The Eighth Pacific Rim Conference in Mathematics

3rd to 11th August 2020

Titles & Abstracts

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Differential geometry

L^2 harmonic theory and Seiberg-Witten Bauer-Furuta theory on non-compact complete Riemannian 4-manifolds
Tsuyoshi Kato

I will talk on some fusion of a topic on Singer conjecture in L^2 harmonic theory with Seiberg-Witten Bauer-Furuta theory on non-compact complete Riemannian 4-manifolds. We explain their analytic settings, certain results and questions.

The Atiyah-Patodi-Singer index and domain-wall fermion Dirac operators
Shinichiroh Matsuo

We introduce a mathematician-friendly formulation of the physicist-friendly derivation of the Atiyah-Patodi-Singer index.

In a previous work, motivated by the study of lattice gauge theory, we derived a formula expressing the Atiyah-Patodi-Singer index in terms of the eta invariant of ""domain-wall fermion Dirac operators"" when the base manifold is a flat 4-dimensional torus. Now we generalise this formula to any even dimensional closed Riemannian manifolds, and prove it mathematically rigorously. Our proof uses a Witten localisation argument combined with a devised embedding into a cylinder of one dimension higher. Our viewpoint sheds some new light on the interplay among the Atiyah-Patodi-Singer boundary condition, domain-wall fermions, and edge modes.

This talk is based on a joint work with H. Fukaya, M. Furuta, T. Onogi, S. Yamaguchi, and M. Yamashita: arXiv:1910.01987.

Life sciences – mathematical modelling and analysis

Propagation, diffusion and free boundaries
Yihong Du

In this talk I will discuss some of the mathematical theories on nonlinear partial differential equations motivated by the desire of providing better models for various propagation phenomena. The talk will start with classical works of Fisher, Kolmogorov-Petrovskii-Piskunov and Aronson-Weinberger, and then focus on recent results on free boundary models with local as well as nonlocal diffusion, which are variations of the models in the classical works.

Travelling wave solutions of the 3-species Lotka-Volterra competition system with diffusion
Chiun-Chuan Chen

One of the central issues in mathematical ecology is to understand how coexistence of many species is possible. This talk is concerned with the problem of whether competition among species helps to sustain their coexistence. We first focus on the existence of a special type of non-monotone traveling waves of the 3-species system and introduce some related results in recent years. Then we show that this type of waves provides new clues about the problem of coexistence.

Number theory

Wild ramification and the cotangent bundle in mixed characteristic
Takeshi Saito

The analogy between the wild ramification in arithmetic geometry and the irregular singularity of partial differential equations has attracted interests of mathematicians. For a D-module on a complex manifold, its singular support is defined on the cotangent bundle. An algebraic variant over a field of positive characteristic is recently introduced by Beilinson. I will discuss an analogue in mixed characteristic case.

Uniform bounds of orbital integrals
Cheng-Chiang Tsai

In this talk, we aim to give a survey about available and expected results on uniform bounds of orbital integrals. Interestingly, both the heuristic and method comes from the geometry of so-called affine Springer fiber, and in particular the expectation that this fibration (between infinite-dimensional varieties) is “semi-small.” We will put an emphasis on this connection.

Base change and central values of triple product L-series
Shunsuke Yamana

Let π_i be an irreducible cuspidal automorphic representation of GL(2,A) with central character ω_i, where A is an adele ring of a number field. When the product $\omega_1\omega_2\omega_3$ is the trivial character of A*, Atsushi Ichino proved a formula for the central value $L(1/2, \pi_1 \times \pi_2 \times \pi_3)$ of the triple product L-series in terms of global trilinear forms that appear in Jacquet’s conjecture. I will extend this formula to the case when $\omega_1\omega_2\omega_3$ is a quadratic character. This is a joint work with Ming-Lun Hsieh.

Partial Differential Equations: Inviscid Fluid Mechanics and General Relativity

Dynamics of Newtonian stars

Juhi Jang

The gravitational Euler-Poisson system is a classical fluid model describing the motion of self-gravitating gaseous Newton stars. We discuss some recent results on expanding, collapsing and rotating star solutions of the Euler-Poisson system.

Probability theory

Mass gap implies quark confinement

Sourav Chatterjee

The confinement of quarks is one of the enduring mysteries of modern physics. I will present a rigorous result that shows that if a pure lattice gauge theory at some given coupling strength has exponential decay of correlations under arbitrary boundary conditions, and the gauge group is a compact connected matrix Lie group with a nontrivial center, then the theory is confining. This gives mathematical justification for a longstanding belief in physics about the mechanism behind confinement, which roughly says that confinement is the result of strong coupling behavior plus center symmetry. The proof is almost entirely based in probability theory, making extensive use of the idea of coupling probability measures.

Recent trends in geometric analysis

Fundamental Gap Estimate in the Hyperbolic Spaces

Guofang Wei

In their celebrated work, B. Andrews and J. Clutterbuck proved the fundamental gap conjecture that the difference of the first two eigenvalues of the Laplacian with Dirichlet boundary condition on a convex domain with diameter D in Euclidean space is greater than or equal to $3\pi^2/D^2$. In several joint works with X. Dai, Z. He, S. Seto, L. Wang (in various subsets), the estimate is generalized, showing the same lower bound holds for convex domains in the unit sphere. In sharp contrast, in recent joint work with T. Bourni, J. Clutterbuck, A. Stancu, X. Nguyen and V. Wheeler, we prove that the product of the fundamental gap with the square of the diameter can be arbitrarily small for convex domains of any diameter in the hyperbolic spaces.

Minimal surfaces and flat surfaces

Hojoo Lee

We will introduce the flat structures on minimal surfaces introduced by Chern and Ricci, respectively.

Positive scalar curvature on foliations

Weiping Zhang

A famous theorem of Lichnerowicz states that if a closed spin manifold carries a Riemannian metric of positive scalar curvature, then the A-hat genus of the manifold vanishes. We will describe various generalizations of this result, as well as some other classical results concerning positive scalar curvature, to the case of foliations. A typical example is Connes' theorem which states that if the A-hat genus of a compact foliated manifold with spin leaves does not vanish, then there is no metric with positive scalar curvature along the leaves.

Symplectic geometry & dynamical systems

The simplicity conjecture
Dan Cristofaro-Gardiner

In the 60s and 70s, there was a flurry of activity concerning the question of whether or not various subgroups of homeomorphism groups of manifolds are simple, with beautiful contributions by Fathi, Kirby, Mather, Thurston, and many others. A funnily stubborn case that remained open was the case of area-preserving homeomorphisms of surfaces. For example, for balls of dimension at least 3, the relevant group was shown to be simple by work of Fathi in 1980; but, the answer in the two-dimensional case, asked in the 70s, was not known. I will explain recent joint work proving that the group of compactly supported area preserving homeomorphisms of the two-disc is in fact not a simple group; this answers the ”Simplicity Conjecture” in the affirmative. Our proof uses new spectral invariants, defined via periodic Floer homology, that I will introduce: these recover the Calabi invariant of monotone twists.