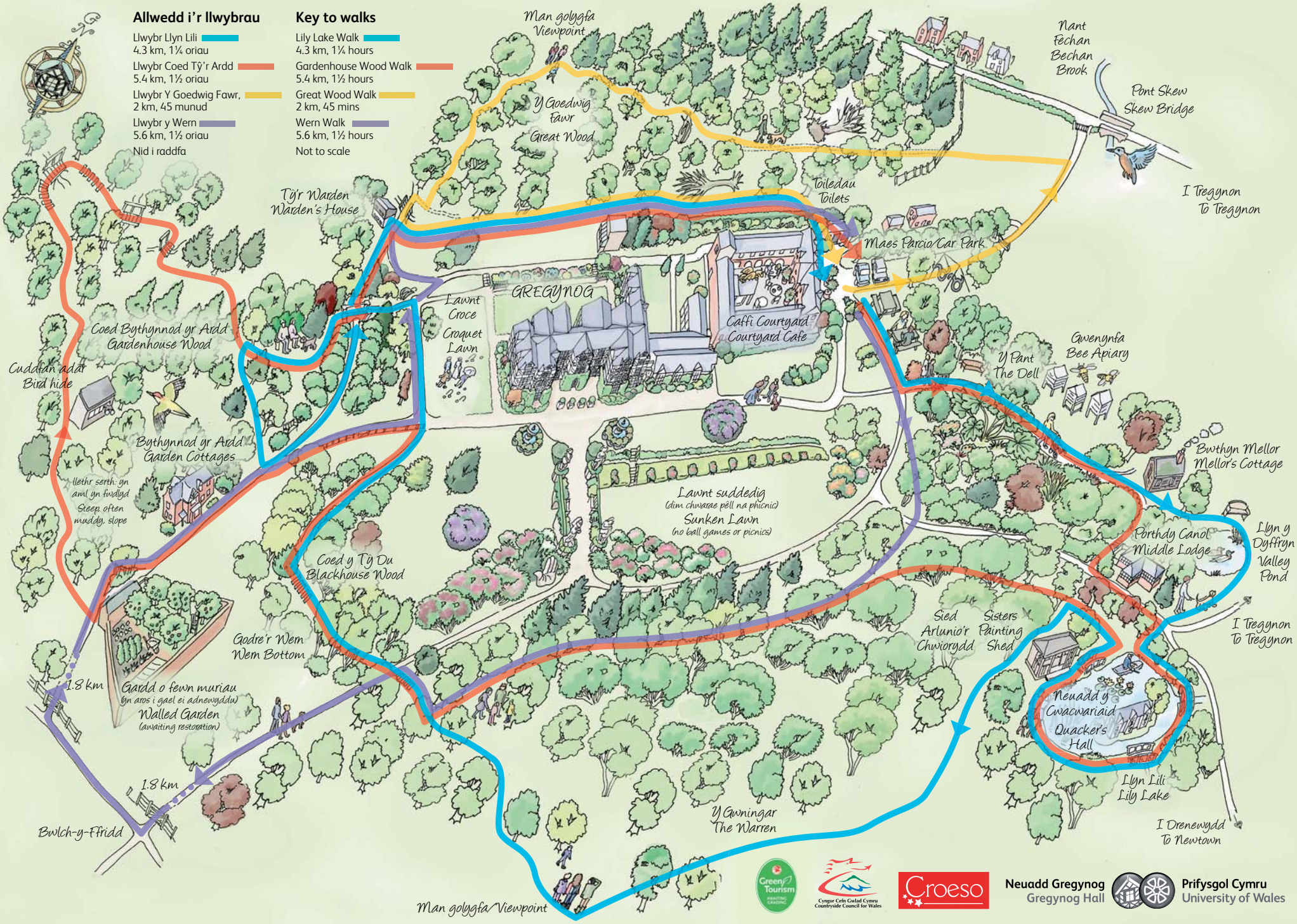
GROUND FLOOR PLAN




Allwedd i'r llwybrau
Llwybr Llyn Lili
4.3 km, 1¼ oriau
Llwybr Coed Tŷ'r Ardd
5.4 km, 1½ oriau
Llwybr Y Goedwig Fawr,
2 km, 45 munud
Llwybr y Wern
5.6 km, 1½ oriau
Nid i raddfa
Key to walks
Lily Lake Walk
4.3 km, 1¼ hours
Gardenhouse Wood Walk
5.4 km, 1½ hours
Great Wood Walk
2 km, 45 mins
Wern Walk
5.6 km, 1½ hours
Not to scale
Man golygfa
Viewpoint
Nant Fechan
Bechan Brook
Pont Skew
Skew Bridge
Y Goedwig Fawr
Great Wood
I Tregynon
To Tregynon
Tŷ'r Warden
Warden's House
Toiledau
Toilets
Maes Parcio/Car Park
GREGYNOG
Lawnt Croce
Croquet Lawn
Caffi Courtyard
Courtyard Cafe
Coed Bythynnod yr Ardd
Gardenhouse Wood
Cuddfan adar
Bird hide
Gwenynfa
Bee Apiary
Y Pant
The Dell
Bythynnod yr Ardd
Garden Cottages
llethr serth: yn aml yn fwdlyd
Steep, often muddy, slope
Bwthyn Mellor
Mellor's Cottage
Lawnt suddedig
(dim chwarae pêl na phicnic)
Sunken Lawn
(no ball games or picnics)
Porthdy Canol
Middle Lodge
Llyn y Dyffryn
Valley Pond
Coed y Tŷ Du
Blackhouse Wood
Sied Arlunio'r Chwiorydd
Sisters Painting Shed
I Tregynon
To Tregynon
Godre'r Wern
Wern Bottom
1.8 km
Gardd o fewn muriau
(yn aros i gael ei adnewyddu)
Walled Garden
(awaiting restoration)
Neuadd y Gwacwariaid
Quacker's Hall
Llyn Lili
Lily Lake
1.8 km
Bwlch-y-Ffridd
Y Gwningar
The Warren
I Drenewydd
To Newtown
Man golygfa
Viewpoint
Green Tourism
Cyngor Cefn Gwlad Cymru
Countryside Council for Wales
Croeso
Neuadd Gregynog
Gregynog Hall
Prifysgol Cymru
University of Wales